Oct. 8, 1946. A. L. JEROME 2,409,044

RAILWAY SIGNALING APPARATUS

Filed Jan. 9, 1943 9 Sheets-Sheet 1

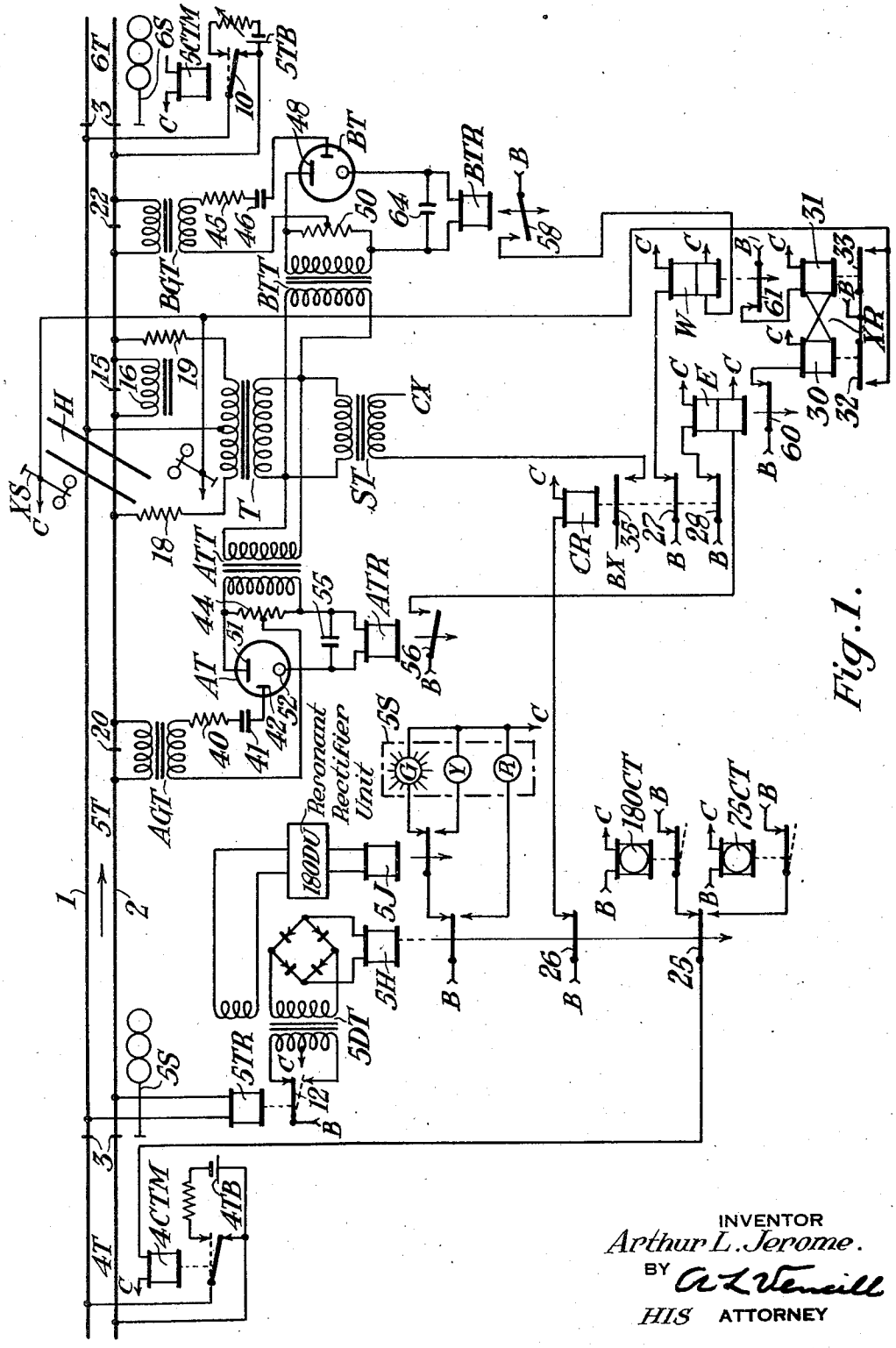


Fig. 1.

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Oct. 8, 1946. A. L. JEROME 2,409,044

RAILWAY SIGNALING APPARATUS

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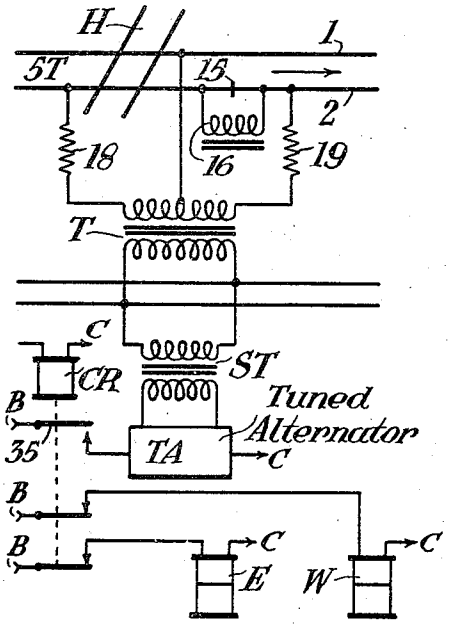


Fig. 2.

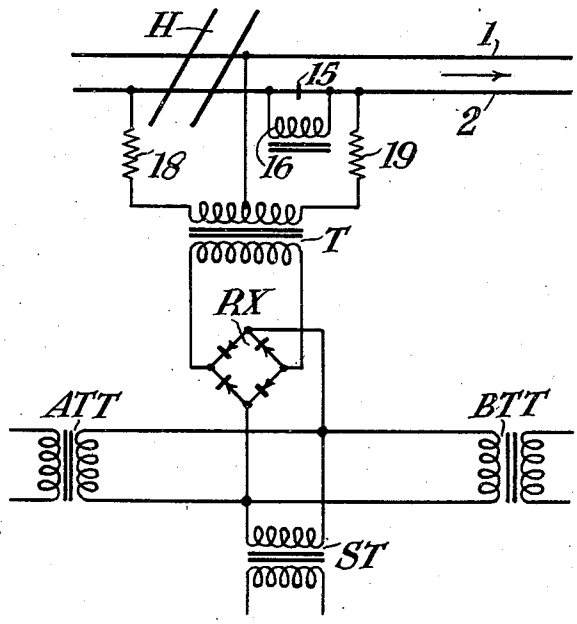


Fig. 3.

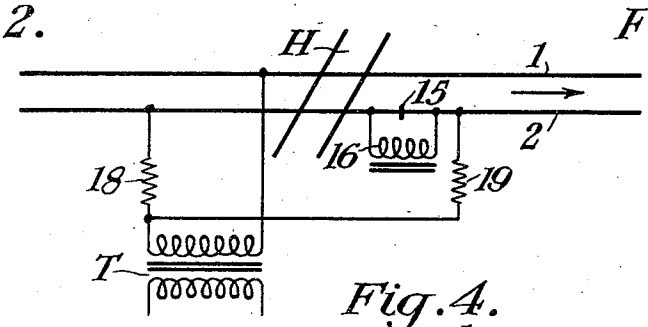


Fig. 4.

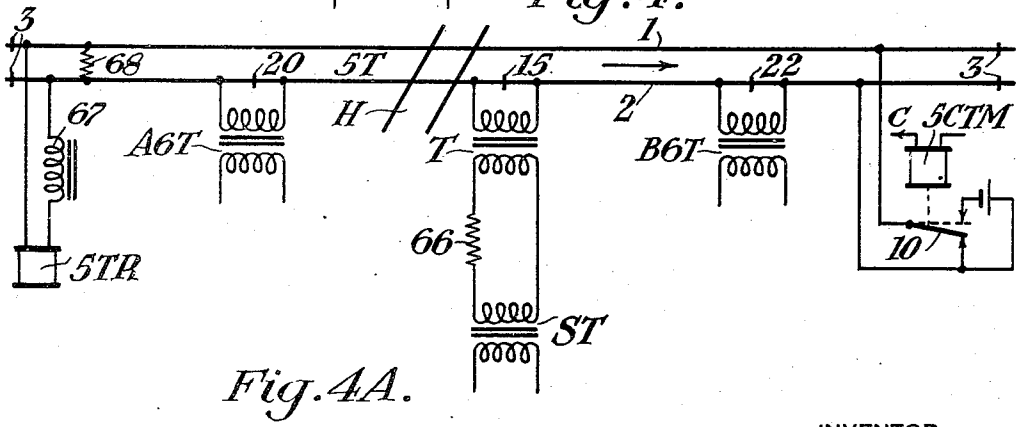


Fig. 4A.

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Oct. 8, 1946. A. L. JEROME 2,409,044

RAILWAY SIGNALING APPARATUS

Filed Jan. 9, 1943 9 Sheets-Sheet 3

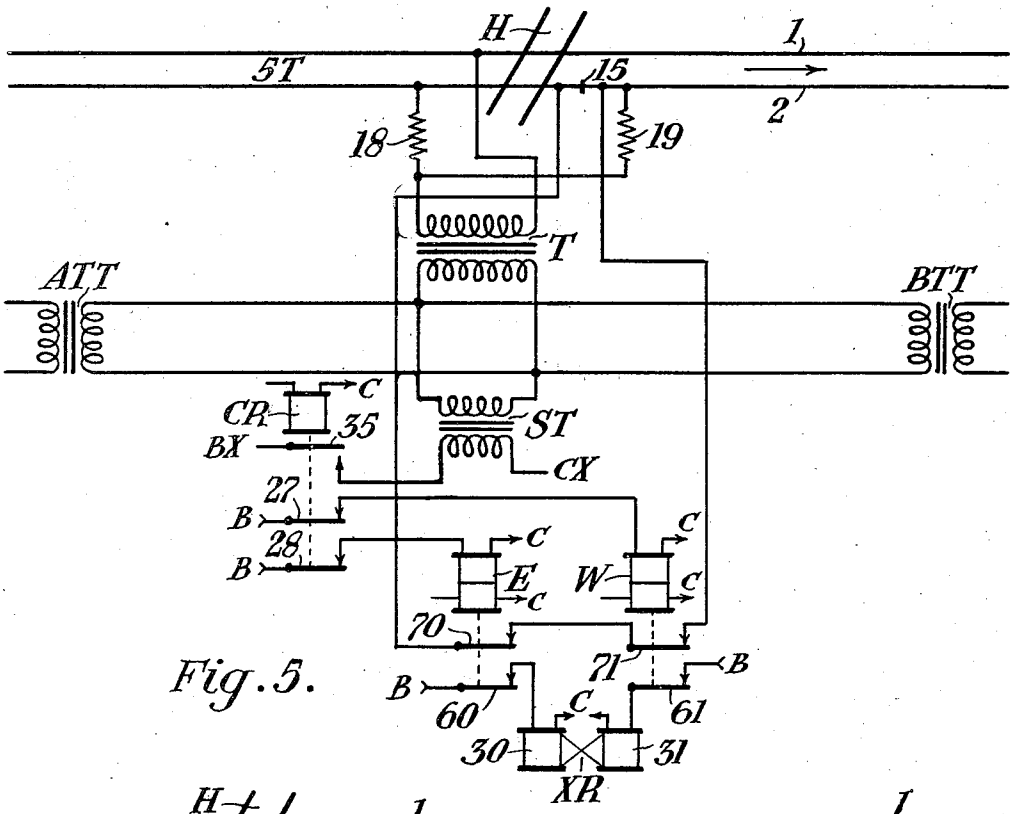


Fig. 5.

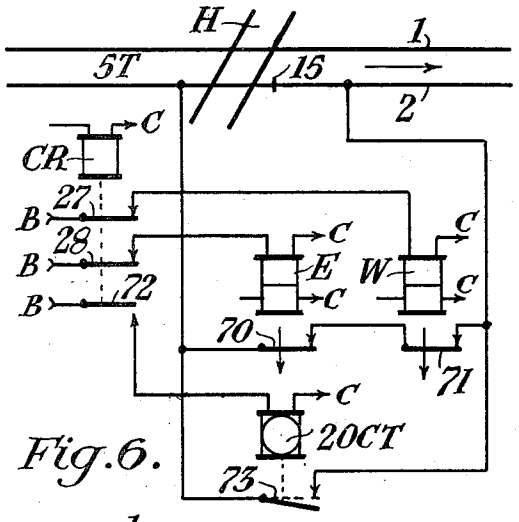


Fig. 6.

