July 12, 1938. P. N. MARTIN 2,123,538

APPARATUS FOR THE CONTROL OF HIGHWAY CROSSING SIGNALS

Original Filed April 26, 1935 2 Sheets-Sheet 1

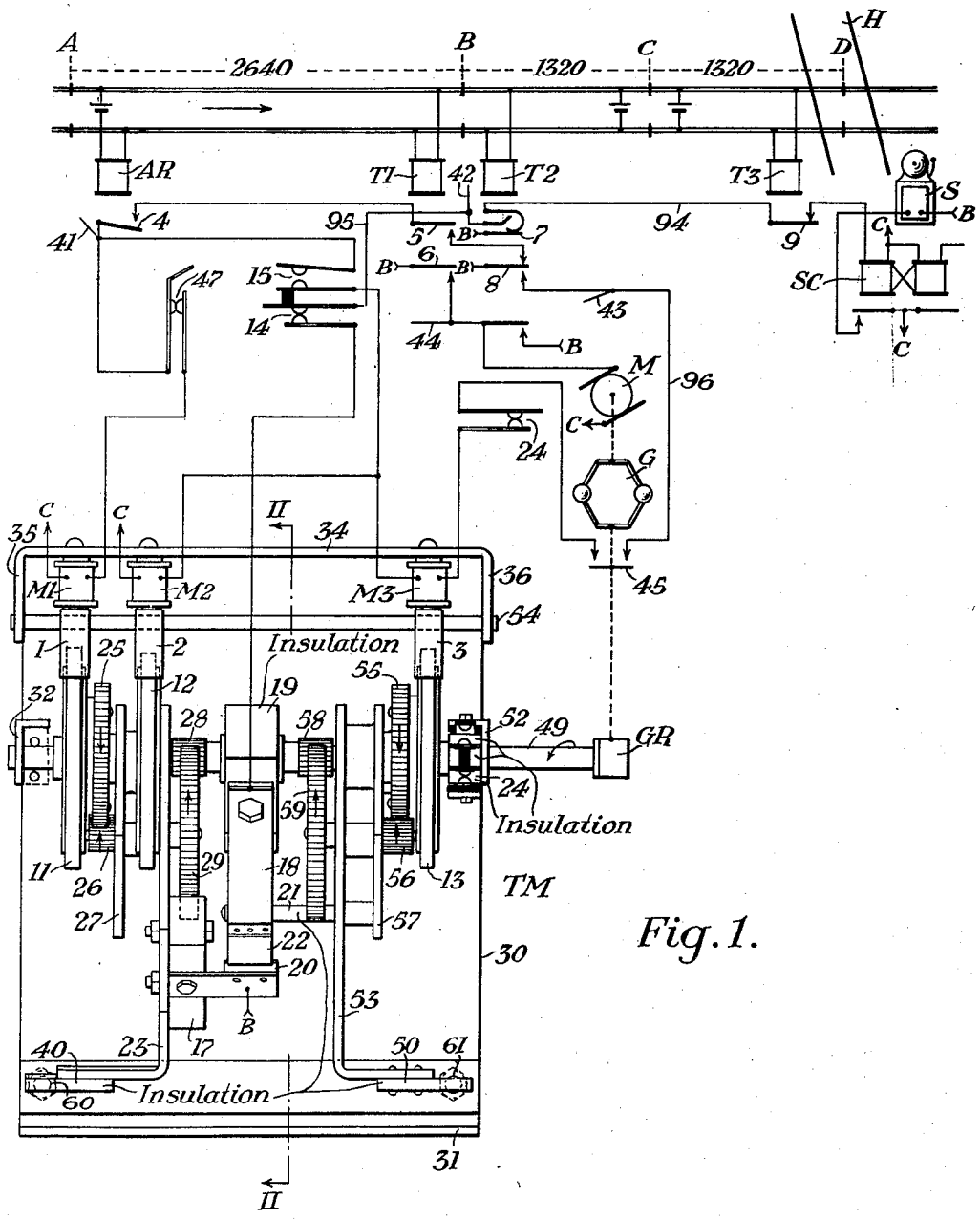

Fig. 1.

INVENTOR
Paul N. Martin
BY
HIS ATTORNEY

July 12, 1938. P. N. MARTIN 2,123,538

APPARATUS FOR THE CONTROL OF HIGHWAY CROSSING SIGNALS

Original Filed April 26, 1935 2 Sheets-Sheet 2

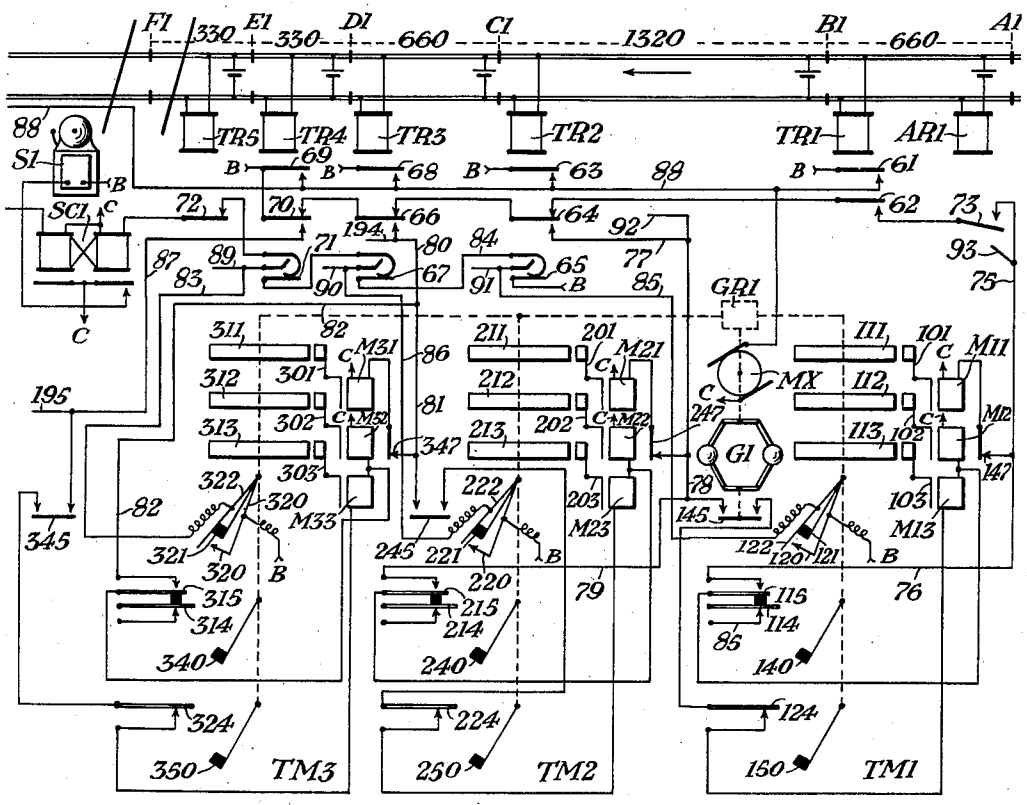

Fig. 3.

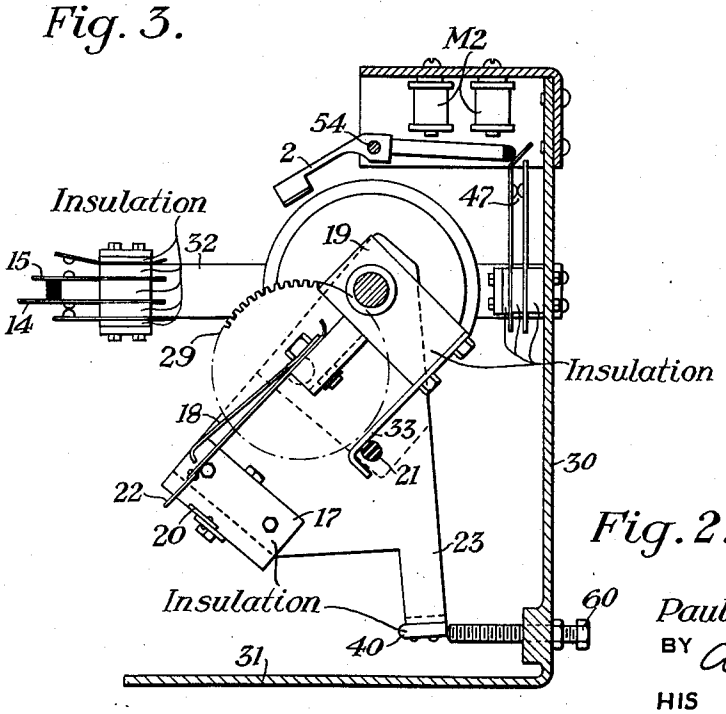

Fig. 2.

