Jan. 25, 1938. W. H. REICHARD 2,106,680

HIGHWAY CROSSING SIGNALING SYSTEM

Filed April 17, 1936 2 Sheets-Sheet 1

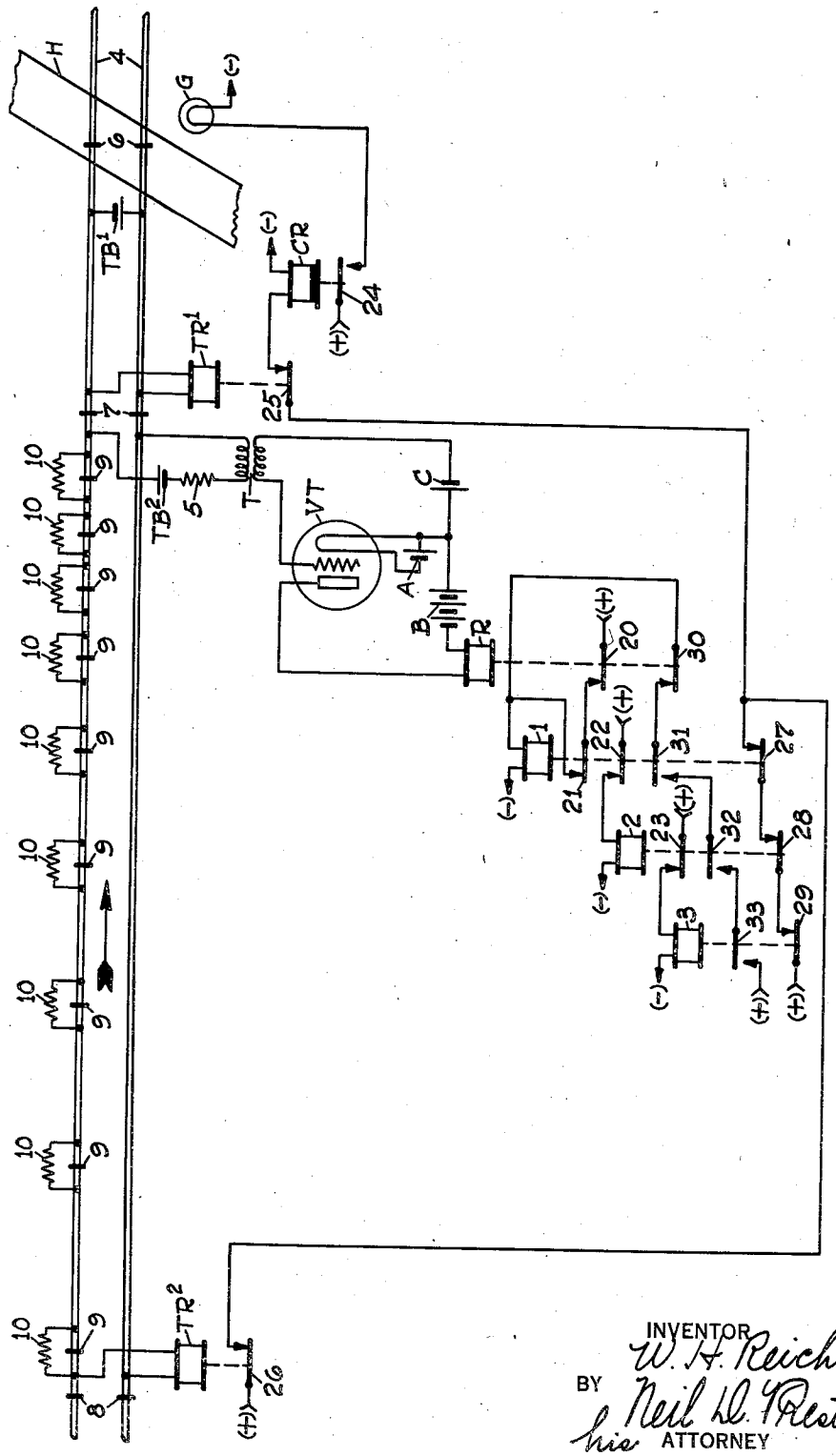


FIG. 1.