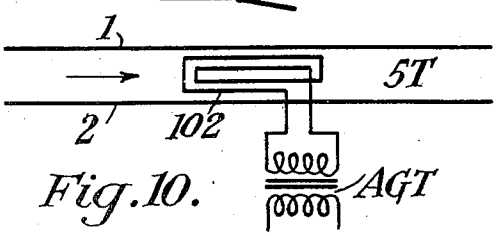


Fig. 10.

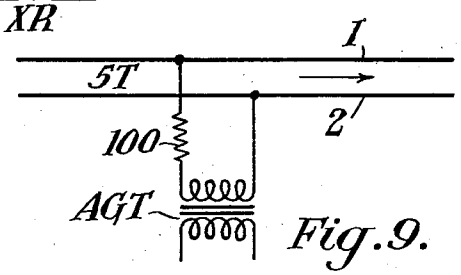


Fig. 9.

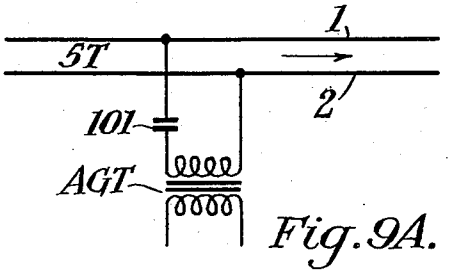


Fig. 9A.

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Oct. 8, 1946. A. L. JEROME 2,409,044

RAILWAY SIGNALING APPARATUS

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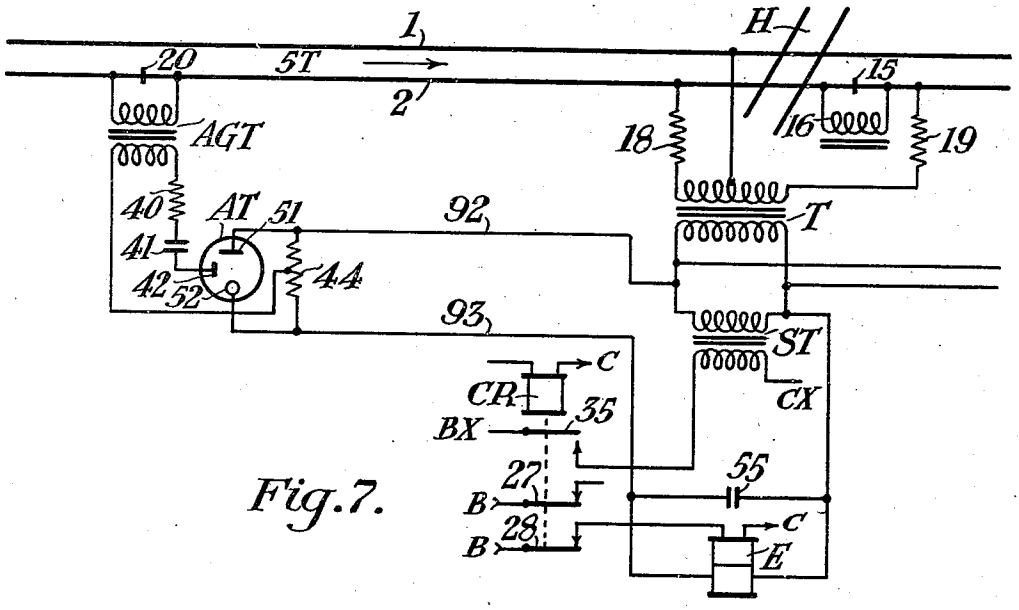


Fig. 7.

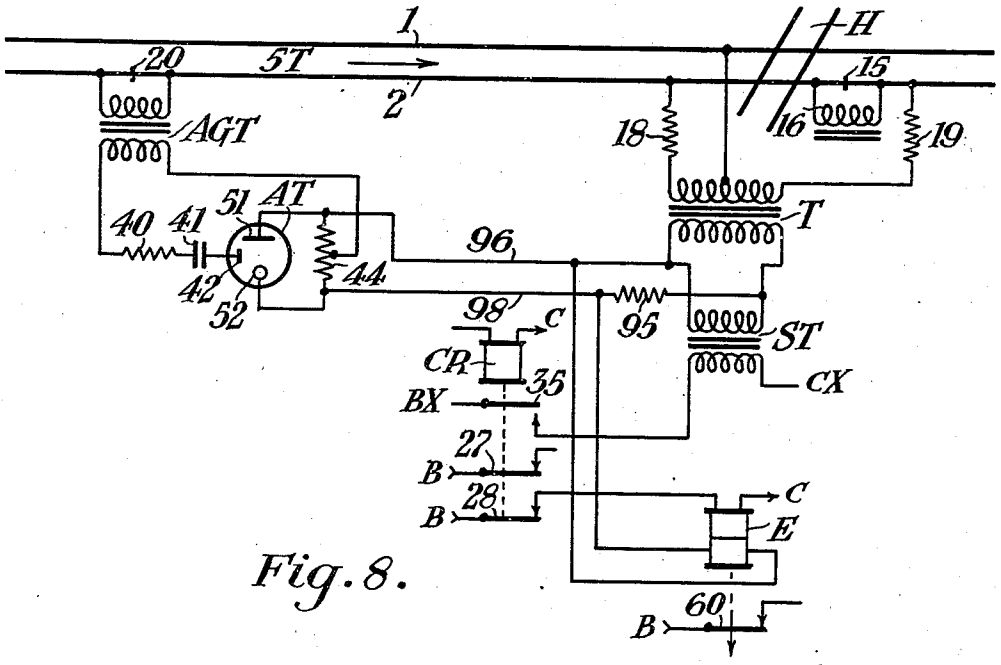


Fig. 8.

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Oct. 8, 1946. A. L. JEROME 2,409,044

RAILWAY SIGNALING APPARATUS

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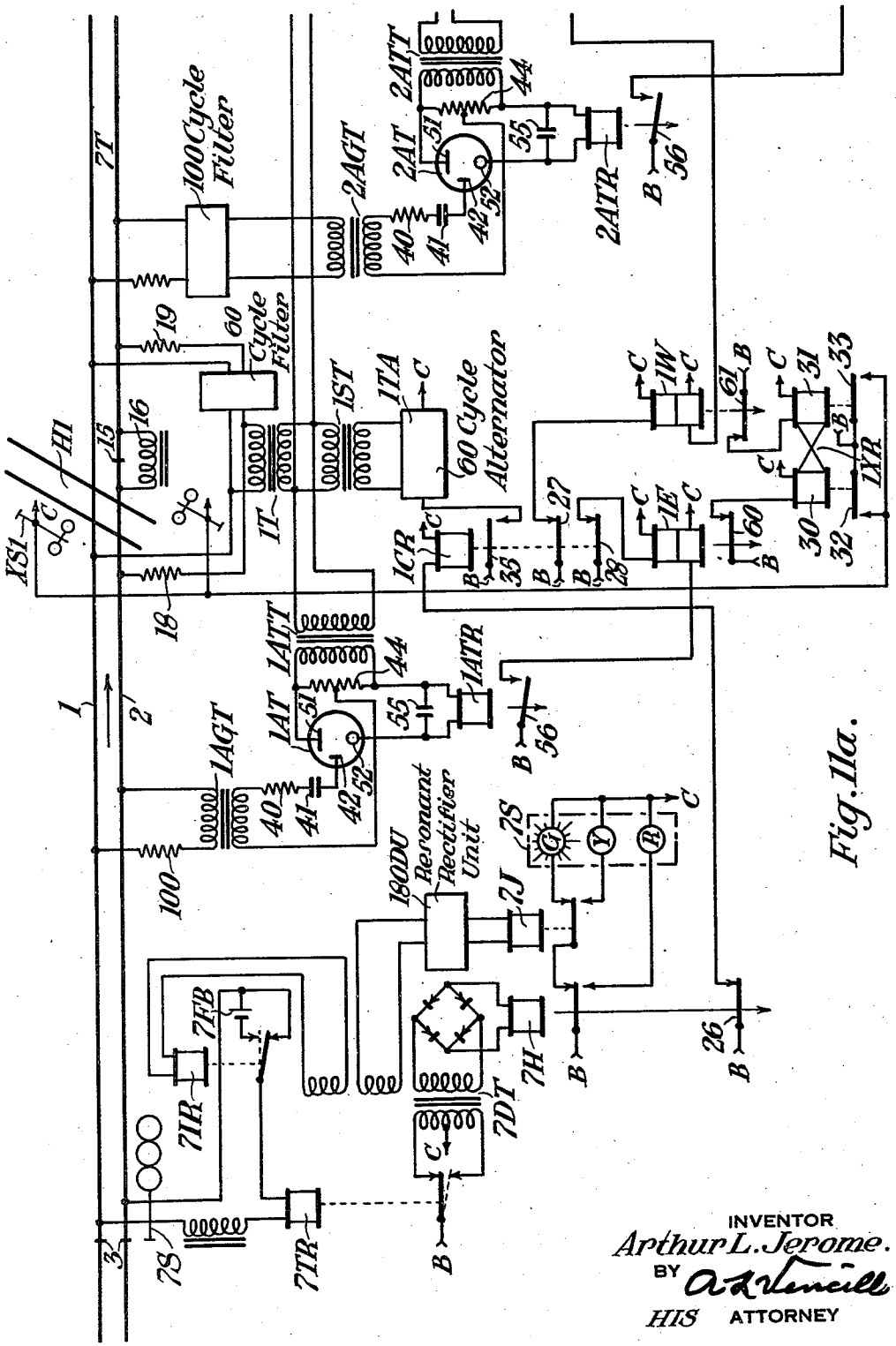


Fig. 11a.

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RAILWAY SIGNALING APPARATUS

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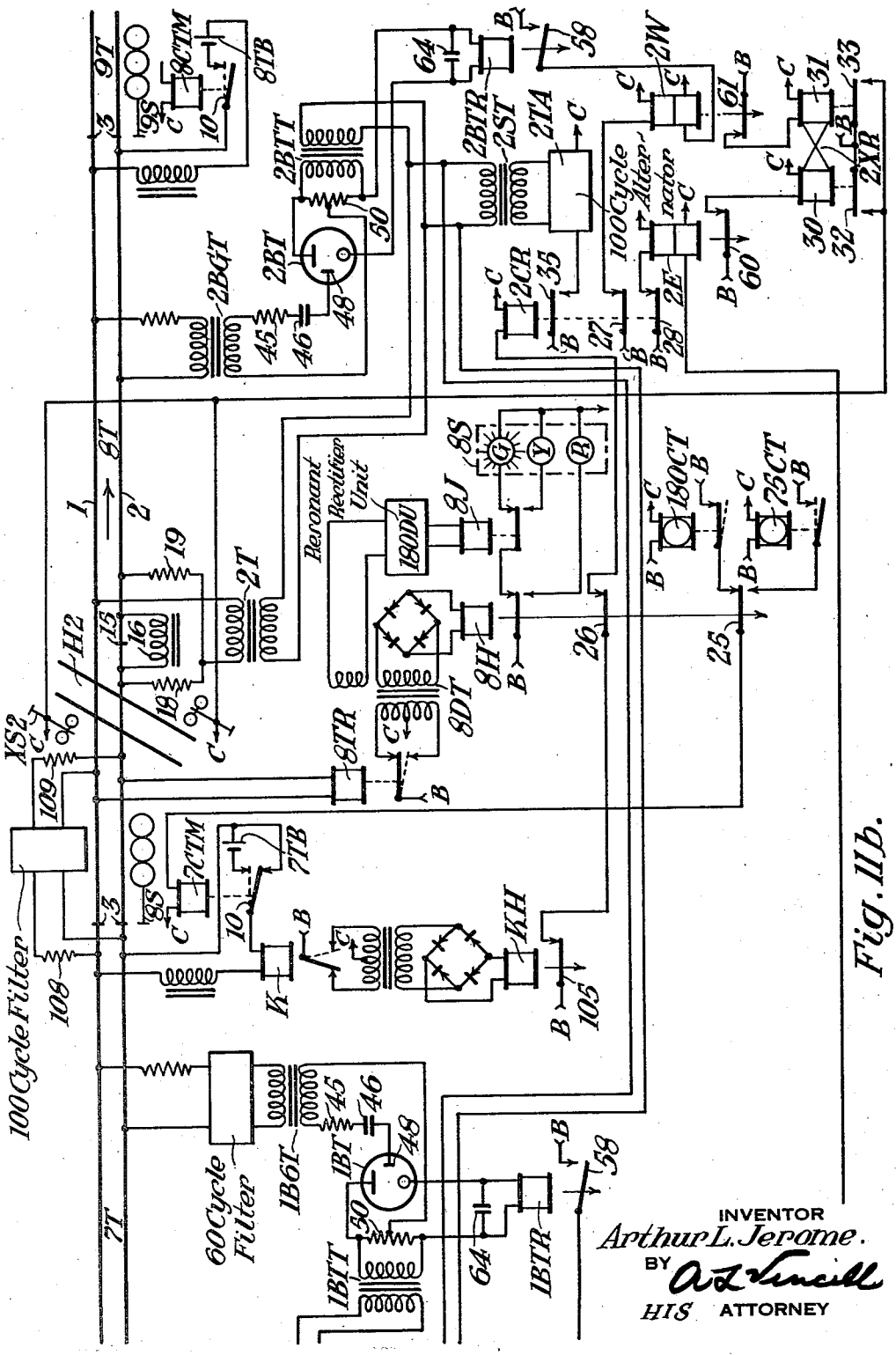


Fig. IIb.