INVENTOR
Paul N. Martin.
BY A R Trimble
HIS ATTORNEY

Patented July 12, 1938 2,123,538

UNITED STATES PATENT OFFICE

2,123,538

APPARATUS FOR THE CONTROL OF HIGHWAY CROSSING SIGNALS

Paul N. Martin, Swissvale, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application April 26, 1935, Serial No. 18,308
Renewed April 24, 1936

26 Claims. (Cl. 246—130)

My invention relates in general to apparatus for the control of highway crossing signals, and particularly to apparatus controlled by a train approaching a highway for effecting the operation of the highway signal for substantially the same period of time irrespective of certain variations of the speed of the train.

There have been various forms of systems heretofore proposed, some of which employ a measuring track circuit and a plurality of operating track circuits which a train successively influences as it approaches the intersection. A feature of my invention lies in the provision of such a system employing a plurality of measuring track sections, certain of which, while employed as measuring sections, also serve as operating sections. Another feature of my invention has to do with the provision of a timing mechanism suitable for use in practicing my invention. Other features and advantages of my invention will appear as the specification progresses.

In the accompanying drawings, Figure 1 is a front elevation of a timing device comprising a part of my invention, associated with a diagrammatically illustrated stretch of track over which traffic normally moves in the direction indicated by the arrow and which is intersected by a highway, and shows this stretch of track equipped with circuits and apparatus in accordance with my invention as required to operate the crossing signal under control of an approaching train for a predetermined period, irrespective of certain variations of the speed of such train; Fig. 2 is a sectional elevation of the mechanical structure of Fig. 1, taken on line II—II; while Fig. 3 shows a second stretch of track with circuits and apparatus diagrammatically illustrating a more elaborate application of my invention.

Referring now particularly to Figs. 1 and 2, the structural details of the time-measuring device will be described. This is a modified form of the planetary drive disclosed in Patent No. 1,966,965, issued July 17, 1934 to B. Lazich and H. E. Ashworth, for Electrical relays. The device as herein employed comprises a main support having a base portion 31 and a back portion 30. Extending forwardly from the back portion 30 are two mechanism-supporting members 32 and 52, drilled to receive an operating shaft 49 and having at the free ends thereof contact spring combinations, the purpose of which will be described hereinafter.

On the left portion of the shaft 49 is mounted a unit comprising a drum 11 and a gear 25 in fixed relation to each other. This unit is free to rotate on the shaft 49. Adjacent this unit is a second unit including an arm 27, a holding drum 12 and a second arm 23. This second unit is also free to rotate on the shaft 49. At the free end of arm 23 a block of insulating material 40 is secured and serves as a means for operating the pairs of springs 14 and 15, comprising the combination mounted on the free end of member 32. These springs have been omitted from the structural view of Fig. 1, but are clearly shown in Fig. 2. Also mounted at an intermediate point on the arm 23 is a block of insulating material 17 supporting a contact member 20. This second unit, including parts 27, 12 and 23, is also provided with a shaft passing through arms 27 and 23 and through the drum 12. On the left end of this shaft is secured a pinion 26 in mesh with the gear 25, while the right end of this shaft has fixed thereto a gear 29 in mesh with a pinion gear 28, the latter of which is in fixed relation to the shaft 49.

Mounted on the central portion of the shaft 49 is an assembly comprising a block of insulating material 19 to which is secured a contact member 22 arranged in operative relation to the contact 20 and provided with a buffer spring 18. The block 19 is also provided with a member 33, clearly shown in Fig. 2, through the medium of which it may be rotated on the shaft 49 by a pin 21.

Mounted on the right portion of the shaft 49 are units very similar to those on the left portion of the shaft. These comprise a drum 13 having a gear 55 in fixed relation thereto, and arms 57 and 53 in fixed relation to each other. These arms carry the previously mentioned pin 21 and a shaft having at opposite ends thereof a gear 59 in mesh with a pinion 58 in fixed relation to the shaft 49 and a pinion 56 in mesh with the gear 55.

Secured to the free end of the arm 53 is a member 50 of insulating material employed to operate the springs 24 of the combination supported by member 52.

Passing through downwardly extending portions 35 and 36 of the main support of the device is a shaft 54 carrying armatures 1, 2 and 3, having frictional surfaces adapted to be brought into cooperative relation with drums 11, 12 and 13 upon energization of their associated magnets M1, M2 and M3 secured to a portion 34 of the main support.

In the operation of the device rotation of the shaft 49 in the direction indicated by the arrow

causes the pinion 28 to rotate gear 29 in a clockwise direction. The gear 29 through the medium of pinion 26 merely transmits rotary motion to the gear 25 and its associated drum 11 as long as magnet M1 remains deenergized. Upon energization of the magnet M1 the frictional surface on armature 1 engages drum 11 and holds it and the associated gear 25 stationary. During the further rotation of shaft 49, since the pinion 26 is unable to rotate gear 25, it climbs around this gear, so to speak, and in so doing raises the arm 23 and the members carried by it. After a predetermined period of operation the contact 20 encounters contact 22 and on further operation carries it and its supporting member 19 so that the arm 33 is rotated away from the pin 21. In case the operation continues long enough, the member 40 is rotated into engagement with the upper one of the contact springs 14, causing these springs to separate and contact 15 to close.

The contact 15 closes a circuit to effect the energization of magnet M2 which enables contact 47 to open and effect deenergization of the magnet M1, as will later be made clear. The frictional surface of armature 2, therefore, engages the drum 12 coincident with the disengaging of the frictional surface of armature 1 from the drum 11. It will be seen therefore that contact 15 is employed to definitely limit the movement of the arm 23, while the magnet M2 serves to hold the drum 12 and the arm 23 to any position to which they have been rotated.

Up to this time rotation of the shaft 49 has also caused pinion 58 to rotate gear 59 and pinion 56, the pinion 56 in turn rotating gear 55 and drum 13. If now magnet M3 is energized, the frictional surface on armature 3 engages drum 13 to prevent further rotary movement of gear 55, thereby causing the subsequent rotation of pinion 56 to effect the raising of arm 53 in the same manner as pinion 26 effected the raising of arm 23. In the course of the raising of arm 53, the pin 21 encounters member 33 after a time interval dependent upon the distance of rotation of contact 22 by contact 20 engaging contact 22, and thus causes the contact 22 to separate from contact 20. Ordinarily this occurs long before the insulation 50 on arm 53 has reached its spring combination.

In the ordinary course, magnets M2 and M3 will be subsequently deenergized, before the member 50 encounters its spring combination, to enable restoration of all parts of the device to normal by force of gravity. If, however, the magnets M2 and M3 remain energized long enough, the member 50 will finally separate contacts 24 in a manner, which will later be made clear, to effect the deenergization of these magnets and thereby prevent damage to the device, by interrupting the circuit of magnet M3.

The stretch of track of Fig. 1 has been divided into three sections comprising a timing section A—B, and two operating sections B—C and C—D, respectively. I have, solely for the purpose of illustrating the invention in its simplest form, assumed that the respective sections are of the lengths indicated (in feet). As will appear hereinafter, the lengths given need not be adhered to.

The timing section A—B is provided with a track battery connected across the rails in series with an approach relay AR, and which battery feeds operating current to the track relay T1 at the exit end of the section. The operating sections B—C and C—D are each provided with the conventional track circuit including a track battery and a track relay. The relays of these sections are designated T2 and T3, respectively, and are normally energized as is the track relay T1. The highway warning signal, herein shown as a bell S, is normally prevented from operating by the energized interlocking relay SC, while the constant speed motor M, employed in driving a speed controlled contact operating device, in the form of a governor G, direct, and the timing mechanism TM through the medium of a suitable gear reduction unit GR, has its operating circuits held open by the track relays T1 and T2.

When a train enters section A—B, the approach relay AR picks up and the track relay T1 of this section releases. When these operations occur, circuits for motor M and magnet M1 are completed. The circuit for motor M extends from a terminal B of a suitable current source, not shown, via the back contact 6 of relay T1 and through the motor M to a C terminal of the current source. The energizing circuit of magnet M1 extends from a B terminal of the current source through the front contact 8 of relay T2, the back contact 5 of relay T1, the front contact 4 of relay AR, back contact 47 of magnet M2 and through the winding of magnet M1 to a C terminal of the current source. The magnet M1 accordingly operates its armature 1 which holds the drum 11 against movement, while the motor M drives contact operating governor G and shaft 49 of the mechanism. The shaft 49 in turning causes arm 23 and the associated contact 20 and part 40 to be moved toward their contacts 22 and 14 as hereinbefore described. The contact 22 is normally held in advance of contact 20 by adjustment of screws 60 and 61 as required to space contacts 22 and 20 a distance requiring a very slightly greater time lapse after initiation of the operation of contact 20 for that contact to engage contact 22 than required for a train travelling at the maximum speed to move from the entrance end to the exit end of the timing section A—B.