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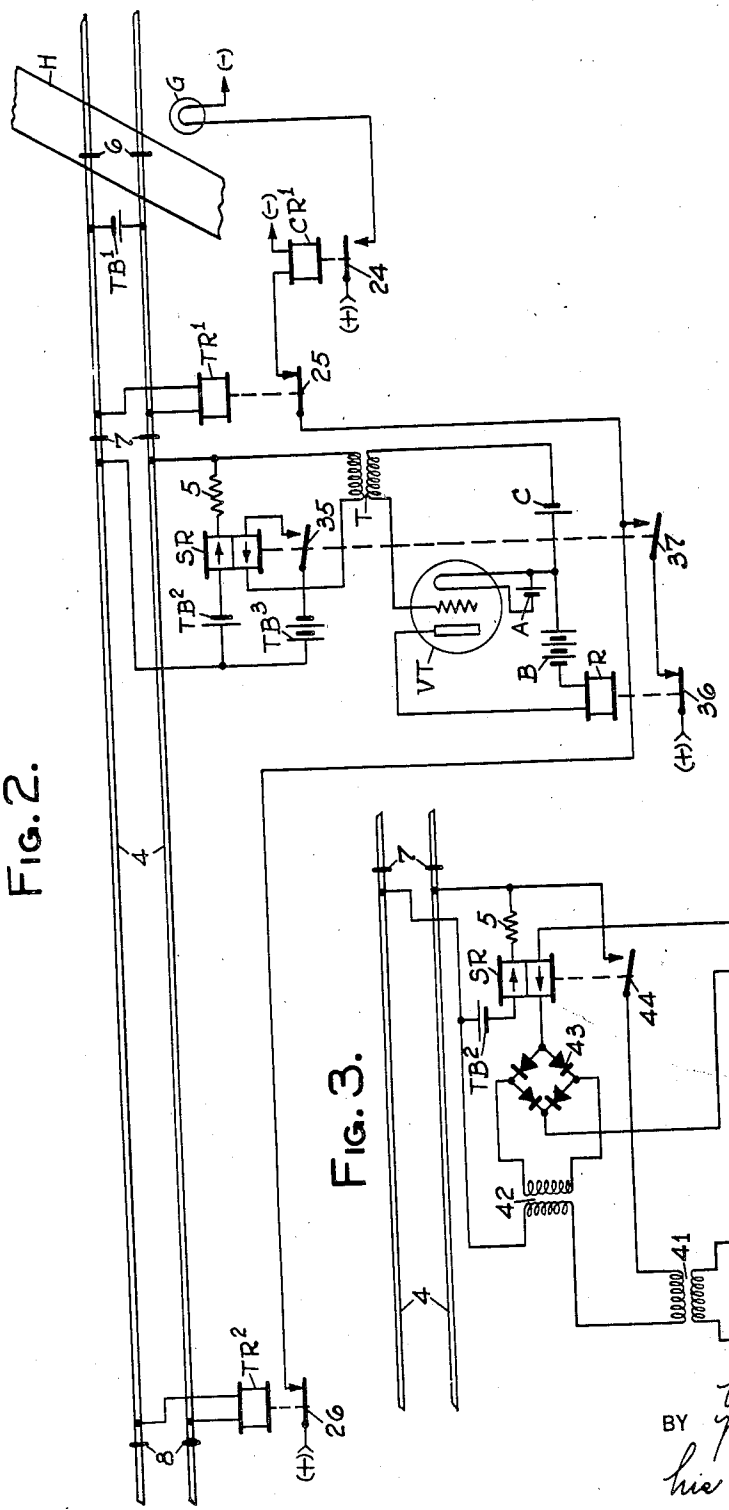


FIG. 2.

FIG. 3.

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2,106,680

HIGHWAY CROSSING SIGNALING SYSTEM

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12 Claims. (Cl. 246—130)

This invention relates in general to signaling systems, and more particularly to signaling systems for protecting traffic on highway crossings over railroads.

It is proposed in accordance with the present invention to provide a signaling system for highway crossings wherein a warning is given to highway traffic for a uniform time prior to the arrival of a train at the highway regardless of the speed of such train. It is further proposed to provide such a highway crossing signaling system wherein the warning given to highway traffic is inherently dependent on motion as well as speed of a train toward the crossing, thereby avoiding unnecessary warning in the event an approaching train stops short of the highway or when a train is moving from the highway crossing.

Other objects, purposes and characteristic features of the present invention will appear as the description thereof progresses, during which references will be made to the accompanying drawings, in which:—

Fig. 1 shows in a diagrammatic and conventional manner one embodiment of the present invention.