Oct. 8, 1946. A. L. JEROME 2,409,044

RAILWAY SIGNALING APPARATUS

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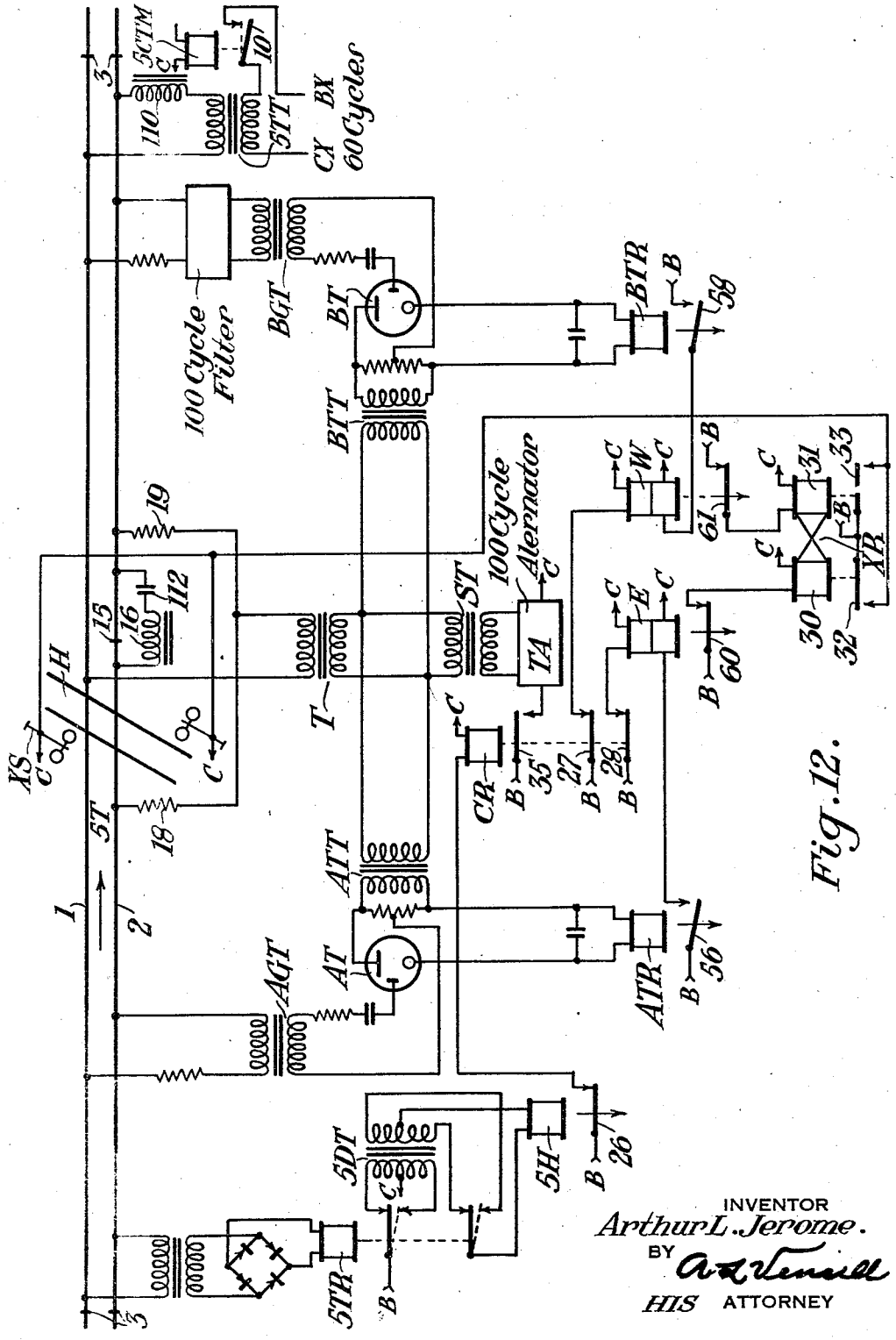


Fig. 12.

INVENTOR
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BY
HIS ATTORNEY

Oct. 8, 1946. A. L. JEROME 2,409,044

RAILWAY SIGNALING APPARATUS

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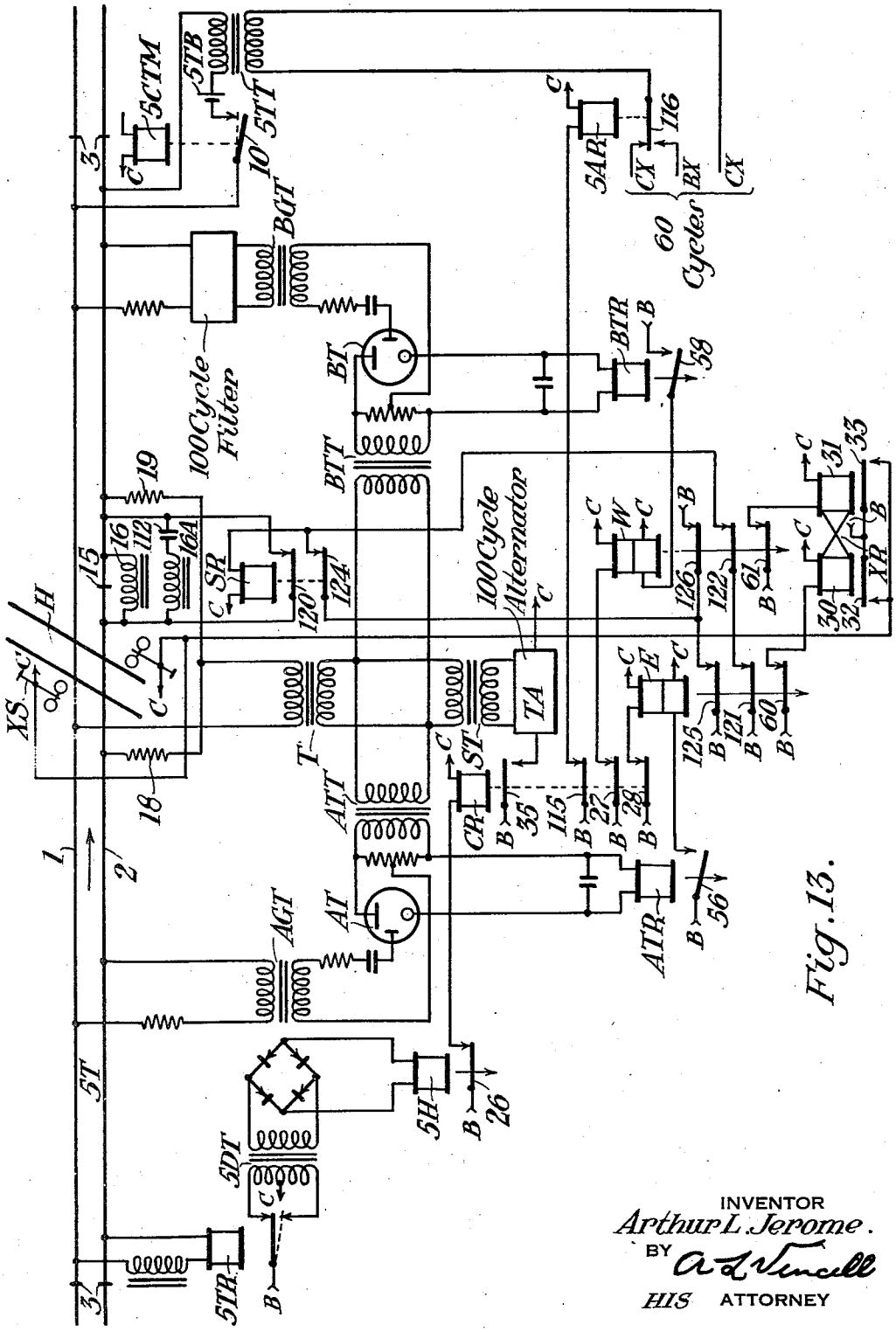


Fig. 13.

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Oct. 8, 1946. A. L. JEROME 2,409,044

RAILWAY SIGNALING APPARATUS

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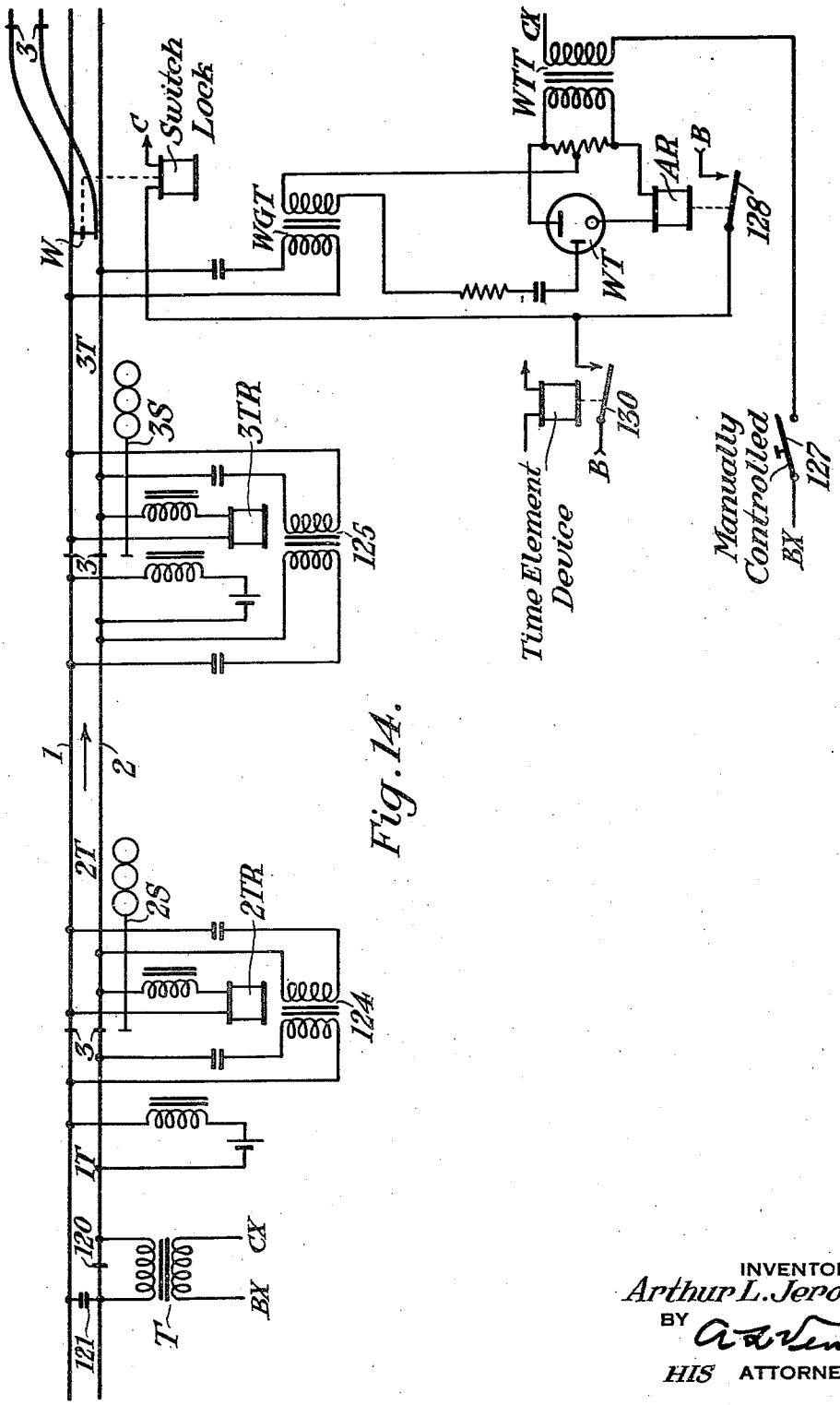


Fig. 14.