For the purpose of this description I have assumed that the maximum train speed will be 90 miles per hour or 132 feet per second and that it is desired o start operation of the signal S substantially 20 seconds before a train reaches the highway H. With a train travelling at this speed the signal must start operating 20 times 132 or 2640 feet distance from the highway. As shown in Fig. 1, the signal must therefore start operating as a train travelling at maximum speed reaches the entry of section B—C. As previously stated, the contacts 20 and 22 of the timing mechanism are normally separated a distance requiring a period of movement of contact 20 slightly longer than the time the train takes to travel the distance A—B, which is 20 seconds for a train speed of 90 miles per hour, to engage contact 22. Therefore, when a train travelling at the maximum speed enters section B—C, contact 20 will not quite have engaged contact 22.

The train on entering section B—C effects the release of track relay T2. When this relay releases, its front contact 8 opens the traced circuit of magnet M1. The relay T2 also, at its contact 7, removes the connection of a B terminal of the current source from the conductor 94 heretofore feeding operating current to signal control relay SC and substitutes therefor the conductor 95 extending through contact 14 to the conductor terminated on contact 22. Since in the present example, that of a train travelling through the measuring section at maximum speed,

contact 20 has not reached contact 22; so the circuit of relay SC is opened by the release of the track relay T2. Relay SC releases and the signal S accordingly operates over the obvious circuit.

It will be apparent that the circuit of the relay SC includes the front contact of track relay T3 and that when a train enters section C—D, relay T3 releases and positively insures operation of signal S while the train remains in section C—D independently of any control exercised by the timing mechanism. It will be obvious, therefore, that in this form of the invention the timing mechanism can at most only control the time at which the signal is to start operating while the train is in section B—C and providing the signal operation has not been started immediately upon the release of track relay T2, as in the case where the train passes through section A—B at the maximum average speed. Since 20 seconds are required for a train travelling at 90 miles per hour, to travel over the two 1320 foot sections B—C and C—D it will be apparent that the same time will be required for a train travelling 45 miles per hour to travel over section C—D; and that as no provisions are made in this form of the invention to prevent it, the operation of signal S will be started on the release of relay T3 whenever a train travelling at 45 miles per hour or less enters section C—D.

Since 20 seconds are required for a train travelling at 90 miles per hour to pass from point B to point D and the same time is required for a train travelling 45 miles per hour to pass from point C to point D, a train travelling at an intermediate speed between 45 and 90 miles per hour will have to start operation of the signal S when the train reaches an appropriate point in section B—C in order to obtain operation of the signal for a 20 second period. In order to make clear the manner in which this is accomplished, it will be assumed that a train travels through the measuring section A—B at an average speed of 75 miles per hour or 110 feet per second. Therefore, to start operation of signal S 20 seconds before point D is reached, it must be started 20 times 110 or 2200 feet from point D. Since the distance between points B and D is 2640 feet it will be evident that the signal S must start operating 2640 minus 2200 or after 440 feet travel into section B—C. A brief interval after the train has consumed 20 seconds time while in section A—B, the contact 20 of the timing mechanism engages contact 22 thereof. Since the assumed average speed of the train through section A—B is 75 miles per hour the time consumed before section B—C is entered will be 2640 divided by 110 or 24 seconds, or 4 seconds after closure of contacts 20 and 22.

In describing the operations which occur when a train travelling at an average maximum speed of 90 miles per hour, it was pointed out that on entry of the train into section B—C track relay T2 released and transferred the conductor 94 from a B terminal of the current through its front contact, to the conductor 95 extending through contact 14 to the conductor terminating in contact 22 of the timing mechanism, and that as there was no connection of a B terminal on this contact at the time, the relay SC released and immediately started operation of the signal S.

Under the present circumstances when relay T2 releases, the relay SC is maintained energized by current supplied from a B terminal connected with contact 20 now engaging contact 22.

Other operations occurring in response to the release of relay T2, and which are of no utility when the train speed through section A—B is at a maximum, will now be described. When the relay T2 releases, in addition to disabling the driving connection between shaft 49 and arm 23 by opening the circuit of magnet M1, completes a circuit for magnets M2 and M3. This circuit extends from a B terminal, through the back contact 8 of relay T2, conductor 96, governor operated contact 45, through contact 24 and through the windings of magnets M3 and M2 in series to a C terminal of the current source. The armature 2 of magnet M2 engages drum 12 at the same time that the armature 1 of magnet M1 releases thereby holding arm 23 and its contact 20 in the position to which they have been advanced. The magnet M3 also operates over this circuit and, through the medium of its armature 3, holds the drum 13 and gear 55 stationary, thereby starting the movement of arm 53 and its pin 21. In the disclosure of Fig. 1 it is assumed that the gear ratio between shaft 49 and arm 53 is the same as that between shaft 49 and the arm 23. It will be seen, therefore, that after 4 seconds of operation, the time required for the train travelling at 110 feet per second to cover 440 feet of section B—C, the pin 21 has been moved a distance corresponding to the distance of movement of contact 22 by contact 20 and an instant later separates these contacts to initiate the operation of signal S by interrupting the circuit of relay SC.

If the speed of the train through the measuring section A—B averages 60 miles per hour or 88 feet per second, the time consumed from the time of entry into the section until the train enters section B—C will be 2640 divided by 88 or 30 seconds and accordingly contact 22 will have been moved by contact 20 for 10 seconds before being stopped. Since pin 21 then begins movement toward contact 22 and moves at the same speed as did contact 20, it will engage contact 22 in ten seconds and therefore will separate contacts 20 and 22 an instant later. With a train speed of 88 feet per second the train travels 880 feet into section B—C before the signal operation is initiated. By subtracting this distance from the total of blocks B—C—D and dividing the remainder by 88 the time of operation of the signal will be found to be 20 seconds. It will be appreciated from the foregoing that for any train speed between the maximum of 90 miles per hour and 45 miles per hour a constant period of operation of signal S is obtained.

It will be apparent that if the speed of the train passing through section A—B averages less than 45 miles per hour the distance of movement of contact 22 will be so great that pin 21 will be unable to reach and separate contact 22 from 20 prior to the entry of the train into section C—D and therefore operation of the signal S will not occur until relay T3 releases.

It will be observed that a substitute operating circuit for motor M is completed by a back contact of relay T2 when the train enters section B—C so that the operation of the motor is continued until the train clears the latter section. As soon as the train clears section A—B relay AR releases and track relay T1 again picks up, but their operation is without any particular effect at this time. When the train enters section C—D, relay T3 releases its front contact 9 thereby insuring operation of signal S irrespective of the condition of the timing mechanism TM.

As soon as the train clears section B—C the relay T2 again picks up, thereby again opening the circuit of motor M and reestablishing a direct connection of a B terminal of the current source with signal control conductor 94 now held open at the back contact of relay T3. The relay T2 also, at its back contact 8, opens the circuit previously traced through magnets M3 and M2 which accordingly become deenergized. When the armatures 3 and 2 of these magnets release, their associated drums 13 and 12 are again free to rotate and accordingly their associated arms 53 and 23 restore to their normal position by gravity.

I will now assume that a train enters section A—B and stops within the section. Under these circumstances arm 23 will continue movement until the insulation 40 encounters and opens contact 14 and closes contact 15. When contact 14 opens, it removes control of the signal S from the timing mechanism and so acts as a safety check in case a train stops in the timing section AB. When contact 15 closes, it completes a circuit for magnet M2 in multiple with that already existing through magnet M1. When the armature 2 of magnet M2 picks up, it permits contact 47 to open the circuit of magnet M1. Magnet M1 accordingly releases its armature 1 to disable the driving connection between shaft 49 and arm 23; while the armature 2 engages drum 11 to hold the arm 23 in its advanced position. When the train advances into section B—C the track relay T2 releases and at its front contact 8 interrupts the circuit of magnet M2. The magnet M2 does not, however, release its armature because of the alternative operating path completed through it and magnet M3 in series at the back contact 8 of relay T2. Since, at this time when relay T2 releases contact 14 of the timing mechanism is open, relay T2 immediately interrupts the circuit of the interlocking relay SC to immediately start operation of signal S to insure an ample time period of operation of the signal in case the train rapidly accelerates after having stopped in section A—B.

If the train remains in section B—C for a prolonged period arm 53 will finally encounter and open contact 24. This contact is opened to prevent damage to the timing mechanism, as was contact 47, and causes magnets M2 and M3 to become deenergized. When the armatures of these magnets release, arms 23 and 53 start to return to their normal position, but as soon as arm 53 moves a short distance contact 24 recloses the energizing circuits of magnets M2 and M3. The alternate energization and deenergization of these magnets therefore continues while the train remains in section B—C. When the train clears the section, restoration of the timing mechanism is brought in the manner already ing mechanism is brought about in the manner already described.