Fig. 2 shows also in a diagrammatic and conventional manner a modified form of the present invention.

Fig. 3 shows a modification which can be made in the form shown in Fig. 2.

In Fig. 1 of the accompanying drawings, H designates a highway crossing a railroad indicated diagrammatically by track rails 4, and G represents a highway crossing signal of any desired type such as a flashing light signal, a warning bell, power operated gates or the like. The direction of railroad traffic has been indicated as from left to right by the arrow on the drawings, and the portion of the track traversed by a train approaching the highway H is divided into two track sections. The first or positive control section extends from insulating joints 6 at the highway to insulating joints 7 located at the left of the highway and the usual track circuit is formed therein by battery TB^1 and track relay TR^1. The second or speed control section adjoins the left hand end of the positive control section and extends from insulating joints 7 to insulating joints 8 and likewise this section is energized from the right hand end by battery TB^2 to normally energize a track relay TR^2 located at the left hand end.

The insulating joints 8 forming the entrance end of the speed control section should be located such a distance from the highway H that a train traveling at the maximum rate of speed reaches the crossing a predetermined time after entering the first portion of this speed control section, which time is the desired crossing signal warning time which in most cases is 20 seconds. The exit end of this speed control section is located at such a point that the slowest normal train movements arrive at the highway about 20 seconds after reaching the very last portion of this speed control section, thus leaving a short positive controlling section between this point and the highway, which section is employed as later described to positively provide a highway warning signal when occupied by a train, or this section may initiate the warning when entered by an unusually slow train or when a train stops in the speed section and later progresses toward the highway.

The speed controlling section or the section between insulating joints 7 and 8 is provided with insulating joints 9 unevenly spaced throughout its length, which joints are shunted by suitable resistors 10 through which the track circuit current flows around the insulating joints 9. The number of these insulating joints 9 may be varied according to the characteristics of the apparatus of the system as will later be evident, and it is to be understood that all such joints need not be placed in the same rail as illustrated but could be arranged in a staggered manner in both rails. It is necessary however to space each of these joints 9 by a shorter distance than the spacing of the left hand adjacent joints, or that is, the joints 9 are spaced by distances progressively decreasing in a constant relation from left to right throughout the speed controlling section.

The track battery TB^2 is connected to the right hand end of this speed section in series with the usual track circuit resistor 5 and the primary of a transformer T, whereby current flows through the track rails and all the resistors 10 in series to attract the armature of track relay TR^2. The secondary of transformer T is connected in the grid circuit of a vacuum tube amplifier VT in series with a grid biasing battery C. The filament of the vacuum tube VT is continuously energized from a suitable source such as battery A, and the output or plate circuit is connected to a relay R in series with a suitable source of plate current such as battery B.

It will be clear that normally the track circuit current from battery TB^2 is of a constant value thereby providing zero secondary voltage in transformer T, and the battery C is arranged to

provide a sufficiently low grid voltage or bias to effect an output or plate current which attracts the armature of relay R. Three timing relays 1, 2 and 3 are provided which are controlled in a cascade manner by relay R, that is, relay 1 is energized over a stick circuit including front contact 20 of relay R and its own front contact 21, relay 2 is energized through front contact 22 of relay 1 and relay 3 is energized through front contact 23 of relay 2.

The highway crossing signal G is controlled by a slow acting relay CR through a back contact 24, which relay CR is in turn normally energized by a circuit including front contact 25 of track relay TR^1 providing either of two multiple circuits are closed, one of these circuits being through front contact 26 of track relay TR^2 and the other being through front contacts 27, 28 and 29 of relays 1, 2 and 3. The control relay CR is then dependent for its energization through front contacts 27, 28 and 29 of the timing relays when a train enters the speed controlling section to drop relay TR^2, the timing relays operating as will presently be described to deenergized relay CR when a train reaches a point in the speed controlling section determined by its speed, and after the train enters the positive controlling section to drop relay TR^1, the control relay CR is obviously deenergized by open front contact 25.