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Patented Oct. 8, 1946

2,409,044

UNITED STATES PATENT OFFICE

2,409,044

RAILWAY SIGNALING APPARATUS

Arthur L. Jerome, Edgewood, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application January 9, 1943, Serial No. 471,838

17 Claims. (Cl. 246—130)

1

My invention relates to railway signaling apparatus and particularly to improved means for indicating occupancy of a portion of a track stretch which may not coincide with the track sections into which the track stretch is divided for the control of traffic through the track stretch.

It is customary to divide the track rails of a track stretch into track sections by insulated joints, and to equip each of these track sections with track circuit apparatus for the control of signaling apparatus governing movement of traffic through the track stretch.

In some situations, as for example the control of highway crossing signals or the locking of switches, it is desirable to determine occupancy of a portion of the track stretch which does not coincide with the track sections which are established for the control of the traffic governing signal equipment. In order to secure the desired control in such situations it has been customary heretofore to divide the track sections into subsections and to equip each of these subsections with track circuit apparatus, while when more than one track section is involved a line circuit controlled by the track relays is provided.

The additional track circuit and other equipment for the subsections is relatively expensive, and if a track stretch includes many highway crossings or track switches so that numerous subsections are required, the cost of the equipment may be excessive.

It is an object of this invention to provide improved train detecting apparatus which may be applied to a stretch of railway track to ascertain occupancy of a portion of said track stretch without interfering with the operation of the track circuit apparatus with which the track sections are provided to control traffic in the track stretch.

Another object of the invention is to provide improved train detecting apparatus which makes it unnecessary to subdivide the track sections of a track stretch when the portion of the stretch in which it is desired to determine occupancy does not coincide with the track sections established to control the traffic governing signals.

A further object of the invention is to provide improved auxiliary track circuit apparatus of the type described which may be arranged so that its failure will not interfere with the operation of the principal track circuit apparatus.

Another object of the invention is to provide auxiliary track circuit apparatus of the type described which may be controlled by the principal

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track circuit apparatus so that the auxiliary track circuit apparatus is normally deenergized and is energized only when the principal track circuit apparatus detects a train in the portion of the track stretch in the vicinity of the auxiliary track circuit apparatus.

A further object of the invention is to provide improved auxiliary track circuit apparatus of the type described which is arranged so that a first set of such apparatus may be employed to detect occupancy of a first portion of a track stretch, and so that a second set of such apparatus may be employed to detect occupancy of a second portion of the track stretch even though the two portions of the track stretch overlap so that some of the track stretch is common to both portions.

Another object of the invention is to provide improved auxiliary track circuit apparatus of the type described which is adapted to detect occupancy of a zone in a track stretch even though this zone extends beyond the confines of a track section.

A further object of the invention is to provide improved auxiliary track circuit apparatus of the type described which employs an electron tube governed by occupancy of a selected zone in a track stretch, the apparatus being arranged so that failure of the electron tube cannot create a hazardous condition.

Another object of the invention is to provide improved highway crossing signal control means employing the auxiliary track circuit apparatus provided by this invention.

A further object of the invention is to provide improved crossing signal control means which is arranged so that the crossing signals are controlled jointly by the principal and the auxiliary track circuit apparatus, and so that failure of the auxiliary track circuit apparatus will not result in failure of the crossing signals to provide adequate warning of the approach of a train.

Other objects of the invention and features of novelty will be apparent from the following description taken in connection with the accompanying drawings.

I shall describe several forms of apparatus embodying my invention, together with several modifications thereof which I may employ, and shall then point out the novel features thereof in claims.

In practicing my invention, at each end of the track zone occupancy of which is to be determined I connect a transformer with the section

rails in such manner as not to substantially interfere with the operation of the principal track circuit apparatus, while permitting energy to be supplied from one transformer to the other only when the intervening track zone is unoccupied. I supply alternating current of a distinctive frequency to the track rails through one of these transformers and I employ energy from the other transformer to vary the potential on the grid or control element of a cold cathode type electron tube, while I supply alternating current to the anode circuit of this type in series with the winding of a control relay. The tube operates to permit half cycles of energy of one polarity only to be supplied therethrough, and then only when energy is supplied over the associated track zone to establish the proper potential on the tube grid or control element.

In the drawings

Fig. 1 is a diagram showing a stretch of railway track equipped with highway crossing signal control apparatus embodying my invention,

Figs. 2, 3, 4, 4A, 5, 6, 7, 8, 9, 9A, and 10 illustrate modifications which may be employed,

Fig. 11 is a diagram showing a stretch of railway track in which the crossing signals for two highway intersections are governed by apparatus embodying this invention,

Figs. 12 and 13 are diagrams showing crossing signal control means embodying this invention applied to track sections in which coded alternating current track circuit energy is employed, and

Fig. 14 is a diagram showing switch locking means embodying this invention.

Similar reference characters refer to similar parts in each of the several views.

Referring to Fig. 1 of the drawings, there is shown therein a stretch of railway track over which traffic normally moves in the direction indicated by the arrow, that is from left to right. The rails 1 and 2 of the track stretch are divided by insulated joints 3 into track sections for signaling purposes. One such section is shown in Fig. 1 and is designated 5T.

The track section 5T has at the entrance end thereof a wayside signal 5S which may be of any appropriate type and is controlled in accordance with traffic conditions in section 5T and in the adjacent section in advance. As shown the signal 5S is of the familiar color light type and has a green or proceed lamp G, a yellow or caution lamp Y, and a red or stop lamp R.

As shown the track section 5T is provided with coded track circuit apparatus of well known design. The track circuit apparatus includes a coding relay 5CTM at the exit end of the section and having a contact 10 which controls connection of the track battery 5TB across the section rails. The relay 5CTM is controlled by traffic conditions in section 6T in the manner well known in the art so that contact 10 of relay 5CTM is operated between its released and picked-up periods so as to cause energy of 75 or 180 code frequency to be supplied to the rails of section 5T according as section 6T is occupied or is unoccupied.

A code following track relay 5TR is connected across the section rails at the entrance end of the section and has associated therewith a decoding transformer 5DT, and auxiliary relays 5H and 5J. When the track section is vacant relay 5TR follows code and its contact 12 alternately establishes the circuits of the two portions of the decoding transformer primary winding so that energy is induced in the transformer secondary windings. The energy from one of the transformer secondary windings is rectified and supplied to code detecting relay 5H so that the contacts of relay 5H are picked up as long as relay 5TR follows code of either 75 or 180 code frequency.

The energy from the other secondary winding of the decoding transformer is supplied through a resonant rectifier unit 180DU to relay 5J. The elements of the unit 180DU are proportioned so that sufficient energy to pick up relay 5J is supplied through the unit when and only when the relay 5TR is responding to energy of 180 code frequency.

The relays 5H and 5J cooperate in the usual manner to control signal 5S so that this signal displays its red or stop indication when relay 5H is released, and when relay 5H is picked up the signal 5S displays its caution or its proceed indication according as relay 5J is released or picked up.

The relay 5H also controls the supply of energy to coding relay 4CTM so that this relay is energized over a circuit controlled by a contact of a code transmitter 75CT or of a code transmitter 180CT depending on whether relay 5H is released or picked up.

The track section 5T includes an intersection with a highway H and this invention is directed to auxiliary track circuit means for controlling the crossing signals XS at the intersection to warn users of the highway of the approach of a train.

An insulated joint 15 is placed in one of the track rails at a point on the right-hand side of the intersection, while the portions of the track rail on opposite sides of the insulated joint are connected together through a reactor 16. The reactor 16 is designed so that it has relatively little impedance to the coded direct current traffic governing energy, but has high impedance to alternating current employed in the control of the crossing signals.

A transformer T has a secondary winding having its center terminal connected to track rail 1, while one end terminal of this winding is connected through a resistance 18 to the portion of rail 2 on one side of the joint 15, and the other end terminal of the transformer secondary winding is connected through resistance 19 to the portion of track rail 2 on the other side of the insulated joint 15. Accordingly, when energy is supplied to the primary winding of transformer T, one half of the transformer secondary winding supplies alternating current to the portion of the track section on one side of the joint 15, and the other half of the transformer secondary winding supplies current to the portion of the track section on the opposite side of the joint 15, while the reactor 16 prevents flow of alternating current energy between the portions of rail 2 on opposite sides of the joint 15 and thus prevents short circuiting of the transformer secondary winding.

The resistances 18 and 19 have relatively high resistance to thereby reduce to a very small value the flow of coded direct current track circuit energy between the track rails through the two portions of the transformer secondary winding.

An insulated joint 20 is located in rail 2 at the point in the rear of the intersection at which it is desired to have operation of the crossing signals initiated by a train moving in the normal direction of traffic, while a similar insulated joint 22 is located in rail 2 at the point in advance of the intersection at which it is desired

to have operation of the crossing signals initiated by a train moving in the reverse of the normal direction.

A grid transformer AGT has the terminals of its primary winding connected to the rail 2 on opposite sides of the insulated joint 20, while a grid transformer BGT has the terminals of its primary winding connected to rail 2 on opposite sides of the joint 22. The transformers AGT and BGT are of such design that their primary windings have little resistance to flow of coded direct current track circuit energy through track rail 2.

The transformers AGT and BGT control electron tubes AT and BT respectively, which in turn control relays ATR and BTR which govern circuits for supplying energy to slow release relays E and W, while the relays E and W control the circuits of the windings of the interlocking relay XR which controls the crossing signals XS.

The electron tubes AT and BT are preferably of the cold cathode, controlled ionization type, while the associated relay together with a source of alternating current are connected across the anode and cathode of the tube to energize the relay by current passed by the tube when the tube is ionized, the voltage of the source of alternating current being, however, normally insufficient to start ionization, but being sufficient to cause the tube to break down when a preselected control electromotive force is applied to the control element or grid of the tube.

Each tube is provided with a grid or control element which is governed by the associated grid transformer. As shown one terminal of the secondary winding of the transformer AGT is connected through a resistance 40 and a condenser 41 to the grid 42 of the tube AT, while the other terminal of the secondary winding of the transformer AGT is connected to an intermediate point on a biasing resistor 44 which is connected across the terminals of the secondary winding of transformer ATT.

Similarly, one terminal of the secondary winding of grid transformer BGT is connected through a resistor 45 and a condenser 46 to the grid 48 of tube BT, while the other terminal of the transformer secondary winding is connected to an intermediate point on a biasing resistor 50 which is connected across the terminals of the secondary winding of transformer BTT.

Alternating current is supplied from a transformer ST to the transformer T, and to transformers ATT and BTT associated with the electron tubes, while the supply of energy to transformer ST is governed by a control relay CR. The alternating current may be supplied from any suitable source, not shown, the terminals of which are designated BX and CX.

The signal lamps and the relays other than the track relay are operated by direct current supplied from a suitable source, such as storage batteries, not shown, the terminals of which are designated B and C.

The equipment is shown in the condition which it assumes when sections 5T and 6T are vacant. At this time energy of 180 code frequency is supplied to relay 5CTM and it operates to supply energy of 180 code frequency to the rails of section 5T. This energy feeds over the section rails and through the reactor 16 and the primary windings of transformers AGT and BGT to the track relay 5TR and operates it so that energy is supplied through the decoding transformer to relays 5H and 5J. As relays 5H and 5J are

both picked up the green or clear lamp G of signal 5S is lighted, while as relay 5H is picked up its contact 25 establishes the circuit to supply energy of 180 code frequency to relay 4CTM so that energy of 180 code frequency is supplied to the rails of section 4T.