If the signal control system is to be applied to a stretch of track over which traffic moves in both directions, the same timing mechanism TM can be used for both directions of traffic, in which case the approach sections on the opposite side of the highway crossing from that illustrated would be equipped in the same manner as are the sections A—B, B—C and C—D; branch conductors 41, 42, 43 and 44, extending from the timing mechanism TM may then be extended to the contacts of the relays thereof corresponding to relays AR, T2 and T1 of the sections shown; while the conductor, corresponding to the one extending from the front contact of relay T3 to the left-hand winding of interlocking relay SC will extend to the right-hand winding thereof.

With a signal control system employing but one timing section as illustrated by Fig. 1, the train speed is measured just once while the train is at a considerable distance from the crossing. With such an arrangement, if there is even a comparatively small error in the measurement, or the train should accelerate after passing through the measuring section, the warning time may be considerably less than that desired. For this reason the safety section CD must be made rather long if it is to give much protection. With a long safety section the full advantage of the constant time feature cannot be obtained, and the warning signal will be operated for an excessive period of time when very slow speed trains pass through the stretch.

In the invention as illustrated in Fig. 3 the stretch of track is divided into five sections, comprising a measuring section A1—B1, combined measuring and operating sections B1—C1, C1—D1, D1—E1, and a final or operating section E1—F1. Sections A1—B1, D1—E1, and E1—F1 serve in the same capacity as do the measuring and operating sections of Fig. 1; while the intervening sections, in addition to serving in the same capacity as does section B—C of Fig. 1 are also employed as measuring sections in a similar manner to section A—B of Fig. 1.

With an arrangement such as illustrated in Fig. 3, the speed of the train is repeatedly checked as it approaches the highway crossing so that any error in the first speed measurement will be checked in the succeeding section, and acceleration will also be checked. Thus, the final safety section E1—F1 can be made very short and full benefit of the timing device can be obtained even for very slow trains. Furthermore, since several timing sections are provided and the measuring of speed and acceleration are repeatedly checked, it is not necessary to pass the signal control circuits of timing mechanisms TM1, TM2 and TM3 through their contacts 114, 214 and 314 corresponding to contacts 14 of timing mechanism TM. In Fig. 3 I have arbitrarily designated the length of timing section A1—B1 as being 660 feet long, as this is believed to be as short a length as can be expected to provide accurate timing for fast trains. For convenience in readily describing the invention in the most simple manner, I have designated the first combined measuring and operating section as being an exact multiple of section A1—B1 and each subsequent combined measuring and control section as being half the length of its preceding section. It will be apparent that, as in Fig. 1, the total distance from the exit end of the first measuring section to the exit end of the section intersected by the highway is 2640 feet or the distance which a train travelling at an assumed maximum speed of 90 miles per hour can travel in 20 seconds.

The three timing sections A1—B1, B1—C1 and C1—D1 are provided with timing mechanisms TM1, TM2 and TM3, respectively. The timing mechanisms are diagrammatically illustrated, as they are structurally the same as mechanism TM. The initial spacing between the contacts, corresponding to 20 and 22 of mechanism TM, however, is initially adjusted in accordance with the time required for a train to pass through its measuring section at a maximum average speed determined by the location of the measuring section, as will be subsequently made clear.

The signal S1 and the associated interlocking

signal control relay SC1 may be identical to the corresponding signal and relay of Fig. 1. Under normal conditions the track relays of the respective sections are energized; the approach relay AR1 of the first section is in its released position; and the timing mechanisms are inactive.

In order to give a 20 second warning before the highway is reached by a train travelling at an assumed speed of 90 miles per hour (132 feet per second), the initial opening between contacts 120 and 122 must be set so that they will only be closed if the train consumes more than the minimum time in passing through the measuring section A1—B1. Since this section is 660 feet long the contacts must therefore be set to close 660 divided by 132, or only slightly over 5 seconds after the train enters section A1—B1.

When a train enters section A1—B1, the approach relay AR1 picks up while the track relay TR1 of this section releases. When these operations occur circuits for motor MX and magnet M11 are completed. The circuit for motor MX extends from a terminal B of the current source, through back contact 61 of track relay TR1, conductor 88 and the motor MX to a C terminal of the current source. The energizing circuit of magnet M11 extends from a B terminal of the current source connected through front contact 70 of track relay TR4 and passing through the front contacts 66 and 64 of track relays TR3 and TR2, the back contact 62 of track relay TR1, front contact 73 of relay AR1, conductor 75, back contact 147 of magnet M12 and through the winding of magnet M11 to a C terminal of the current source. The magnet M11 accordingly operates its armature 101 which holds drum 111 stationary; while the motor MX drives the contact operating governor G1 and the shafts of time measuring mechanisms TM1, TM2 and TM3 through the medium of gear reduction GR1 and other mechanical links; these and the shafts corresponding to shaft 49 of mechanism TM are diagrammatically indicated by interrupted lines. The gears and pinions of all three timing mechanisms will now be driven by the motor MX, but no useful function will be performed by any of them excepting those employed to drive contact 120 of mechanism TM1, having its magnet M11 energized.

Now if the train has averaged the maximum speed of 90 miles per hour through section A1—B1, it enters section B1—C1 just as contact 120 is about to engage contact 122. Before this can occur track relay TR2 releases and at its front contact 64 opens the circuit of magnet M11 to stop the movement of contact 120. The relay TR2 also, at its contact 65, transfers the circuit of signal control relay SC1 from connection with a B terminal of the current source to the dead conductor 85 of mechanism TM1. The relay SC1 accordingly releases and closes the circuit through signal S1 to insure its operation for the 20 second period before the train reaches the highway.

The exit end of section B1—C1 is 1320 feet or 20 seconds running time from the highway for a train travelling 45 miles per hour. Therefore, if the average train speed through section A1—B1 is less than 90 miles per hour and over 45, in order to give a 20 second warning the signal must start operating when the train has reached a point in section B1—C1, depending on its average speed through section A1—B1. For the purpose of describing the operation it will be assumed that a train passes through section A1—B1 at an average speed of 75 miles per hour. At this rate of speed 6 seconds will pass before the train enters section B1—C1 and therefore contact 120 will engage and advance contact 122 with it during its last one second of operation.

When the train enters section B1—C1 relay TR2 releases and at contact 65 transfers conductor 84 from connection with the associated B terminal of the current source into connection with conductor 85 now connected with a B terminal of the current source via contacts 122 and 120. The relay TR2 also, at its front contact 64, interrupts the circuit of magnet M11 and at this back contact closes circuits for magnets M21, M12 and M13, respectively. The common portion of these circuits extends from the B terminal connected via front contacts 70 and 66 of relays TR4 and TR3, and the back contact 64 to conductor 77. The circuit of magnets M12 and M13 extends via conductor 78, governor contact 145, contact 124 and through the windings of magnets M13 and M12 in series to a C terminal of the current source. The circuit of magnet M21 extends via back contact 247 of magnet M22 and through the winding of magnet M21 to a C terminal of the current source.

The armature 101 of magnet M11 now releases drum 111 so that further rotation of contact 120 by motor MX is prevented. At the same time, the armature 102 of magnet M12 picks up and engages drum 112, thereby preventing retrograde movement of contact 120. Coincident with these operations the armature 103 of magnet M13 picks up and engages drum 113 thereby enabling the motor MX to begin advancing pin 121 on arm 53 toward contact 122. As previously pointed out in the description of Fig. 1, the operation of the highway signal must be delayed until the train arrives within 20 seconds running time of the highway. Since the train travelling at 75 miles per hour will travel 2200 feet in 20 seconds and the distance from the entrance of section B1—C1 to the highway is 2640 feet, operation of the signal S1 must be delayed for 4 seconds after section B1—C1 is entered to give the train time to cover the first 440 feet thereof before contacts 120 and 122 are separated. In other words, the movement of pin 121 must be at only one-fourth the speed of that of contact 120. This difference in speed ratio is readily obtained by changing the ratio between the gears of timing mechanism TM1 corresponding to 55—56 and 58—59 of mechanism TM. As described in connection with Fig. 1, after the expiration of 4 seconds contacts 120 and 122 are separated and interrupt the circuit of the signal control relay SC1, thereby starting operation of the signal S1 20 seconds before the train will arrive at the highway when travelling at the stated speed of 75 miles per hour.

Since the exit end of section B1—C1 is 1320 feet from the exit end of section E1—F1, the initial opening between contacts 220 and 222 are set to correspond to a train speed of 1320 divided by 20, or 66 feet per second (45 miles per hour). A train travelling at this speed will require 20 seconds to travel the distance B1—C1 (1320 feet). So the initial opening between contacts 220 and 222 will be such that they will only be closed slightly after the elapse of time required for a train travelling at 66 feet per second to travel the distance of section B1—C1. Since this section is 1320 feet long this time will be 1320 divided by 66, or 20 seconds.

A train travelling through section A1—B1 at a lower speed than 45 miles per hour will allow movement of contact 122 by contact 120 for a

distance requiring more time for pin 121 to separate these contacts than required for the train to move through section B1—C1, and therefore operation of the signal S1 is not initiated while the train is passing through section B1—C1 at speeds averaging below 45 miles per hour.