When a train traveling toward the highway H passes the first insulating joint 9, the resistance in the track circuit provided by the first resistance 10 and the windings of the track relay TR^2 will be shunted out, thereby causing an increase in current through the primary of transformer T. During this current increase in the primary, a secondary voltage is induced in transformer T which increases the negative grid bias on the vacuum tube VT sufficiently to cause a reduction in the output plate current and release the armature of relay R. The current in relay R however immediately returns to its normal value and attracts its armature after the train passes the first insulated joint 9, but it will be clear that a similar track circuit current increase occurs to momentarily release the armature of relay R when the train passes each of the other insulating joints 9. In this manner when a train progresses at uniform speed in the normal direction of traffic through the speed controlling section, the armature of relay R is momentarily released at time spaced intervals of decreasing lengths in accordance with the decreasing linear distances separating the various insulating joints 9 throughout the section.

The momentary dropping of relay R obviously drops relay 1 by opening its stick circuit at front contact 20, the dropping of relay 1 then drops relay 2 at front contact 22 and the dropping of relay 2 then likewise drops relay 3 at front contact 23. However, if the relay R is picked up at the time all the relays 1, 2 and 3 become deenergized, the timing relays 1, 2 and 3 immediately pick up in the same sequence, or relay 1 is energized over a circuit including back contacts 31, 32 and 33 of relays 1, 2 and 3 and front contact 30 of relay R and relays 2 and 3 are subsequently picked up in order as previously described.

It will be clear that the energizing circuit for relay CR is open as soon as relay 1 drops and remains open until all relays 1, 2 and 3 are again picked up, but the characteristics of relay CR and the characteristics of the timing relays are so arranged that the control relay CR requires a time to release its armature after deenergization which is slightly longer than the cumulative drop away times plus the cumulative pick up times of the timing relays 1, 2 and 3. In other words, if the timing relays 1, 2 and 3 drop in sequential order and immediately pick up again in the same order, the control relay CR is not deenergized for a sufficient length of time to release its armature, consequently the signal G does not receive energy through back contact 24.

Now considering that a train traveling at the maximum rate of speed enters the speed controlling section to sequentially drop the timing relays 1, 2 and 3 as just described upon passing the first insulated joint 9, the second joint 9 is so spaced therefrom that this train passes over the second joint to drop relay R a second time at substantially the same time that relays 1, 2 and 3 have all dropped, thereby preventing the timing relays from immediately picking up due to open front contact 30 of relay R which prevents energization of relay 1. In this manner the fastest train movement toward the highway prevents the timing relays from immediately picking up after their deenergization and causes the relay CR to be deenergized for an extended period of time which is sufficient to release its armature and energize signal G through back contact 24 thus displaying a warning indication at the highway immediately after this train enters the speed controlling section.

The timing relays which had released during the time of train travel from the first to the second joint 9, start to pick up at the end of the second momentary release of the armature of relay R, and may even all complete their pick up, but the present train progressing at maximum speed reaches the third insulating joint to again cause their deenergization before the relay CR has been energized for a sufficient length of time to attract its armature. Consequently it will be clear that while the present train is proceeding through the speed controlling section, the increasingly rapid momentary operations of relay R will be effective to retain control relay CR deenergized and continue the warning indication at signal G. When the train enters the absolute control section to drop relay TR^1 it will be clear that energization of relay CR is provided by the opening of front contact 25.

However, when a train traveling at a speed slower than this maximum rate enters the speed controlling section, the timing relays immediately drop as previously described upon passing the first insulating joint 9, but this slower speed train does not reach the second insulating joint as quickly thereafter as did the maximum speed train previously considered, thereby allowing the timing relays to sequentially pick up again and reenergize relay CR before the second insulating joint 9 is passed. A warning signal is not immediately given by this slower speed train as the energizing circuit for relay CR is not opened for a time sufficient to release its armature.

It will be clear however that as this slower speed train progresses farther into the speed controlling section, it will consume substantially the same length of time in traveling the distance between a certain two of the insulating joints 9 that the previously considered fastest train consumed in traveling between the first two joints, thereby delaying the continuous dropping and picking up cycle of the timing relay to drop relay

CR and energize the warning signal G at that point. In other words, the present slower speed train progresses into the speed controlling section without effecting a warning at the crossing to a point where the joints 9 are spaced by a distance which it can travel in the predetermined time required to affect the timing relay means in a manner to display a warning at the highway.

In this manner the system shown in Fig. 1 operates to give a warning at a highway immediately after a train traveling at a maximum speed enters a certain speed controlling section, but when a train traveling at a slower speed enters this section the warning is delayed until such train progresses a greater distance into the speed controlling section, which greater distance is made inversely proportional to the train speed, thereby giving a warning signal for a substantially uniform time prior to the arrival of a train at the highway regardless of the speed of the train. However, if a train in approaching the crossing gives a warning signal at a certain point in the speed controlling section but subsequently stops in this section, it will be clear that the warning will cease as the timing relays will pick up and remain up to energize relay CR and de-energize the signal G.