As relay 5H is picked up its contact 26 establishes the circuit of control relay CR and it is picked up so that its contact 27 establishes a circuit for relay W, while its contact 28 establishes a circuit for relay E. Accordingly, relays E and W are both energized and they establish the circuits of the windings 30 and 31 of relay XR so that contacts 32 and 33 of the interlocking relay are both picked up, and interrupt the supply of energy to the crossing signals XS and thus prevent operation of the crossing signals.

As relay CR is picked up its contact 35 interrupts the supply of energy to transformer ST, and thus cuts off the supply of alternating current to the track rails and to the electron tubes. Accordingly the electron tubes and other portions of the auxiliary track circuit apparatus do not function when the track section is vacant, while the crossing signals are controlled by the usual track circuit apparatus as long as the section is vacant.

When a train moving in the normal direction of traffic enters section 5T the track relay 5TR ceases to follow code and relays 5H and 5J release and cause the signal 5S to display its red or stop indication and change the energy supplied to relay 4CTM from 180 to 75 code frequency.

On release of relay 5H its contact 26 interrupts the circuit of relay CR and relay CR releases so that its contact 35 establishes the circuit of the primary winding of transformer ST and energy is supplied from this tranformer to the primary windings of transformers ATT, BTT and T.

On the supply of energy to transformer T energy is supplied from one half of the transformer secondary winding through resistor 18 to the portion of the track section in the rear of the intersection. This energy feeds from an end terminal of the transformer secondary winding through resistor 18, rail 2, primary winding of transformer AGT, through the wheels and axles of the vehicles forming the train, and over rail 1 to the center terminal of the transformer primary winding.

Similarly, energy is supplied from the other half of the secondary winding of transformer T to the portion of the track section in advance of the intersection. This energy feeds from the end terminal of the transformer through resistor 19, track rail 2, primary winding of transformer BGT, thence over back contact 10 of relay 5CTM or through the battery 5TB and front contact 10 of relay 5CTM, and rail 1 to the center terminal of the transformer secondary winding.

In addition on the supply of energy to transformer ST energy is supplied therefrom to transformers ATT and BTT with the result that energy is induced in the secondary winding of each of these transformers and is impressed between the anode and cathode of the associated tube, while a portion of the transformer secondary voltage is impressed on the grid of the associated tube through the biasing resistor.

As pointed out above, the voltage of the energy impressed between the anode and cathode of each tube is insufficient to cause ionization of the tube. The potential applied to the grid of each tube by energy supplied thereto through the biasing re-

sistor is insufficient to cause ionization of the tube, so that unless energy is supplied to the tube grid from the associated grid transformer the tube is not ionized and no current flows in the tube anode circuit.

On the supply of alternating current through the primary winding of grid transformer AGT energy of relatively high voltage low amperage is induced in the transformer secondary winding and is supplied therefrom to the grid 42 of the tube AT.

During the half cycles in which the energy supplied from the grid transformer AGT to the grid 42 of the tube AT are of positive relative polarity the potential on the tube grid is increased to a value effective to ionize the tube and cause it to become conducting.

The transformers AGT and ATT are supplied from the same source so the energy impulses supplied from these transformers to the tube AT are substantially in phase. The various parts of the equipment are arranged so that when an impulse of energy of positive polarity is supplied from grid transformer AGT to the grid of tube AT, the impulse of energy supplied from the transformer ATT is of such polarity that the positive terminal of the transformer secondary winding is connected to the anode 51 of the tube AT. The tube AT, therefore, breaks down and energy flows through the tube to relay ATR over the circuit which is traced from an end terminal of the secondary winding of transformer ATT to the tube anode 51, through the tube space to cathode 52, and winding of relay ATR to the other terminal of the transformer secondary winding.

The tube AT, once it has become conducting, continues to be conducting throughout most of the positive half cycle of energy from the transformer ATT. The next or negative half cycle of energy from the transformer ATT serves to deenergize the tube and restore it to its normal condition, while as long as energy continues to be supplied from the grid transformer to the tube grid, the tube is rendered conducting on each subsequent positive half cycle so that an impulse of energy is supplied to the winding of relay ATR during every other half cycle of the alternating current.

A condenser 55 is preferably connected across the terminals of the winding of relay ATR, and during the supply of each impulse of energy through the tube AT, a charge is built up on the condenser 55, while in the intervals between impulses of energy from the tube, energy from the condenser feeds to the relay winding and maintains the flow of energy through the relay winding and thus maintains the relay contacts picked up. If desired the relays ATR and BTR may be of a type the contacts of which are slow to release so that they will remain picked up in the intervals between the energy impulses supplied to the relay winding, and thus eliminate the need for condensers connected across their terminals.

On the supply of alternating current to the primary winding of transformer BGT the tube BT is rendered conducting and energy from transformer BTT is supplied through the tube to relay BTR to pick up its contact.

On picking up of relay ATR its contact 56 establishes a circuit to supply energy to a winding of relay E, while on picking up relay BTR its contact 58 establishes a circuit to supply energy to relay W.

There is a short period between the time at which relay CR releases and interrupts the circuits which it controls for supplying energy to relays E and W, and the time at which relays ATR and BTR pick up and establish circuits for the relays E and W. The relays E and W are of a type which are slow in releasing so their contacts remain picked up throughout this period and maintain the circuits of the windings of the interlocking relay XR.

Accordingly, when a train enters section 5T relay CR releases and interrupts the circuits which it controls for supplying energy to the relays E and W, while the auxiliary track circuit apparatus provided by this invention is placed in operation and causes the relays ATR and BTR to be picked up and establish circuits to supply energy to the relays E and W so that they continue to prevent operation of the crossing signals.

When the train advances beyond the joint 20, the wheels and axles of the vehicles forming the train provide a path between the rails 1 and 2 which shunts the alternating current away from transformer AGT, and energy is no longer supplied to the transformer AGT while energy is no longer supplied from the transformer AGT to the grid of tube AT. Accordingly, the tube AT ceases to be conducting so energy ceases to be supplied to relay ATR and its contact 56 releases and interrupts the supply of energy to relay E. Contact 60 of relay E therefore releases and interrupts the circuit of the winding 30 of relay XR so that the contact 32 controlled by winding 30 releases and establishes the circuit of the crossing signals XS and these operate to warn users of the highway of the approach of a train.

When the train advances beyond the joint 15 the supply of energy to transformer BGT is cut off and the tube BT is rendered non-conducting so relay BTR releases and interrupts the circuit of relay W with the result that contact 61 of relay W interrupts the circuit of winding 31 of the interlocking relay XR. The internal construction of the relay XR is such that on deenergization of winding 31 while winding 30 is deenergized the contact 33 is prevented from moving all of the way to its released position.

When the rear of the train vacates the portion of the track section in the rear of the joint 15 alternating current is again supplied through the primary winding of transformer AGT so energy is supplied from the transformer secondary winding to the grid 42 of tube AT so that the tube is rendered conducting and energy is supplied to relay ATR to pick up its contact 56.

The alternating current energy supplied to transformer AGT at this time is supplied through the winding of relay 5TR. The value of this alternating current energy is too small to cause operation of the relay, however.

On picking up of contact 56 of relay ATR energy is supplied to relay E and its contact 60 establishes the circuit of the winding 30 of relay XR so that contact 32 is picked up and discontinues operation of the crossing signals XS, which is proper as the rear of the train has cleared the highway intersection.

The internal construction of the interlocking relay XR is such that on picking up of contact 32 contact 33 is prevented from moving to its released position to establish the circuit of the crossing signals.

When the rear of the train advances beyond the joint 15 the shunting effect of the train on the alternating current supplied to the portion

of the track section in the rear of the joint 15 is relatively small because of the impedance of the reactor 16 to the alternating current. Accordingly, as soon as the rear of the train passes over the joint 15 there is a substantial increase in the alternating current supplied to transformer AGT and the tube AT is rendered conducting so relay ATR will become picked up to discontinue operation of the crossing signals. The reactor 16, therefore, serves to insure that operation of the crossing signals will be discontinued as soon as the train clears the intersection.

When the rear of the train advances beyond the joint 22, alternating current is again supplied through the primary winding of transformer BGT so that the tube BT is again rendered conducting. Accordingly, relay BTR picks up and establishes a circuit for relay W and contact 61 of relay W picks up and establishes the circuit of winding 31 of the interlocking relay XR so that contact 33 of relay XR is picked up.

When the train advances far enough to vacate section 5T the impulses of coded direct current supplied from the track battery 5TB to the track rails during the picked-up periods of contact 19 of coding relay 5CTM feed through the primary windings of transformers BGT and AGT and through the reactor 16 to the track relay 5TR and operate it so that energy is supplied through the decoding transformer 5DT to relay 5H. At this time energy of 75 code frequency is supplied to section 5T and the rate of operation of relay 5TR is such that too little energy is supplied to relay 5J through the associated resonant unit to pick up the relay contacts. Accordingly, relay 5J remains released and on picking up of relay 5H energy is supplied to the yellow lamp Y of signal 5S over a front contact of relay 5H and a back contact of relay 5J, while on picking up of relay 5H its contact 25 changes the energy supplied to section 4T from 75 to 180 code frequency.

In addition, on picking up of relay 5H its contact 26 establishes the circuit of relay CR so that its contacts 27 and 28 establish circuits to supply energy to relays W and E, while its contact 35 interrupts the supply of energy to transformer ST and thus cuts off the supply of alternating current energy to the track rails, and also cuts off the supply of energy to the transformers ATT and BTT associated with the tubes AT and BT. Accordingly, energy is no longer supplied through the tubes to relays ATR and BTR and they release and interrupt the circuits which they control for supplying energy to the relays E and W. Before this occurs, however, energy is supplied to relays E and W over the circuits established by relay CR so the relays E and W remain picked up and maintain the circuits of the windings 30 and 31 of interlocking relay XR and thus prevent operation of the crossing signals at this time.

This system also operates to provide proper control of the crossing signals on movement of a train through the track stretch in the reverse of the normal direction.

When a train moving in the reverse direction enters section 5T it shunts the track rails so as to prevent the supply of coded direct current to the track relay 5TR and it remains released so that relay 5H releases. On release of relay 5H its contact 26 interrupts the circuit of relay CR so that it releases and interrupts the circuits which it controls for supplying energy to relays E and W. In addition, on release of relay CR its contact 35 establishes the circuit for supplying energy to the transformer ST so that energy from this transformer is supplied to the transformers ATT and BTT associated with tubes AT and BT, and is also supplied through transformer T and over the section rails to the grid transformers AGT and BGT to render the tubes conducting. Accordingly energy is supplied through the tubes to pick up relays ATR and BTR and they establish circuits for relays E and W and thus prevent operation of the crossing signals XS.

When the train advances beyond the joint 22 transformer BGT is shunted and tube BT is rendered non-conducting so that relay BTR releases and interrupts the circuit of relay W. Contact 61 of relay W, therefore, releases and interrupts the circuit of winding 31 of relay XR and contact 33 of relay XR releases and establishes the circuit of the crossing signals XS so that they operate to warn users of the highway of the approach of a train.

When the train advances beyond the joint 15 it shunts the transformer AGT so that tube AT is rendered non-conducting and relay ATR releases and causes release of relay E with resultant interruption of the circuit of the winding 30 of relay XR. The internal construction of relay XR is such, however, that contact 32 is prevented from moving to its released position at this time.

When the train vacates the portion of the track section between insulated joints 15 and 22 energy is again supplied to transformer BGT so that tube BT is rendered conducting and relay BTR is picked up and establishes the circuit of relay W. Accordingly contact 61 of relay W picks up and establishes the circuit of the winding 31 of relay XR so that contact 33 is picked up and discontinues operation of the crossing signals XS.

When the train vacates the portion of the track section between insulated joints 15 and 20 energy is again supplied to transformer AGT so that tube AT is rendered conducting and energy is supplied to relay ATR to pick up its contact and establish the circuit of relay E with the result that contact 60 of relay E establishes the circuit of the winding 30 of relay XR.