If the train speed through section A1—B1 is below 45 miles per hour and is then increased to or above 45 miles per hour while the train passes through section B1—C1, less than 20 seconds will be consumed by the train while passing through section B1—C1 and accordingly contacts 222 and 220 will be open when track relay TR3 releases. The circuit of relay SC1 will, under these circumstances, accordingly be interrupted by the dropping of contact 67 thereof because conductor 86 will at this time be dead and operation of the signal S1 will accordingly immediately commence.

If, however, a train continues through section B1—C1 at a speed below 45 miles per hour, when it enters section C1—D1 track relay TR3 releases and at its contact 67 transfers the circuit of relay SC1 from control by timing mechanism TM1 to lead 86 of the timing mechanism TM2, now connected to a B terminal of the current source via contacts 222 and 220. The relay TR3 also at its front contact 66 interrupts the circuits of magnets M12, M13 and M21, and at its back contact 66 completes circuits for magnets M31, M23 and M22. Magnets M12 and M13 of the timing mechanism TM1 now release their armatures from engagement with drums 112 and 113, thereby enabling the contacts and associated parts of their mechanism TM1 to restore to their normal position. The magnet M21 of timing mechanism TM2 releases its armature from engagement with drum 211 to stop the advance of contact 220 and accordingly also of contact 222.

The circuits completed for magnets M31, M23 and M24 extend from the B terminal of the current source connected to contact 66 from contact 70 of relay TR4, over conductors 80 and 81, through the contact 347 and winding of magnet M31 to a C terminal of the current source; and from conductor 81 through contact 245 of the contact operating governor G1, contact 224, and the windings of magnets M23 and M22 in series to a C terminal of the current source. The magnet M22 moves its armature 202 into engagement with drum 212 to hold contact 220 in its advanced position at the same time that armature 201 of magnet M21 disengages from the drum 211 to stop the advance movement of contacts 220 and 222; while magnet M23 moves its armature 203 into engagement with drum 213 to start the advance movement of pin 221 toward contact 222. When the magnet M31 energizes, it moves its armature 301 into engagement with its drum 311 thereby causing contact 321 of timing mechanism TM3 to start moving toward contact 322 to measure the average speed of the train through section C1—D1.

It will be observed that the exit end of section C1—D1 is just 660 feet from the exit end of section E1—F1 at the highway and therefore is 20 seconds running time therefrom for a train travelling at 22.5 miles per hour. The timing mechanism TM2 exercises control over the operation of signal S1 only providing the average train speed through section B1—C1 is such as to require operation of the signal while the train is travelling through section C1—D1 in the same manner as TM1 exercises such control of the signal if its operation is required while the train is travelling through section B1—C1. For example, with the train passing through section B1—C1 at an average speed of 30 miles per hour and contacts 220 and 222 set to close after 20 seconds, as already described, contact 220 will move for a period of 30 seconds and will move contact 222 for a period of ten seconds before the train enters section C1—D1. A train travelling at a speed of 30 miles per hour travels 44 feet per second and therefore to obtain a 20 second period of operation of the signal S1 its operation must be started when the train has approached within 880 feet of the exit end of section E1—F1 or after the train has had time to travel over the first 440 feet of section C1—D1. This distance will be covered in ten seconds. Since in this instance the measuring section B1—C1 is equal in length to the distance C1—F1 to the highway crossing, as was the case in the form of the invention shown in Fig. 1, both portions of the time measuring mechanism TM2 operate their contacts at the same speed, and accordingly ten seconds after section C1—D1 is entered pin 221 will separate contact 222 from 220 and interrupt the circuit of relay SC1 to start operation of the signal S1 20 seconds before the train, travelling at 30 miles per hour, reaches the highway.

When the circuit through magnets M23 and M22 are interrupted, the armatures 203 and 202 of these magnets release their associated drums 213 and 212 and accordingly the contacts and arms of the timing mechanism TM2 restore to their normal position. When the circuit through magnet M31 is interrupted its armature 301 disengages the drum 311 to stop the advance movement of contact 320. Retrograde movement of the contact 320 is at this time prevented owing to the energized condition of magnet M32 and the consequent engagement of its armature 302 with drum 312; while movement of the pin 321 toward its contact 322 is started consequent to the energization of magnet M33 in a manner well understood in the light of the preceding description.

It will be recalled that when a train enters section C1—D1 a circuit is completed for magnet M31 of time mechanism TM3 to start contact 320 moving toward contact 322 to measure the time required for the train to travel through section C1—D1. It will also be observed that the exit end of section D1—E1 is just 330 feet from the exit end of section E1—F1 at the highway and therefore is 20 seconds running time therefrom for a train travelling 11.25 miles per hour. The timing mechanism TM3 exercises control over the operation of signal S1 only providing the average train speed through section C1—D1 is such as to require operation of the signal while the train is travelling through section D1—E1 in the same manner as TM1 and TM2 exercise such control of the signal if its operation is required while the train is travelling through their operating sections B1—C1 or C1—D1, respectively. Since the exit end of section C1—D1 is 660 feet from the exit end of section E1—F1 the opening of contacts 320 and 322 is initially a distance corresponding to a train speed of 660 divided by 20, or 33 feet per second (22.5 miles per hour). A train travelling at this speed will require 20 seconds to travel the distance of section C1—D1 (330 feet). So the initial opening of the contacts 320 and 322 will be such that they will only be closed slightly after the elapse of time required for a train travelling at 33 feet per second to travel the distance of section C1—D1. Since this section is 660 feet long this time will be 660

divided by 33, or 20 seconds. Therefore if a train passes through section C1—D1 at an average speed of 15 miles per hour contact 320 will be moved for a period of 30 seconds, and contact 322 will be engaged and moved by contact 320 during the latter ten seconds of this movement. Then, when the train enters section D1—E1 the track relay T4 releases and at its contact 71 transfers the circuit of relay SC1 from the timing mechanism TM2 to conductor 83 of the timing mechanism TM3 now connected to a B terminal of the current source via contacts 322 and 320. The relay TR4 also at contact 70 interrupts the circuit of magnets M31, M22 and M23 and completes a circuit including magnets M32 and M33 of TM3. This latter circuit extends via conductor 87, governor contact 345, contact 324, and the windings of magnets M33 and M32 in series to a C terminal of the current source. The magnets M22 and M23 now release their armatures 202 and 203 from engagement with their drums 212 and 213, thereby enabling the contacts and other parts of the mechanism TM2 to restore to their normal position. The magnet M31 also releases its armature 301 to stop the advance movement of contact 320; while magnet M32 moves its armature 302 into engagement with drum 312 to prevent retrograde movement of the contact 320. The magnet M33 moves its armature 303 into engagement with drum 313 and thereby starts movement of pin 321 toward contact 322. Since section D1—F1 is equal in length to its measuring section C1—D1 it will be apparent from the foregoing description that the proper speed of movement of pin 321 will be the same as that of contact 320. Therefore, after ten seconds operation, pin 321 will engage and separate contacts 320 and 322 to start operation of the signal S1 when the train reaches a point in section D1—E1 20 seconds running time from the highway.

When the speed of the train through the respective measuring and operating sections has been so low that it is still 20 seconds or more running time from the highway, signal S1 will not be initiated by any of the timing mechanisms, but will be initiated when the train enters operating section E1—F1. When a train enters this section track relay TR5 releases and at its front contact 72 opens the circuit of signal control relay SC1 to insure operation of signal S1 while the train remains in section E1—F1 irrespective of whether the operation of signal S1 has or has not been previously started.

It will be observed that during the approach of a train toward the highway, track relays TR2, TR3 and TR4 at their respective back contacts 63, 68 and 69 successively connect B terminals of the current source to conductor 88 to maintain the operating circuit of motor MX closed as long as any of the timing mechanisms are being employed. When the train clears section D1—E1 the track relay TR4 again picks up and at its back contact 69 opens the circuit of motor MX. The relay TR4 also at its back contact 70 interrupts the circuit of magnets M33 and M32 thereby enabling the contacts and associated parts of timing mechanism TM3 to restore to their normal position.

It will be apparent that the approach relay AR1 releases and track relays TR1—TR5 successively pick up as the train passes through the respective sections. When the train clears section E1—F1 the track relay recloses the initial circuit of signal control relay SC1 at contact 72, and the relay SC1 accordingly again picks up to stop the operation of signal S1. The circuits and apparatus are now in their normal position, as shown.