In the modified form of the present invention as shown in Fig. 2 and Fig. 3, the insulating joints 9 and resistors 10 are not required in the speed controlling section as this form operates to cause a warning highway signal indication when the rate of change of the track circuit current caused by a train progressing through the speed controlling section exceeds a predetermined value. The principle of operation of this form is that a train progressing through the speed controlling section at a constant rate toward the source of energy for the track circuit continually increases the track circuit current by continually shunting out a greater portion of the resistance of the rails.

This track circuit current increase however does not occur at a constant rate but occurs at a rate increasing as the train gets nearer the exit end of the section, or for example, while a train is traveling the first quarter of the length of the section one quarter of the track rail resistance is shunted out so that the track circuit current increases nearly 33⅓ percent, but while the same speed train is traveling the second quarter of the length, one third of the remaining track rail resistance is shunted so that the track circuit current now increases 50 per cent. It may now be seen that a fast train at the entrance of the speed controlling section could produce a certain rate of track circuit current change which could not be produced by a slower speed train as soon, but the same rate could be produced by the slower speed train after traveling farther into the section. In other words, the distance into the section which a train must travel to produce a certain rate of current change is inversely proportional to the speed of the train.

In order to provide an easily detectable current change in the track circuit in Fig. 2, an auxiliary battery TB^3 of a higher potential than the usual track battery TB^2 is connected across the rails 4 at the exit end of the speed controlling section when a train enters the other end of the section. A series relay SR is provided having two windings, the upper winding being in series with the usual track battery TB^2 and adjusted so that the normal track circuit current when the section is unoccupied does not attract its armature but the current increase provided by the entrance of a train into the left hand end of the section to shunt out relay TR^2 is sufficient to attract its armature. The picking up of relay SR connects the higher potential battery TB^3 to the track rails 4 through its front contact 35 in series with the lower winding and the primary of the transformer T.

The current from the higher potential battery TB^3 flows through the lower winding of relay SR in a manner to provide a flux opposing the flux produced by the current from battery TB^2 flowing through the upper winding, but these upper and lower windings are so proportioned that the flux produced by the lower winding does not offset a sufficient portion of the flux produced by the upper winding to release the armature of relay SR, but as the train reaches the extreme right hand portion of the speed controlling section to shunt out the majority of the rail resistance, the difference in the effective energization between the upper and lower windings is sufficiently reduced to release its armature. Relay SR is thus released upon the completion of a train movement through the speed controlling section to disconnect battery TB^3 from the track rails and restore the usual form of track circuit energized by battery TB^2 alone.

The other portions of the system in Fig. 2 are very similar to Fig. 1, the means responsive to the rate of current change in the track circuit being the same relay R controlled according to the potential obtaining in the secondary of transformer T as amplified by the same vacuum tube VT. The relay R is normally energized due to the plate current of tube VT provided by a certain grid potential C, and when the rate of current change in the primary of transformer T reaches a predetermined value, a secondary voltage is induced which reduces this potential on the grid of tube VT to a point which in turn decreases the output plate current sufficiently to release the armature of relay R.

In this manner when a train traveling toward the highway passes the insulating joint 8, the track relay TR^2 is dropped and relay SR is picked up, thus maintaining the control relay CR^1 energized through front contact 36 of relay R, front contact 37 of relay SR and front contact 25 of relay TR^1. However, as soon as the train causes a predetermined rate of increase in the current supplied by battery TB^3, a voltage is induced in the secondary of transformer T which effects the release of relay R thereby dropping relay CR^1 to energize the warning signal G at the highway H. The front contact 37 of relay SR is provided in the energizing circuit for relay CR^1 as a precaution against the possibility of unduly withholding the warning in the event relay SR fails to pick up upon entrance of a train into the speed controlling section thus preventing the energization of the track circuit with a potential sufficient to permit the required rate of current increase.