When the train vacates section 5T, the impulses of coded direct current supplied to the section rails feed to relay 5TR and operate it so that relay 5H is picked up to establish the circuit of relay CR and it picks up to establish circuits for the relays E and W and to discontinue operation of the auxiliary track circuit apparatus.

When the front of a train moving in the normal direction, or the rear of a train moving in the reverse direction, is at a point in the track section intermediate the insulated joints 15 and 22, alternating current from transformer T is prevented from reaching transformer BGT, but coded direct current supplied at the exit end of the section flows through the primary winding of transformer BGT and may cause impulses of energy to be induced in the secondary winding of the transformer and therefore cause impulses to be supplied to the grid of the tube BT. The transformer BGT and the other portions of the apparatus are proportioned so that the impulses of energy supplied to the tube grid as a result of the flow of the impulses of coded direct current through the primary winding of transformer BGT are of such value as to be ineffective to render the tube conducting. Accordingly the relay BTR is released under the conditions outlined.

The relay BTR may be of a type the contacts of which are slow to pick up, while the condenser

64 connected across the terminals of the relay winding renders the relay slow to pick up. The relay BTR and the associated condenser may be proportioned so that the relay will not pick up if supplied with impulses of energy at the frequency of the coded track circuit energy if the impulses of coded track circuit energy supplied through the transformer BGT should cause the tube BT to become conducting.

The coded track circuit current is of relatively low frequency, the highest code speed usually employed being 180 cycles a minute, or 3 cycles a second. The alternating current employed in the track circuit is of much higher frequency, such as 60 or 100 cycles a second, so there will be a great difference between the frequency of the supply of impulses of energy to relay BTR when the tube BT is rendered conducting by alternating current supplied to the transformer BGT and when the tube is rendered conducting by coded track circuit energy supplied through the transformer BGT. Accordingly, the relay BTR and the associated apparatus may be proportioned so that the relay will pick up when alternating current is supplied to transformer BGT, but to not pick up when coded track circuit energy is supplied to transformer BGT.

It will be seen that this crossing signal control system operates so that the traffic governing track circuit apparatus operates to prevent operation of the crossing signals as long as the track section is vacant, while the auxiliary track circuit apparatus is deenergized as long as the section is vacant. As soon as the track section is occupied the auxiliary track circuit apparatus is energized and control of the crossing signals is transferred to the auxiliary track circuit apparatus, while the auxiliary track circuit apparatus serves to prevent operation of the crossing signals until the train advances to within a selected distance from the crossing.

When a train moving in either direction enters an approach section for the crossing, the crossing signals are placed in operation, while the auxiliary track circuit apparatus operates to discontinue operation of the crossing signals as soon as the approach section is vacated. The crossing signals remain under the control of the auxiliary track circuit apparatus as long as the section is occupied, but as soon as the section is vacated the traffic governing track circuit apparatus assumes control of the crossing signals and discontinues operation of the auxiliary track circuit apparatus.

Since the auxiliary track circuit apparatus is normally deenergized and becomes energized only when the section is occupied, the wear on the electron tubes is reduced to a minimum and their life is correspondingly increased, while the energy consumed by the auxiliary track circuit apparatus is reduced to a minimum.

This system is arranged so that failure of the electron tubes or other portions of the auxiliary track circuit apparatus will not produce an objectionable failure of the crossing signals nor interfere with the proper functioning of the traffic governing signal apparatus.

If when a train moving in the normal direction of traffic enters the section the tube AT is defective and will not function, relay ATR will remain released and will not establish a circuit for relay E, and this relay will release and interrupt the circuit of the winding 30 of relay XR so that contact 32 releases and establishes the circuit of the crossing signals. Accordingly, operation of the crossing signals will be initiated as soon as the train enters section 5T instead of being delayed until the train advances beyond the insulated joint 20.

In addition when the tube AT is defective, operation of the crossing signals will not be discontinued when the train passes the joint 15. Instead the signals will continue to operate until the train vacates the track section. When this occurs the traffic governing track circuit apparatus functions in the normal manner and discontinues operation of the crossing signals and of the auxiliary track circuit apparatus.

Similarly, if the tube BT is defective operation of the crossing signals will be initiated as soon as the section is occupied and will be continued until the section is vacated.

If the tube failure is caused by short circuiting of the elements of the tube, the tube will cease to serve as a rectifier and alternating current will be supplied through the tube. The relay energized by current supplied through the tube is of the direct current type and its contacts will remain released on the supply of alternating current to the relay winding.

Failure of the tubes, therefore, will cause operation of the crossing signals to be initiated sooner and to be continued longer than usual. While this additional time of operation of the crossing signals may delay users of the highway, it will not create a hazardous condition, and the operation of the equipment is such that users of the highway are always provided with a warning of the approach of a train for at least the normal period.

In like manner failure of the line circuits connecting transformers ATT and BTT with the transformer T, or of the line circuits over which the relays ATR and BTR control the relays E and W, will result in prolonged operation of the crossing signals but will not cause a failure of the crossing signals to operate, and will not interfere with operation of the traffic governing signal apparatus. Failure of the line circuit over which relay 5H controls the relay CR, will result in continued operation of the auxiliary track circuit apparatus to control the crossing signals, while operation of the crossing signals will be started and stopped at the usual times, and operation of the traffic governing signals will not be affected.

The auxiliary track circuit apparatus is shown controlled by the traffic governing signal apparatus so as to be deenergized when the associated track section is vacant, and to be energized and control the crossing signals only when the section is occupied. This is the preferred arrangement, but it is contemplated that the relay CR may be omitted and the auxiliary track circuit apparatus be continuously energized and have complete control of the crossing signals.

The auxiliary track circuit apparatus is shown arranged to provide for control of the crossing signals on movement of trains in the reverse as well as in the normal direction of traffic. If control of the crossing signals on movement of trains in the reverse direction is not required, the tube BGT and associated apparatus such as transformers BTT and BGT, and relays BTR and W, may be omitted, and the auxiliary track circuit apparatus may be employed to detect occupancy only of the portion of the track section between insulated joints 20 and 15.

In the system shown in Fig. 1 the alternating current employed in the auxiliary track circuit apparatus is supplied from a commercial source

of current. If such a source is not available the alternating current may be supplied by a tuned alternator, and Fig. 2 illustrates such an arrangement.

Referring to Fig. 2 there is shown therein a tuned alternator TA which may be of any well known construction and which when supplied with direct current supplies alternating current of a suitable frequency, such as 60 or 100 cycles a second, to the transformer ST. The supply of direct current to the alternator TA is controlled by back contact 35 of relay CR so that the alternator is deenergized as long as the track section is vacant and is energized and causes alternating current to be supplied to the auxiliary track circuit apparatus as long as the section is occupied.

In the systems shown in Figs. 1 and 2 alternating current of the same frequency is supplied over the track rails to the grid transformers as is supplied to the tube anode circuits. If desired energy of different frequencies may be employed for these purposes, and Fig. 3 shows such a modification.

As shown in Fig. 3 energy is supplied from the transformer ST to the transformer T through a rectifier RX with the result that the frequency of the energy supplied from transformer T to the track rails is twice that supplied from transformer ST to the transformers ATT and BTT.

Accordingly, because of the higher frequency of the energy supplied to the tube grids, there will always be a time during each half cycle in which energy of positive polarity is supplied to the anode of a tube that the potential on the tube grid is such as to render the tube conducting. This will be true even though there is a considerable phase shift in the energy supplied over the track rails relative to the energy supplied to the tube anode circuits. The tube characteristics are such that once a tube becomes conducting it continues to be conducting regardless of changes in the grid potential as long as energy of proper potential and polarity is supplied to the tube anode circuit, so the use of the higher frequency energy in the track circuits will not substantially reduce the time during which a tube is conducting, and the relay which is energized by current supplied through the tube will be supplied with energy an adequate proportion of the time to keep its contacts picked up.

The impedance of the reactor 16 to flow of alternating current therethrough is proportional to the frequency of the alternating current, and if alternating current of relatively high frequency, such as is made possible by the use of the frequency doubling arrangement shown in Fig. 3, is employed in the track circuits, the reactor 16 may be proportioned so as to have little resistance to the coded direct current track while having high impedance to the alternating current track circuit energy so that a train on one side of the joint 15 will have little shunting effect with respect to alternating current supplied to the portion of the track section at the other side of the joint 15. This will insure prompt termination of operation of the crossing signals when a train passes beyond the joint 15, while it also permits the coded direct current track circuit energy to be readily supplied through the reactor so that the maximum length of track section over which the coded track circuit apparatus may be operated will not be substantially affected.

In the modifications shown in Figs. 1, 2 and 3, the transformer T is provided with two secondary windings one of which supplies energy to the portion of the track stretch at one side of the joint 15 and the other of which supplies energy to the portion of the track stretch at the other side of the joint 15. If desired energy may be supplied from the same secondary winding to the portions of the track stretch on both sides of the joint 15, and Fig. 4 shows such an arrangement.

Referring to Fig. 4, one end terminal of the secondary winding of transformer T is connected to track rail 1, while the other end terminal of this winding is connected through resistance 18 to the portion of rail 2 at the left of joint 15 and through resistance 19 to the portion of rail 2 at the right of joint 15. When a train is in the portion of the track stretch at either side of the joint 15, the supply of alternating current to the grid transformer on that side of the intersection is cut off, while the resistor included in the circuit for supplying energy from the transformer T to the track rails limits the current taken from the transformer and thus prevents excessive reduction in the value of the energy supplied from the transformer to the portion of the track section at the other side of the joint 15.

When a train is in the portion of the track section at one side of the joint 15 it exerts a shunting effect through resistors 18 and 19 on the portion of the section at the other side of the joint. The resistance of resistors 18 and 19 is so high, however, that the shunting effect exerted through them will not interfere with operation of the apparatus on the side of the joint opposite from the train.

In the modifications described above the secondary winding of the transformer T is connected across the section rails and a reactor is connected around the insulated joint 15 at the highway intersection to permit flow of direct current track circuit energy around the joint 15 while preventing flow of alternating current auxiliary track circuit energy between the portions of the track section on opposite sides of the joint 15 to thereby insure prompt cessation of operation of the crossing signals when the rear of a train passes over the insulated joint 15.

The need for the reactor can be eliminated by connecting the secondary winding of transformer T around the joint 15 as shown in Fig. 4A. In this modification the transformer T is proportioned so that its secondary winding has little resistance to flow of direct current, while a current limiting resistance 66 is connected in series with the primary winding of the transformer T to limit the energy supplied through the transformer T to the track rails.

The grid transformers AGT and BGT are shown connected in series with the track rail 2, but they may be connected across the rails 1 and 2 as shown in Fig. 9. A reactor 67 may be connected in series with the track relay 5TR to prevent flow of alternating current energy in the winding thereof, while an impedance of appropriate form, such as a resistance 68, is connected across the section rails intermediate the insulated joint 20 and the entrance end of the section to permit flow of alternating current between the track rails while substantially preventing flow of direct current between the section rails.

The supply of energy to the transformer ST may be governed by a relay CR as shown in Fig. 1,

so that energy is supplied to the transformer when and only when the associated track section is occupied.

When a train enters section 5T so that energy is supplied to the transformer ST, energy is supplied therefrom through the resistance 66 to the transformer T, while energy is supplied from the transformer T to the grid transformers AGT and BGT over the circuit which is traced from the left-hand terminal of the secondary winding of transformer T over rail 2, through the primary winding of transformer AGT, through wheels and axles of the vehicles forming the train to rail 1, over contact 10 of relay CTM to rail 2, and thence through the primary winding of transformer BGT to the right-hand terminal of the secondary winding of transformer T. Accordingly, each of the grid transformers supplies energy to the associated tube so that the auxiliary track circuit apparatus operates as explained in connection with Fig. 1 to prevent operation of the crossing signals.

When the train advances beyond joint 20, the shunt between the track rails provided by the train prevents flow of energy from transformer T through the primary winding of transformer AGT so the tube associated with transformer AGT ceases to be conducting and operation of the crossing signals is initiated. At this time energy from transformer T continues to be supplied through the primary winding of transformer BGT, but when the train advances beyond the joint 15 the supply of energy to transformer BGT is cut off and the relay associated with this transformer releases.