In case a train enters one of the sections and remains therein for a prolonged period the same protective features as employed in the arrangement of Fig. 1 become effective to disable the driving connection between the motor and contact operating arm or member. For example, if a train enters section A1—B1 and then stops, the member 140 will finally move into operative relation with contacts 114 and 115. The contact 115 extends the B side of the current source, at the time connected to conductors 75 and 76, through the winding of magnet M12 to a C terminal of the current source. When M12 becomes energized it opens the circuit of magnet M11 at back contact 147 thereby stopping the movement of contact 120 and member 140; while magnet M12 moves its armature 102 into engagement with drum 112 to hold contact 120 in its advanced position. No further operations will now occur until the train proceeds into section B1—C1. When the train enters section B1—C1 the track relay TR2 releases and at its front contact 65 simply transfers the circuit of signal control relay SC1 to timing mechanism lead 85. Since contacts 120 and 122 are closed, operation of the signal is prevented from being started until the train has remained in section B1—C1 the extended time required for pin 121 to separate contact 122 from 120. Starting of the signal operation will therefore ordinarily not occur unless the train stops in the operating section. As the train proceeds through section B1—C1 timing mechanism TM2 functions as already described to measure the speed of the train through section B1—C1. If, therefore, the average speed of the train through section B1—C1 is below 45 miles per hour contacts 220 and 222 will be closed at the time track relay TR3 releases and will prevent the circuit of relay SC1 being opened, consequent to the release of timing mechanism TM1 at this time. The subsequent time of operation of signal S1 will obviously depend on the manner of progress of the train through the remaining sections of the stretch.

It will be observed that should the train remain in one of the measuring sections other than A1—B1 for an undue period the contact corresponding to 24 of mechanism TM will eventually open to prevent damage to the device. For example, if a train enters section B1—C1 and then stops, member 150 will finally open contact 124 and thereby interrupt the circuit of magnets M13 and M12 and cause the timing mechanism TM1 to function in the same manner as does TM under the same circumstances.

If the signal control system of Fig. 3 is to be applied to a stretch of track over which traffic moves in both directions, the approach sections for traffic moving in the opposite direction to that indicated will be equipped in the same manner as are sections A1—B1, C1—D1, etc.; branch conductors 89—93, 194 and 195, extending from the timing mechanisms TM1, TM2 and TM3 and the motor operating conductor 88, will be extended to the contacts of the relays corresponding to relays of sections A1—B1, etc.; while the conductor, corresponding to the one extending from contact 72, will be extended to the left-hand winding of the interlocking signal control relay SC1.

In case the invention is applied to a downgrade

stretch of track, or if for any other reason a stretch through which most trains are accelerating, this may be compensated for by increasing the speed of movement of the contacts corresponding to 22 of TM with respect to the contacts corresponding to 20; or by increasing the initially set opening between these contacts. Alternatively, the acceleration may be compensated for by appropriately modifying the lengths of the operating sections with respect to their measuring sections. The latter method is also applicable to a location where traffic moves over the stretch in both directions and it is desired to compensate for acceleration in one direction of train movement and deceleration for train movement in the other direction.

The governors employed are not utilized for in any manner exercising speed control of the driving motors, but the proper operation of the motors employed in driving the timing mechanisms TM, TM1—TM3 is checked by contacts of the governors. For example, in Fig. 1 if the governor contact 45 is not closed, the back contact 8 of relay T2 will be unable to complete the circuit of magnets M2 and M3. This will result in contact 20 of the mechanism restoring to normal at once so that the current supply over contact 22 will be immediately interrupted when front contact 7 of relay T2 releases, and operation of the signal S will be immediately started.

The employment of the approach relays AR and AR1 is optional; their purpose being to prevent operation of the first operated contact of their associated timing device merely because of temporary failure of the track circuit and consequent release of the track relay T1 or TR1 without the presence of a train.

In either form of the invention, if a train enters the signal control stretch and then recedes out of the stretch the operated timing mechanism or mechanisms, as the case may be, will restore to their initial position. For example, it will be assumed that a train has entered section D1—E1 and then recedes out of the signal control territory. As the train clears section D1—E1, relay TR4 picks up and at its back contact 70 opens the circuit of magnets M33 and M32 thereby enabling the restoration of contacts 320 and 322 and their associated parts to normal. While the train is occupying section C1—D1 clear of section D1—E1 relay TR3 is released and at its back contact 66 the usual circuit for magnet M31 is completed. Contact 320 is therefore advanced toward contact 322 while the train remains in section C1—D1. The relay TR3 also at back contact 66 closes the usual circuit through magnets M23 and M22 thereby causing contact 220 to be held in its normal position while contact 222 is advanced. On the entrance of the train into section B1—C1 relay TR2 releases, but without effect other than to maintain the motor circuit closed while the train remains in the section, by closing contact 63. When the train clears section C1—D1 relay TR3 again picks up and at its back contact 66 opens the circuits of magnets M31, M23 and M22. When magnet M23 releases it enables contact 222 to restore to normal. When magnet M31 becomes deenergized, since there is no holding circuit provided for M32, it enables contact 321 and 322 if operated to restore to normal. When the train clears section C1—D1 the usual circuits for energizing magnets M21, M12 and M11 are completed at the front contact 66 of relay TR3. The advance movement of contacts 220 and 122 is therefore started. When the train enters section A1—B1 relay TR1 releases and AR1 picks up. When the train clears section B1—C1 relay TR2 again picks up and at its front contact 65 recloses the circuit of signal control relay SC1. This relay therefore picks up and stops the operation of signal S1. The relay TR2 also at back contact 64 interrupts the circuits of magnets M21, M13 and M12, thereby enabling the operated contacts 220 and 122 of the mechanisms TM2 and TM1 to restore to normal, and at its front contact 64 closes the usual circuit of magnet M11, thereby starting the advance movement of contact 120. When the train clears section A1—B1 relay TR1 again picks up and AR1 releases. The relay TR1 at back contact 61 opens the circuit of motor MX which accordingly comes to rest, and at back contact 62 opens the circuit of magnet M11, thereby enabling the restoration of contact 120 to normal.

From the foregoing it will be quite clear that I have succeeded in providing a signal control system for use at a highway intersection, and employing one or a plurality of novel timing devices according to the extent of control desired; and that such device and the circuit arrangements I employ enable me to obtain a substantially constant operating period of the highway crossing signal for trains of varying speeds even when their speed is being accelerated or decelerated as the train approaches the highway

Although I have herein shown and described only two forms of apparatus embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a stretch of railway track divided into a plurality of sections each equipped with a track circuit including the usually provided track relay and the last section of which is intersected by a highway, a signal for controlling traffic on said highway at such intersection, a motor, means controlled by the track relay of the first section of the stretch on a train entering such section for starting the operation of said motor, means controlled by the track relay of the second section of the stretch for continuing the operation of said motor while the train is passing through such second section of the stretch; a relay for controlling said signal, normally included in a closed operating circuit including contacts of the track relay of the second section of the stretch, normally open contacts actuated by said motor included in an alternative circuit for said relay arranged to be closed by said motor a predetermined time after the operation of said motor is started so that if the time consumed by a train in passing through the first section of the stretch and into the second is greater than that required for said motor to close its contacts such contacts will prevent the track relay of said second section from opening the circuit of said signal control relay; and means, including said motor, controlled by the track relay of the second section under such circumstances for later reopening said normally open contacts to open the circuit of said signal control relay a time period after the entry of a train into said second section depending on the

time consumed by the train in passing through said first section.

2. In combination, a stretch of railway track divided into a plurality of sections each equipped with a track circuit including the usually provided track relay and the last section of which is intersected by a highway, a signal for controlling traffic on said highway at such intersection, a motor, means controlled by the track relay of the first section of the stretch on a train entering such section for starting the operation of said motor, means controlled by the track relay of the second section of the stretch for continuing the operation of said motor while the train is passing through such second section of the stretch; a relay for controlling said signal, normally included in a closed operating circuit including contacts of the track relay of the second section of the stretch, normally open contacts included in an alternative circuit for said relay arranged to be closed by said motor a predetermined time after the operation of said motor is started so that if the time consumed by a train in passing through the first section of the stretch and into the second is less than that required for said motor to close said normally open contacts the circuit of said signal control relay will be opened by the track relay of said second section, means controlled by the track relay of such second section under such circumstances for preventing said motor from closing said normally open contacts, the motor closing said normally open contacts and preventing the opening of the circuit of said signal control relay by the track relay of said second section in case the time consumed by the train in passing through the first and into the second of said sections is greater than that required for said motor to close said normally open contacts; and means, including said motor, controlled by the track relay of the second section under the latter circumstances for reopening said normally open contacts to thereby open the circuit of said signal control relay a time period after the entry of the train into said second section depending on the time consumed by the train in passing through said first section.

3. In combination, a stretch of railway divided into sections of track one of which is intersected by a highway, a highway crossing signal located at the intersection, a pair of contacts, means governed by a train on its entry into a first section in approaching the highway for driving one contact of said pair toward the other and encountering and moving the other with it in case the time consumed by the train in travelling such first section is greater than a set minimum period, means governed by the train on its entry into a second section in approaching the intersection for separating the other contact of said pair from the first contact thereof at the expiration of a period dependent on its period of engagement with the first contact of the pair during the travel of the train over the first section, operating means controlled by the train for setting said signal into operation when the train reaches said second section; and means controlled by said pair of contacts by the engagement of the second contact by the first one of the pair while the train is travelling through the first section to render said operating means ineffective on encountering the second section.