In this form of the present invention, it may be found that a more easily detectable rate of current increase can be provided in the speed controlling section by superimposing alternating current energy across the track rails upon the entrance of a train into the left hand end, this being due to the greater impedance offered by the rails to alternating current than to direct current energy. One manner of applying such alternating current energy to the system shown in Fig. 2 has been illustrated in Fig. 3, wherein an alternating current source of preferably a

high frequency such as generator 40 supplies current to the primary of a transformer 41, the secondary of the transformer 41 being connected across the track rails upon picking up of the relay SR through front contact 44. The primary of another transformer 42 is included in this alternating current circuit with its secondary connected to a full wave rectifier 43, the output of the rectifier energizing the primary of the grid transformer T in series with the lower opposing winding of relay SR.

In this manner alternating current energy is applied to the track rails 4 by the picking up of relay SR, and transformer 42 and rectifier 43 provides a value of direct current in the primary of the grid transformer T which is proportional to the value of alternating current flowing in the rails 4. Consequently it will be clear that the rate of increase in the alternating current to the track rails caused by a train traveling toward the highway in the speed controlling section will produce a proportional rate of increase in the direct current in the primary of transformer T to thus effect the vacuum tube amplifier VT in the same manner as in Fig. 2. The output direct current of the rectifier 43 is connected through the lower winding of relay SR to oppose the effect of the upper winding in the same manner as the current from battery BT^3 in Fig. 3.

A system for controlling the warning signal at a highway crossing is thus provided by the apparatus shown in Fig. 2 and Fig. 3 which provides substantially the same signal control in response to train speeds as described in connection with Fig. 1. In Fig. 2 and Fig. 3, a warning is given by a train at such a point in the speed controlling section where a predetermined rate of change in the track circuit current obtains, thus utilizing the principle that a train traveling at any constant speed through a track section toward the source of energy produces a constantly increasing rate of change in the track circuit current so that by providing a means responsive to a predetermined rate of current change, the warning signal may be controlled thereby to give a warning indication only after the train progresses a distance into the section which is inversely proportional to its speed.

It is contemplated that many means other than that shown herein may be devised for detecting the predetermined rate of current change in the track circuit, and that various other means may also be provided which enables a train to produce a more sharply rising rate of current change. For example, special treatment of the rails may be provided in the speed controlling section of Fig. 2 and Fig. 3 such as insulating joints shunted by resistance or impedance units as in Fig. 1, except that in this case these joints may be uniformly spaced. It is also to be understood that various timing devices other than the timing relays 1, 2 and 3 may be employed in the system of Fig. 1.

In addition to the obvious advantage of providing a warning at a highway crossing for a substantially fixed length of time prior to the actual arrival of a train at the highway regardless of the train speed, the present invention has the feature of preventing an unnecessary warning in the event a train has stopped in the speed controlling section or is receding from the crossing. The illustrated control means for the highway signal are all so organized that an energized condition of all the control devices is necessary to withhold the warning indication thereby providing a safe condition in the event of a failure of any energizing circuit or apparatus.

The above rather specific description of the selected forms of the present invention is given solely by the way of example, and is not intended, in any manner whatsoever, in a limiting sense. It is also to be understood that various modifications, adaptations and alterations may be applied to meet the requirement of practice, without in any manner departing from the spirit or scope of the present invention, except as limited by the appended claims.

What I claim is:—

1. In a signaling system for highway crossings on railroads, a track section traversed by trains approaching the highway crossing, means increasing the electrical resistance of the track section at points lineally spaced by distances decreasing from the entrance to the exit of the track section, a source of energy connected across the rails at the exit end of the track section, detecting means responsive to changes in current supplied by the source of energy to the track section as caused by a train passing said points of increased resistance in the track section, and means for initiating, and continuing, the operation of a highway crossing signal in accordance with the frequency of response of the detecting means.

2. In a signaling system for highway crossings on railroads, a track section traversed by trains approaching the highway crossing, means increasing the electrical resistance of a track rail at increasingly frequent points from the entrance to the exit of the track section, a source of energy connected across the rails at the exit end of the track section, detecting means operated by changes in current supplied by the source of energy to the track section as caused by a train passing said points of increased resistance in the track rail, timing means distinctly responsive to operation of the detecting means above a predetermined frequency, and signal control means governed by the timing means.

3. In a signaling system for highway crossings on railroads, a track circuit having rail resistance localized at points spaced by distances decreasing in length from the entrance to the exit ends, responsive means inductively operated by current changes in the track circuit caused by a train passing said localized rail resistance points, and means for controlling a highway crossing signal in accordance with the frequency of operation of the responsive means.