As soon as the rear of the train advances beyond the joint 15 energy from transformer T is supplied to transformer AGT over the circuit which is traced from the left-hand terminal of the secondary winding of transformer T over track rail 2, through primary winding of transformer AGT and resistor 68 to rail 1, and thence through the wheels and axles of the vehicles of the train to rail 2 and the right-hand terminal of the winding of transformer T. Accordingly, the tube associated with transformer T is rendered conducting and operation of the crossing signals is discontinued promptly when the rear of the train clears the intersection.

When the rear of the train passes over joint 22 energy from transformer T is again supplied to transformer BGT and the relay associated with this transformer picks up. When the train vacates the track section coded direct current supplied at the exit end of the section feeds to the track relay 5TR and operates it so that the supply of energy to transformer ST is cut off and the auxiliary track circuit apparatus ceases to function.

The equipment operates in a similar manner on movement of a train through the track stretch in the reverse direction.

In the modifications shown in Figs. 1 to 4 the coded direct current track circuit energy must be supplied through the reactor 16. This reactor will have some resistance to the coded direct current and will therefore reduce the maximum operable length of track circuit. This can be overcome by substituting for the reactor a circuit controlled by the auxiliary track circuit apparatus and shunting the joint 15, and Fig. 5 shows such an arrangement.

Referring to Fig. 5, a circuit shunting the joint 15 is established when the contacts of relays E and W are picked up. This circuit includes front contact 70 of relay E and front contact 71 of relay W. The equipment is otherwise the same as that shown in Fig. 1 except that the reactor 16 is omitted, while a transformer with a single secondary winding, as shown in Fig. 4, is employed to supply energy to the section rails. This type of transformer is necessary to prevent short circuiting of the transformer secondary by the shunt circuit which is at times established around the joint 15.

When the track stretch is vacant relays E and W are held picked up by energy supplied over front contacts of relay CR so contacts 70 and 71 establish the circuit shunting the joint 15 and coded track circuit energy may flow around joint 15 through the shunt circuit. The resistance of the shunt circuit may be extremely low so that there is little impedance to the flow of coded direct current track circuit energy over the section rails.

When a train enters the track section relay CR releases and establishes the circuit to supply energy to transformer ST so that the auxiliary track circuit apparatus functions as explained in connection with Fig. 1 to supply energy to relays E and W and keep them picked up although the circuits controlled by relay CR for supplying energy to these relays are interrupted.

When the train enters the approach section at the left of joint 15 relay E releases and its contact 60 interrupts the circuit of winding 30 of the interlocking relay XR to thereby initiate operation of the crossing signals, while contact 70 of relay E interrupts the shunt circuit around joint 15. Since the section is occupied at this time there is no need for the coded direct current to be supplied around joint 15 and interruption of the shunt circuit will not interfere with operation of the traffic governing signal system.

When the train advances beyond joint 15 relay W releases and its contact 71 additionally interrupts the shunt circuit around the joint 15. Accordingly, when the rear of the train passes beyond the joint 15 the train ceases to exert any shunting effect on the alternating current supplied to the portion of the track section at the left of joint 15, and the auxiliary track circuit apparatus associated with the portion of the track section at the left of joint 15 will function immediately after the rear of the train passes over joint 15, and relay E will pick up to discontinue operation of the crossing signals.

When the train advances farther in the track stretch relay W will be picked up, as explained in connection with Fig. 1, while on picking up of relay W its contact 71 completes the circuit shunting the joint 15. At this time, however, the train is so far removed from the joint 15 as to have little or no effect on energy supplied from transformer T to the section rails, and the relays E and W are maintained energized by the auxiliary track circuit apparatus.

When the train advances far enough to vacate the section 5T, coded direct current supplied to the track rails at the exit end of the section feeds over the track rails and through the shunt circuit established by front contacts 70 and 71 of relays E and W to the track relay and operates it so that the relay 5H is picked up and establishes the circuit of relay CR. Accordingly, the relay CR picks up and its contact 35 cuts off the supply of energy to transformer ST and thus discontinues operation of the auxiliary track circuit apparatus, while contacts 27 and 26 of relay CR establish circuits for the relays W and E so that their con-

tacts are maintained picked up to maintain the shunt circuit around the joint 15 and to prevent operation of the crossing signals.

The modification shown in Fig. 5, like that shown in Fig. 1, operates so that if on entrance of a train into the track section, one of the electron tubes is defective, or the auxiliary track circuit apparatus does not function for any other reason, operation of the crossing signals will be initiated as soon as the train enters the section instead of being deferred until the train advances to a predetermined point in the section. In addition, the equipment shown in Fig. 5 operates so that operation of the crossing signals will not be discontinued when the train passes the intersection if the auxiliary track circuit apparatus is not functioning properly.

When the equipment is arranged as shown in Fig. 5, if the auxiliary track circuit apparatus is defective, the circuit shunting the insulated joint 15 will not be established when the approach sections on opposite sides of the highway crossing are vacated. Accordingly, when the train vacates the track section, coded direct current energy supplied at the exit end of the section cannot feed to the track relay, and the associated relay 5H will remain released and will not establish the circuit of relay CR. As a result the relay E or W will remain released, the one depending on which part of the auxiliary track circuit apparatus is defective, and the crossing signals will continue to operate, while the signal at the entrance to section 5T will display its stop indication and energy of 75 code frequency will be supplied to the rails of the adjacent section in the rear to cause the signal for that section to display its caution indication.

The continued operation of the crossing signals and the continued display of a stop indication by the signal at the entrance to section 5T will provide an indication that the equipment is not functioning properly.

The failure of the equipment shown in Fig. 5 to resume normal operation when the section is vacated if the auxiliary track circuit apparatus is not functioning properly may be overcome by employing means to periodically establish a circuit shunting the joint 15, as shown in Fig. 6.

Referring to Fig. 6, a coding device 20CT is provided which has a contact 73 which when closed establishes a circuit shunting the joint 15. The contact 73 of the coder 20CT may be operated at any appropriate rate, such as 20 code frequency, which is substantially different than the rate of operation of the coders controlling the supply of traffic governing energy to the section rails. The coder 20CT may operate continuously, or it may be controlled as shown by contact 72 of relay CR so as to operate only when the section is occupied.

With the arrangement shown in Fig. 6 when a train passes through the section and the auxiliary track circuit apparatus is functioning properly, the relays E and W will be picked up and establish the shunt circuit around joint 15 when the section is vacated, as explained in connection with Fig. 5. If when the section is vacated one of the relays E or W remains released, the shunt circuit controlled by these relays will not be established, but contact 73 of coder 20CT will periodically establish a circuit shunting the joint 15. During the closed periods of contact 73 coded track circuit energy supplied at the exit end of the section will feed around the joint 15 over the circuit established by contact 73 to the track relay and operate it so that the associated code detecting relay 5H picks up to establish a circuit for relay CR. When CR picks up it establishes circuits for relays E and W and they pick up to discontinue operation of the crossing signals, and to establish the circuit which they control for shunting the joint 15.

With the arrangement shown in Fig. 6, when a train is in section 5T with the end of the train adjacent one side of the joint 15, during the closed periods of contact 73 of coder 20CT the train will exert shunting effect on the auxiliary track circuit energy supplied to the portion of the track section on the opposite side of the joint 15. The relays E and W may be of a type which are slow enough in releasing to remain picked up during the periods in which contact 73 is closed, and thus prevent momentary operation of the crossing signals.

In the modifications shown in Fig. 1 a relay ATR is energized through the tube AT and controls the supply of energy to a winding of relay E. It is possible, however, to energize the winding of relay E from the tube AT, and thus eliminate the relay ATR, and Fig. 7 illustrates such a modification.

The modification shown in Fig. 7 is the same as that shown in Fig. 1 except that the relay ATR and the transformer ATT have been eliminated and the anode circuit of tube AT has been connected to a winding of relay E, while the grid biasing resistor 44 is connected between the line wires 92 and 93. The condenser 55, employed in the system shown in Fig. 1, is connected across the terminals of the winding of relay E.

As long as the section is vacant relay E is held picked up by energy supplied over contact 28 of relay CR as explained in connection with Fig. 1. When a train enters the section relay CR releases and causes energy to be supplied to transformer ST so that energy is supplied over the track to transformer AGT to render the tube AT conducting, while energy is also supplied to the tube anode circuit. Accordingly, energy is supplied through the tube over the line wires 92 and 93 to a winding of relay E and serves to keep the contacts of relay E picked up.

The various parts of the equipment are arranged so that the energy supplied to the relay E through the tube AT is of the same relative polarity as the energy supplied to the relay E over the circuit controlled by contact 28 of relay CR so that the contacts of relay E will remain picked up on transfer of control of the relay from the principal to the auxiliary track circuit apparatus.

When a train enters the portion of the track section between insulated joints 15 and 20, energy is no longer supplied to transformer AGT and the tube AT ceases to be conducting and energy is no longer supplied to relay E and its contact releases to initiate operation of the crossing signals.

When the portion of the track section between insulated joints 15 and 20 is vacated, energy is again supplied to transformer AGT so that the tube AT is rendered conducting and energy from the transformer ATT is supplied through the tube AT to a winding of relay E to pick up its contact and discontinue operation of the crossing signals. When the track section is vacated relay CR is picked up and discontinues operation of the auxiliary track circuit apparatus and establishes a circuit to energize relay E.

The modification shown in Fig. 8 is similar to that shown in Fig. 7. In the sytem shown in Fig. 8 the transformer ATT is not employed and

the secondary winding of transformer ST is connected across the anode and cathode of tube AT through a current limiting resistor 95 and over line wires 96 and 98, while the grid biasing resistor 44 is connected between wires 96 and 98. A winding of relay E is connected across wires 96 and 98 on the side of resistor 95 remote from the transformer ST.

When relay CR is released so that energy is supplied to transformer ST, energy is supplied through transformer T to the track rails, and thus to transformer AGT to render the tube conducting. In addition, when energy is supplied to transformer ST, energy will be supplied from the transformer secondary winding through the resistor 95 to line wires 96 and 98, and therefrom to the winding of relay E.

During the half cycles in which the impulses of energy induced in the secondary winding of transformer ST are such that energy of positive polarity is supplied to wire 96, energy will be supplied through the tube AT, assuming that it is conducting, so that the transformer secondary is in effect short circuited through the tube, and the tube serves to divert energy from the winding of relay E. The resistor 95 serves to limit the supply of energy from the transformer ST and thus prevents overloading of the tube AT.

During the half cycles in which the impulses of energy induced in the secondary winding of transformer ST are such that energy of positive polarity is supplied to line wire 98, energy will not be supplied through the tube AT, and all of the energy supplied through resistor 95 will be supplied to the winding of relay E.

Accordingly, when the tube AT is conducting, the impulses of energy of one polarity supplied to the winding of relay E are of substantially lower value than those of the other polarity, and as a result there is a substantial direct current component in the energy supplied to the winding of relay E and is effective to maintain the contacts of the relay E picked up.

The various parts of the equipment are arranged so that the direct current component of the energy supplied from transformer ST to a winding of relay E is of the same relative polarity as the energy supplied to relay E over the circuit controlled by relay CR. This insures that the contacts of relay E will remain picked up when control of relay E is transferred from relay CR to the auxiliary track circuit apparatus.

When the portion of the track section between the insulated joints 20 and 15 is occupied energy is not supplied to transformer AGT and the tube AT ceases to be conducting. Under these conditions impulses of energy of the same value are supplied to the winding of relay E during both halves of the cycles of energy induced in the secondary winding of transformer ST. Accordingly, there is no direct current component in the energy supplied to the winding of relay E at this time and the contacts of the relay release and initiate operation of the crossing signals, while the winding of the relay may have high inductance to reduce the flow of alternating current therein.

When the portion of the track section between the joints 15 and 20 is vacated and the tube AT is again rendered conducting, the direct current component is again present in the energy supplied from transformer ST to the winding of relay E and its contact is picked up to discontinue operation of the crossing signals.

When the track section is vacated relay CR is picked up and its contact 35 interrupts the circuit of transformer ST to thereby prevent operation of the auxiliary track circuit apparatus, while relay E is maintained picked up by energy supplied over front contact 23 of relay CR.

The modifications shown in Figs. 7 and 8 have been illustrated and described in connection with the circuits associated with the tube AT, but it is to be understood that these modifications are equally applicable to the circuits associated with the tube BT.