4. In combination, a stretch of railway divided into sections of track one of which is intersected by a highway, a highway crossing signal located at the intersection, a pair of contacts, means governed by a train on its entry into a first section in approaching the highway for driving one contact of said pair toward the other and encountering and moving the other with it in case the time consumed by the train in travelling such first section is greater than a set minimum period, means governed by the train on its entry into a second section in approaching the intersection for separating the other contact of said pair from the first contact thereof at the expiration of a period dependent on its period of engagement with the first contact of the pair during the travel of the train over the first section, operating means controlled by the train for setting said signal into operation when the train reaches the second section of said stretch, and means controlled by said pair of contacts by the engagement of the second contact by the first one of the pair while the train is travelling through the first section to render said operating means ineffective.

5. In combination, a stretch of railway divided into sections of track one of which is intersected by a highway, a highway crossing signal located at the intersection, a pair of contacts, means governed by a train on its entry into a first section in approaching the highway for driving one contact of said pair toward the other and encountering and moving the other with it in case the time consumed by the train in travelling such first section is greater than a set minimum period, means governed by the train on its entry into a second section in approaching the intersection for separating the other contact of said pair from the first contact thereof at the expiration of a period dependent on its period of engagement with the first contact of the pair during the travel of the train over the first section, operating means controlled by the train for setting said signal into operation when the train reaches the second section, and means controlled by said pair of contacts by the engagement of the second contact by the first one of the pair while the train is travelling the first fixed distance to render said operating means ineffective on encountering the specified second section, and for a period thereafter depending on the period of time elapsing while the train travelled through the first encountered section.

6. In combination, a stretch of track divided into a plurality of sections the latter of which is intersected by a highway, a highway crossing signal, signal actuating means, means associated with the second one of said sections responsive to the entrance of a train therein moving toward the highway to render said signal actuating means active, time measuring means responsive to the entrance of a train into the first section of the stretch for measuring the time consumed by the train in such first section prior to its entry into the second section, means actuated by said time measuring means for preventing the means of such second section from effecting the actuation of said signal in case more than a minimum set time is consumed by the train in the first section prior to its entry into the second, a second time measuring means set into operation by the entrance of the train into the second section for disabling said first time measuring means after the expiration of a period determined by the time consumed by the train in such first section prior to its entry into the second, and a third time measuring means set into operation in response to the entry of the train into the second section for transferring such control from said second time measuring

means to said third time measuring means in certain instances.

7. In combination with a stretch of track divided into a plurality of sections each equipped with a track circuit including a track relay and the latter of which is intersected by a highway, a signal for the highway, a control circuit for said signal including contacts of the track relays of said sections, excepting the first, successively operated by a train approaching the highway to disable said control circuit and thereby effect the actuation of said signal, a plurality of time measuring means associated with the stretch and each including a pair of contacts associated with the contacts of a different one of the track relays; means controlled by the track relay of the first section on the entrance of a train into the stretch for causing one of said time measuring means to close its contacts, when the time consumed by the train in such first section and before it enters the second section is greater than a minimum set period, to prevent the actuation of said signal by the operation of the contacts of the track relay of such second section on entry of the train therein; means set into operation by the track relay of the second section on the entry of a train therein for again opening the contacts of said actuated time measuring means while the train remains in the second section, a second of said time measuring means set into operation by the actuation of the track relay of the second section effective to close its contacts and prevent the actuation of said signal by operation of the contacts of the track relay of the third of such sections on entry of the train therein and also preventing the opening of the first operated time measuring contacts from being effective to initiate the actuation of said signal, and means set into operation by the actuation of the track relay of the third section for again opening the contacts of the second actuated measuring means to subsequently effect the actuation of said signal.

8. In combination with a stretch of track comprising three sections each equipped with a track circuit including the usual track relay and the third section of which is intersected by a highway, a highway signal; a control circuit, including serially related contacts of the track relays of the second and third of said sections, normally closed to prevent actuation of said signal; a time measuring means including a constant speed motor and a pair of normally open signal control contacts associated with the contacts of the track relay of said second section, means responsive to the operation of the track relay of the first section on the entrance of a train therein approaching the highway for starting the operation of said motor, other means responsive to the operation of said track relay for establishing a driving connection between said motor and one contact of said normally open pair to effect the advance movement of the one contact toward the other and to effect the engagement and movement of the other through the medium of the one in case the time consumed by the train in the first section and prior to its entry into the second is greater than a predetermined minimum, the engagement of the contacts of said pair being effective to prevent the subsequent actuation of the contacts of the track relay of said second section when the train enters it from opening the control circuit, means responsive to the actuation of the track relay of said second section for holding said one contact in its advanced position and for disabling the previously employed driving connection; means also responsive to the actuation of the latter relay to, by means of said motor, advance the other contact of said pair out of engagement with the one contact after a delay determined by the period of their engagement while being advanced by said first employed driving connection to open said control circuit a predetermined period after the entry of the train into said second section, the contacts of the track relay of said third section being responsive to also open said circuit upon entry of the train into said third section irrespective of whether it has or has not been previously opened to insure the actuation of said signal on entrance of the train into the third section if it has not previously been started.

9. In a signaling system for warning traffic on a highway of the approach of a train over a stretch of track intersected by a highway, a signal, an operating circuit for said signal, means including a normally closed circuit for preventing the closure of said operating circuit, a pair of train controlled contacts included in said normally closed circuit and opened in response to the entry of the train into a predetermined portion of such track, a time measuring mechanism having a pair of normally open contacts electrically associated with said train controlled contacts; train controlled means for actuating said time measuring mechanism so that a first of its said contacts moves toward the second of its contacts upon the entrance of a train into a second predetermined portion of such track to the rear of but adjoining said first specified portion at a rate of movement just insufficient to enable their closure by the time such train enters the first predetermined portion when averaging its maximum speed and for engaging and moving the second contact of its pair by the first in case the train movement in such second predetermined portion has been at a somewhat slower speed, means for stopping the movement of the first contact of such pair upon the entrance of the train into the first specified portion of the track and for opening said train controlled contacts to enable the operation of the signal to occur at once if said pair of normally open contacts have not been closed, and means for thereafter moving the second of said latter pair of contacts clear of the first thereof if they have been closed to enable the actuation of the signal after the expiration of a period determined by the lapse of times occurring after the closure of said latter contacts.

10. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, a time measuring device having a plurality of movable members, a motor and cooperating magnets, means operated when a train approaches a fixed point to the rear of the intersection to energize the motor and one of its magnets to move forward one of said members into engagement with the other, means operated when the train reaches a second fixed point to maintain the motor energized and to energize the other of said magnets in lieu of the first to thereby hold the first operated member in its forwardly moved position and to thereafter move the other of said members forward out of engagement with the first operated member, and means for setting said signal into operation when said other member

is moved out of engagement with the first operated member.

11. In combination with a stretch of railway track divided into a plurality of sections each provided with the usual track circuit including a track relay and the latter section of which is intersected by a highway, a signal at the highway for warning highway traffic of the approach of trains over the stretch, contacts on each of the track relays of each excepting the first encountered sections for initiating the actuation of said signal when a train enters such sections, a timing mechanism associated with the first encountered section set into operation on the entrance of a train into the first section and having means at the time operated to prevent the actuation of the contacts of the track relay of the second section from immediately starting the operation of the signal in case the time consumed by the train in such first section prior to its entry into the second is greater than a set period, other means in said timing mechanism responsive to the entrance of the train into the second section for disabling its first operated means an interval after the train has entered the second section depending on the time consumed by the train in the first before entering the second; a second timing mechanism, set into operation by the track relay of the second section on the train entering it, and having means at the time operated to prevent the actuation of the contacts of the track relay of the third section from immediately starting the operation of the signal in case the time consumed by the train in such second section prior to its entry into the third is greater than a set period, and means in said second timing mechanism responsive to the entrance of the train into the third section for disabling the first operated means of said second timing mechanism an interval after the train has entered the third section depending on the time consumed by the train in the second before entering the third section.