4. In a signaling system, a track circuit, resistors distributed in series with a rail of the track circuit at points separated by distances decreasing toward the source of energy, and means responsive to the frequency of track circuit current changes caused by a train shunting the resistors from the track circuit.

5. In a signaling system for highway crossings on railroads, a track section having a direct current source of energy at the exit end, a normally released relay having a first winding in series with the track circuit source of energy and adjusted to pick up upon occupancy of the track section, a second source of energy connected to the exit end of the track section through a front contact of the relay in series with a second winding arranged to oppose the effect of the first winding of the relay, means for detecting the rate of change of current from the second source

of energy caused by movement of a train in the track section, and means for controlling a highway crossing signal in accordance with said rate of current change.

6. In a signaling system for highway crossings on railroads, a track section having a direct current source of energy at the exit end, a normally released relay having a first winding in series with the track circuit source of energy and adjusted to pick up upon occupancy of the track section, a source of alternating current energy connected to the exit end of the track section through a front contact of the relay, means providing rectified direct current proportional to the amount of alternating current flowing to the track section, a second winding on the relay energized by said rectified direct current to oppose the effect of the first winding, means for detecting the rate of change of said rectifier direct current caused by movement of a train in the track section, and means for controlling a highway crossing signal in accordance with said rate of current change.

7. In a signaling system, a track section, a source of energy connected to the track section, means in the section for abruptly and repeatedly changing the current supplied by the source of energy to the track section at an increasing frequency as a train traverses the track section at a constant speed, and signal controlling means responsive to the frequency of said current changes.

8. In a signaling system, a track section, a source of energy connected to the track section, means in the section for impulsing the current supplied by the source of energy to the track section at a frequency proportional to the speed and dependent upon the position of a train traversing the track section, and signal controlling means responsive to the frequency of said current changes.

9. In a signaling system for highway crossings on railroads; a track section traversed by trains approaching a highway crossing; a source of unidirectional current connected across the rails at the exit end of said track section; a transformer having a primary winding and a secondary winding and having its primary winding connected in series with said source of unidirectional current to cause the magnetic flux in said transformer to build up as a train traversing the track section approaches said crossing, and to cause a voltage to be induced in said secondary winding of a value dependent on the rate of change of said magnetic flux; a highway signal controlling traffic moving on the highway; and means controlled by the voltage induced in said secondary winding for controlling said signal and effective to render said signal active only if said voltage is above a predetermined value.

10. In a signaling system for highway crossings on railroads; a track section traversed by trains approaching a highway crossing; a source of unidirectional current connected across the rails at the exit end of said track section; a transformer having a primary winding and a secondary winding and having its primary winding connected in series with said source of unidirectional current to cause the magnetic flux in said transformer to build up as the rail resistance is shunted out as a train traversing the track section approaches said crossing, and to cause a voltage to be induced in said secondary winding of a value dependent on the rate of change of said magnetic flux; a highway signal controlling traffic moving on the highway; and means controlled by the voltage induced in said secondary winding for controlling said signal and effective to render said signal active when the rail resistance is shunted out at more than a predetermined rate.

11. In a signaling system for highway crossings on railroads; a track section traversed by trains approaching a highway crossing; a source of unidirectional current connected across the rails at the exit end of said track section; a transformer having a primary winding and a secondary winding and having its primary winding connected in series with said source of unidirectional current to cause the magnetic flux in said transformer to build up as the rail resistance is shunted out as a train traversing the track section approaches said crossing, and to cause a voltage to be induced in said secondary winding of a value dependent on the speed of the train; a highway signal controlling traffic moving on the highway; and means controlled by the voltage induced in said secondary winding for controlling said signal and effective to render said signal active dependent on the speed of the train.

12. In a signaling system for highway crossings on railroads; a track section traversed by trains approaching a highway crossing; a source of unidirectional current connected across the rails at the exit end of said track section; a transformer having a primary winding and a secondary winding and having its primary winding connected in series with said source of unidirectional current to cause the magnetic flux in said transformer to build up as the rail resistance is shunted out as a train traversing the track section approaches said crossing, and to cause a voltage to be induced in said secondary winding of a value dependent on both the speed and the location of the train in said section; a highway signal controlling traffic moving on the highway; and means controlled by the voltage induced in said secondary winding for controlling said signal and effective to render said signal active in accordance with the location of the train and its speed.

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