12. In combination with a stretch of railway track divided into a plurality of sections each provided with the usual track circuit including a track relay and the latter section of which is intersected by a highway, a signal at the highway for warning highway traffic of the approach of trains over the stretch, contacts on each of the track relays of each excepting the first encountered sections for initiating the actuation of said signal when a train enters such sections, a timing mechanism associated with the first encountered section set into operation on the entrance of a train into the first section to and having means actuated to prevent actuation of the contacts of the track relay of the second section from initiating the actuation of the signal in case the time consumed by the train in such first section prior to its entry into the second is greater than a set period, means in said timing mechanism responsive to the entrance of the train into the second section for disabling its first actuated means an interval after the train has entered the second section depending on the time consumed by the train in the first before entering the second; a second timing mechanism, set into operation by the track relay of the second section on the train entering it and having means to prevent actuation of the contacts of the track relay of the third section from initiating the actuation of the signal in case the time consumed by the train in such second section prior to its entry into the third is greater than a set period; a third timing mechanism, set into operation by the track relay of the third section on the train entering it and having means to prevent actuation of the contacts of the track relay of the fourth of said sections from initiating the actuation of the signal in case the time consumed by the train in such third section prior to its entry into the fourth is greater than a set period; means in said third timing mechanism responsive to the entrance of the train into the fourth section for disabling its first actuated means an interval after the train has entered the fourth section depending on the time consumed by the train in the third section before entering the fourth, the contacts on the track relay of the section intersected by the highway being effective to initiate the actuation of said signal upon a train entering its section in case the actuation of such signal has not previously been initiated.

13. In a circuit switching device, a driven shaft, a plurality of circuit switching arms mounted for free rotation on said shaft and retained in normal position by gravity, means for establishing a driving connection between said shaft and one of said arms, means for then stopping such arm and for holding it in its operated position, means for then establishing a driving connection between said shaft and another of said arms, and means actuated by the last operated arm for nullifying the effect of the operation performed by the actuation of the first arm.

14. In combination, an electromagnet, a shaft, means for driving said shaft, a gear wheel journaled on said shaft, a drum secured to said gear wheel, an armature controlled by said electromagnet and arranged to hold said drum when said electromagnet is energized to prevent rotation of said gear wheel, a contact arm pivoted on said shaft and provided with means for rotating said arm in response to rotation of said shaft when rotation of said gear wheel is prevented by said armature, and groups of contacts controlled by said arm.

15. In combination, an electromagnet, a shaft, means for driving said shaft, a gear wheel journaled on said shaft, a drum secured to said gear wheel, an armature controlled by said electromagnet and arranged to hold said drum when said electromagnet is energized to prevent rotation of said gear wheel, a contact arm pivoted on said shaft and provided with means for rotating said arm in response to rotation of said shaft when rotation of said gear wheel is prevented by said armature; a second gear wheel and second drum in fixed relation to each other and journaled to said shaft, a second electromagnet, an armature controlled by the second electromagnet and arranged when energized to hold the second drum stationary to prevent rotation of said second gear wheel, a second contact arm pivoted on said shaft and provided with means for rotating said second arm in response to rotation of said shaft when rotation of said second gear wheel is prevented, a pair of contacts jointly controlled by said arms, and other contacts controlled independently by said arms.

16. In combination, a driven shaft, a circuit control arm mounted for free rotation on said shaft, a gear and drum member also mounted and free to rotate on said shaft, a second shaft passing through said arm and having on one end thereof a pinion in engagement with said gear and having on the other end thereof a gear in engagement with a pinion fixed to said driven

shaft, means for at times holding said drum and its associated gear stationary to enable the movement of said arm by said driven shaft through the medium of said pinions and gears, a contact member moved by said arm throughout its period of movement; and means actuated by said arm, after a predetermined distance of movement thereof, to disable the driving connection between it and the first shaft and for holding it in its advanced position.

17. In a circuit switching device, a driven shaft, a pair of circuit switching arms mounted for free rotation on said shaft, normally inactive driving connections between said shaft and arms, electro-magnetic means for each arm effective to make the driving connection between it and the shaft active when such means is energized, a pair of circuit controlling contacts one contact of which is carried by one of said arms, a contact supporting member carrying the other contact of said pair and being mounted for free rotation on said shaft, means for energizing the electro-magnetic means of the arm carrying a contact of said pair to move such contact into engagement with the one on the contact carrying member, means for then holding said arm in its advanced position and for effecting the deenergization of its electro-magnetic means, means for also energizing the electro-magnetic means of the other arm, and means carried by said other arm for moving the contact supporting member and with it the other contact of the pair out of engagement with the contact on the first arm.

18. In a circuit switching device, a driven member, an arm suspended from said member, magnetic means for effecting movement of said arm by said member, other magnetic means for disabling said first magnetic means and for holding said arm in the position to which it has been moved, a pair of circuit control elements having their position with respect to each other modified by the movement of said arm, a second arm suspended from said member, a third magnetic means for effecting movement of the second arm by said member, and means carried by said second arm for also modifying the position of said circuit control elements with respect to each other.

19. In a circuit switching device, a driven shaft, a pair of circuit switching arms mounted for free rotation on said shaft, a pair of circuit controlling contacts one of which is carried by one of said arms, a contact supporting member carrying the other contact of said pair and being mounted for free rotation on said driven shaft, means for establishing a driving connection between such one of said arms and said driven shaft to move such arm and the contact of the pair carried by it into engagement with the contact of the pair carried by the supporting member; means for then holding such arm in its advanced position, effecting the interruption of the first established driving connection, and for establishing a driving connection between said driven shaft and the other of said arms; and means carried by such other of said arms for moving the contact carrying member and with it the other contact of the pair out of engagement with the contact on the first arm.

20. In combination, an insulated track section, a track circuit for said section including a normal track relay connected across the rails at one end of the section and a source of current and an auxiliary track relay serially connected across the rails at the other end of the section, and a control circuit including a back contact of said normal track relay and a front contact of said auxiliary track relay in series.

21. In combination, a stretch of railway formed into an insulated track section, a track circuit for said section including a normal track relay connected across the rails at one end of the section and a current source and an auxiliary track relay serially connected across the rails at the other end of the section, said normal track relay proportioned to release when a train enters the section and said auxiliary track relay proportioned to pick up in response to a train entering the section, a signaling device, and a control circuit for governing said device and including a back contact of the normal track relay and a front contact of the auxiliary track relay in series.

22. In combination, a stretch of railway track intersected by a highway and provided with an insulated track section on one side of the highway, a highway crossing signal located at the intersection, a track circuit for said section including a normal track relay connected across the rails at one end of the section and an auxiliary track relay and a current source serially connected across the rails at the other end of the section, operating means controlled by a train upon reaching the exit end of the section in approaching the highway to operate the signal, time measuring means operative a predetermined time interval after being energized to render said operating means ineffective to operate the signal, and a control circuit to energize the time measuring means including a back contact of the normal track relay and a front contact of the auxiliary track relay in series.

23. In combination, a stretch of railway intersected by a highway and formed into a measuring track section and an operating track section on one side of the intersection, a track circuit for the operating track section including a track relay, a track circuit for the measuring track section including a normal track relay connected across the rails at one end of the section and a current source and an auxiliary track relay serially connected across the rails at the other end of the section, a highway crossing signal located adjacent the intersection, an operating circuit to operate the signal and including a back contact of the relay of the operating section, a speed measuring means operative at times to render said operating means ineffective to operate the signal but normally inactive, and a control circuit effective when closed to render the speed measuring means active and including a back contact of said normal track relay and a front contact of said auxiliary track relay in series.

24. In combination, a stretch of railway track intersected by a highway and formed into a measuring track section and an operating track section on one side of the highway, a track circuit for the operating track section including a normally energized relay which releases when a train enters the section, a track circuit for the measuring track section including a normally de-energized relay which becomes energized when a train enters the section and remains energized as long as the train remains in the section, a highway crossing signal located at the intersection, operating means for operating the signal and including a back contact of the relay of the operating section, electroresponsive means operative when energized a predetermined time interval to modify the control of said operating means, and a circuit to energize said electrore-

sponsive means and including a front contact of the relay of the measuring section.

25. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, a timing track section and an operating track section traversed by a train in the order named when approaching the intersection, a relay for controlling the operation of said signal, a circuit for governing said relay including a first branch path having a normally closed contact and a second branch path having a normally open contact and another normally closed contact, means connected with the operating section to open said normally closed contact of the first branch path in response to entry of a train into the operating section, time measuring means governed by the timing section effective to close said normally open contact when a train traversing the timing section consumes more than a given interval prior to its entry into the operating section, and means governed by the time measuring means to open said other contact in said second branch path after a predetermined prolonged period of operation.

26. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, a timing track section and an operating track section traversed by a train in the order named when approaching the intersection, a track circuit for each of said sections including a normally energized track relay, a signal relay effective when deenergized to cause operation of the signal, a circuit for energizing said signal relay including a front contact of the track relay of the operating section, slow acting means including a normally open contact in multiple with said front contact, said slow acting means operative when actuated a predetermined time interval to close said normally open contact to retain the signal relay energized after a train enters the operating section, a control circuit for actuating said slow acting means and including a back contact of the track relay of the timing section, and means including another contact in said control circuit to prevent such operation of said slow acting means when a train enters the operating section in the event of a failure of the track circuit of the timing section.

PAUL N. MARTIN.