In the modifications already described the primary windings of the grid transformers AGT and BGT have been connected in series with the track rail 2 so that coded direct current track circuit energy must be supplied through these windings. While the transformers AGT and BGT may be provided with primary windings having low resistance to the coded direct current track circuit energy, these windings will have some resistance to such energy, and will reduce somewhat the maximum length of track section over which the coded track circuit can be operated. The series connection of the grid transformers is not essential, and these transformers may be connected across the rails as shown in Fig. 9.

Referring to Fig. 9 the transformer AGT has one terminal of its primary winding connected to one track rail and has the other terminal of its primary winding connected to the other track rail through a resistor 100 which serves to limit flow of coded direct current track circuit energy through the transformer primary winding.

The transformer AGT is located at a point in the track stretch far enough in the rear of the highway crossing so that if operation of the crossing signals is initiated when a train advances beyond the transformer, the crossing signals will be operated for at least a predetermined interval before the train reaches the intersection.

The equipment at the intersection as well as the equipment associated with transformer AGT may be arranged as shown in any of the modifications previously described.

In operation, when a train enters the section so that alternating current is supplied to the section rails at the intersection, this energy is supplied to the primary winding of transformer AGT with the result that energy is supplied from the transformer secondary winding to the grid of the associated tube to render it conducting and thus prevent operation of the crossing signals. When the train advances beyond the transformer AGT the supply of alternating current to the transformer is cut off and the tube associated with transformer AGT ceases to be conducting and operation of the crossing signals is initiated and is continued until the train vacates the portion of the track section between transformer AGT and the intersection.

In addition, when a train is present in the track section and is approaching the transformer AGT, it shunts alternating current from the transformer and thus reduces the value of the energy supplied from the transformer AGT to the grid of the associated tube. The shunting effect of the train on the transformer AGT gradually increases as the train approaches the transformer and before the train reaches the transformer, may cause the energy supplied to the grid of the associated tube to be reduced to a value ineffective to maintain conductivity of the tube. As a result operation of the crossing signals will be initiated before the train reaches the transform-

er, and the signals will be operated for somewhat longer than the minimum period prior to arrival of the train at the intersection. The shunting effect of the train on the transformer AGT will vary somewhat with ballast conditions, so the point to which the train must advance before operation of the crossing signals is initiated will vary with changes in ballast conditions. However, as operation of the crossing signals is always initiated when the train advances beyond the transformer AGT, and as this provides for the minimum period of operation of the signals, the system is entirely safe and any variation in the period of operation of the signals is in excess of the minimum period.

If preferred as shown in Fig. 9A a condenser 101 may be substituted for the resistor 100 in the circuit of the primary winding of the transformer AGT. The condenser 101 operates to permit alternating current auxiliary track circuit energy to be supplied to the transformer AGT, while preventing flow of the coded direct current signal control energy to this transformer.

The transformer AGT may be inductively coupled with the track rails. As shown in Fig. 10 a loop 102 consisting of a plurality of turns of wire is mounted between the track rails with portions of the loop adjacent the rails 1 and 2. The ends of the loop are connected to the terminals of the primary winding of the transformer AGT.

When alternating current is supplied to rails 1 and 2 at the intersection, and the portion of the track section between the loop and the intersection is vacant, alternating current flows in the portion of the rails 1 and 2 adjacent the loop 102 and induces energy in the loop from which it is supplied to the primary winding of transformer AGT, so that energy is supplied from the secondary winding of transformer AGT to the grid of the associated tube and causes the tube to be conducting.

When the portion of the track section between the loop and the intersection is occupied, alternating current no longer flows in the portion of the rails 1 and 2 adjacent the loop 102, and energy is no longer supplied from the loop through transformer AGT to the tube grid and the tube becomes non-conducting.

The modification shown in Fig. 10, like that shown in Fig. 1, operates so that the crossing signals are not started until the train advances beyond a predetermined point in the track section.

The modification shown in Fig. 10 results in no impedance whatever to the supply of coded direct current energy over the track rails and consequently does not affect the length of track circuit which can be operated.

This crossing signal control system is adapted for use where there are two highway crossings relatively close together so that the approach sections for the crossing signals overlap, while the system is also adapted for use where a crossing is adjacent an end of a track section so that an approach section for the signal for that crossing extends into the adjacent track section, and Fig. 11 is a diagram illustrating these modifications.

Fig. 11 consists of Figs. 11A and 11B which when placed together with Fig. 11B at the right, is a diagram of a stretch of railway track over which traffic normally moves in the direction indicated by the arrow, that is from left to right. The rails 1 and 2 of the track stretch are divided by insulated joints 3 into track sections for signaling purposes. Two track sections are shown, and are designated 7T and 8T.

Each track section has at the entrance end thereof a wayside signal, designated S with an appropriate prefix, while each track section is provided with coded track circuit apparatus for controlling the signal for the section, and for also controlling the supply of coded energy to the rails of the adjacent section in the rear. The coded track circuit apparatus employed in sections 7T and 8T is similar to that employed in the system shown in Fig. 1 and a detailed description of the track circuit apparatus is unnecessary.

The track circuit apparatus for section 7T includes coded feed-back equipment for indicating at the exit end of the section whether or not the section is occupied. The coded feed-back equipment may be arranged in any manner well known in the art, and has been shown arranged as shown in Letters Patent of the United States No. 2,286,002 to Frank H. Nicholson.

The track stretch includes intersections with highways H1 and H2. The intersection with highway H1 is located in section 7T, while the intersection with highway H2 is located in section 8T at a point adjacent the entrance end of the section so that on movement of a train in the normal direction through the track stretch it is necessary to start operation of the crossing signals XS2 for the intersection H2 before the train enters section 8T.

The crossings H1 and H2 are located so close together that the approach sections for the signals for the two crossings overlap. It is necessary on movement of a train in the normal direction through the track stretch to initiate operation of the crossing signals XS2 before the train advances to the point in the track stretch at which it is necessary to initiate operation of the crossing signals XS1 on movement of a train through the track stretch in the reverse direction.

Alternating current of one frequency, such as 60 cycles per second, is employed in the auxiliary track circuit apparatus for the control of the crossing signals XS1, and alternating current of a different frequency, such as 100 cycles per second, is employed in the auxiliary track circuit apparatus for the control of the crossing signals XS2, while filters of well known design are provided at appropriate points to prevent interference between the two sets of auxiliary track circuit apparatus.

The construction of the filters is not a part of this invention, and to simplify the disclosure these have been shown diagrammatically in the drawings.

The same reference characters are employed in Fig. 11 to identify the various elements of the auxiliary track circuit apparatus as are employed in Fig. 1, while in Fig. 11 the reference characters for the auxiliary track circuit apparatus for the control of signals XS1 are preceded by the prefix 1, and those for the apparatus for signals XS2 are preceded by the prefix 2.

The equipment is shown in the condition which it assumes when the track stretch is vacant. At this time energy of 180 code frequency is supplied to coding relay 8CTM so that it supplies energy of this code frequency to the rails of section 8T and this energy feeds to track relay 8TR and operates it with the result that energy is supplied through the decoding transformer 8DT to relays 8H and 8J. As relays 8H and 8J are both picked up signal 8S displays its green or clear

indication, and as relay 8H is picked up energy of 180 code frequency is supplied to coding relay 7CTM.

During the picked-up periods of the contact 10 of relay 7CTM master code energy is supplied from track battery 7TB to the track rails through the winding of relay K. This energy moves the contact of relay K to one position, while when contact 10 of relay 7CTM is released it connects the relay K across the section rails so that impulses of feed-back energy supplied at the entrance end of the section feed to the winding of relay K and move its contact to its other position. As a result of movement of the contact of relay K between its two positions energy is supplied through the associated decoding transformer and rectifier to the relay KH and keeps its contact 105 picked up so that energy is supplied over the circuit including front contact 26 of relay 8H to relay 2CR and it is picked up to prevent operation of the crossing signals XS2 and of the auxiliary track circuit apparatus for controlling those signals.

The master code energy supplied to section 7T feeds to the track relay 7TR and operates it so that relays 7H and 7J are picked up to cause signal 7S to display its green or clear indication, while each time relay 7TR releases the relay 7IR operates in the usual manner to supply an impulse of feed-back energy to the section rails.

As relay 7H is picked up its contact 26 establishes the circuit of relay 1CR so that it is picked up to prevent operation of the crossing signals XS1 and of the auxiliary track circuit apparatus for controlling those signals.

When a train moving in the normal direction of traffic enters section 7T the track relay 7TR ceases to follow code so relays 7H and 7J release and cause signal 7S to display its stop indication, while relay 1CR releases and establishes the circuit of the associated alternator 1TA so that the auxiliary track circuit apparatus associated with the crossing H1 operates as explained in connection with Fig. 1 to maintain the relays 1E and 1W energized and thus prevent operation of the crossing signals XS1 on release of relay 1CR.

In addition, on entrance of the train into section 7T the supply of impulses of feed-back energy over the section rails is cut off and relay K ceases to follow code so energy is no longer supplied through the associated decoding transformer to relay KH and its contact 105 releases and interrupts the circuit of relay 2CR. Accordingly, relay 2CR releases and its contact 35 establishes the circuit of the associated alternator 2TA so that the auxiliary track circuit apparatus associated with crossing H2 operates as explained in connection with Fig. 1 to maintain the relays 2E and 2W energized and thus prevent operation of the crossing signals XS2 on release of relay 2CR.

The alternator 1TA supplies energy of a frequency of 60 cycles per second, while the transformer 1T is connected to the portion of the track rails of section 7T at the right of the crossing H1 through a filter, the elements of which are proportioned to freely permit flow of energy of a frequency of 60 cycles a second therethrough, but so as to substantially prevent flow of energy of a different frequency, such as 100 cycles a second. Similarly, the primary winding of the grid transformer 1BGT is connected across the rails of section 7T through a filter proportioned to permit flow of energy of 60 cycles a second and to substantially prevent flow of energy of 100 cycles.

Connection is established around the insulated joints 3 separating the rails of sections 7T and 8T through a suitable filter arranged to pass alternating current of a frequency of 100 cycles a second and to prevent flow therethrough of energy of a frequency of 60 cycles, while the primary winding of transformer 2AGT is connected across the rails of section 7T through a filter arranged to permit flow of energy of 100 cycles, and to prevent flow of energy of 60 cycles.

Accordingly, energy may be supplied from transformer 1T to the rails of section 7T and therefrom to the transformer 1BGT to control the tube 1BT, while 60 cycle energy supplied to the rails of section 7T is prevented from flowing to transformer 2AGT, and is also prevented from flowing to the rails of section 8T. Similarly, energy of 100 cycle frequency supplied by transformer 2T to the rails of section 8T feeds through the filter to the rails of section 7T, from which it is supplied to the primary winding of transformer 2AGT to control the tube 2AT, but is prevented from flowing to the transformers 1BGT and 1T.

The reactor 16 at the crossing H1 prevents energy of 100 cycle frequency supplied to the rails of section 7T at the exit end of the section from flowing to the portion of section 7T at the left of the crossing H1.

It will be seen, therefore, that when a train enters section 7T, the tube 1BGT is controlled by energy supplied from transformer 1T, while the tube 2AGT is controlled by energy supplied from transformer 2T, and that even though the portions of section 7T over which the tubes 1BT and 2AT are controlled overlap for a substantial distance there is no interference between the controls for the two tubes.

At this time the coded track circuit apparatus for section 8T is unaffected and it continues to function in the normal manner, while relay 7CTM continues to supply coded direct current energy of 180 code frequency to the rails of section 7T. The filter through which energy of 100 cycle frequency is supplied from the rails of section 8T to the rails of section 7T is of such construction that impulses of coded direct current supplied to the rails of section 7T will not be supplied through the filter to the rails of section 8T. Furthermore, this filter is connected to the rails of sections 7T and 8T through resistors 108 and 109 which are of such high resistance that even if the filter is defective, so that direct current may be supplied through the filter too little energy will be supplied through the resistors 108 and 109 from section 7T to section 8T to operate the track relay 8TR.

When the train under consideration advances beyond transformer 1AGT the tube 1AT ceases to be conducting and relay 1ATR releases and interrupts the circuit of relay 1E to thereby initiate operation of the crossing signals XS1. When the train advances beyond the crossing H1 tube 1BT ceases to be conducting and relay 1BTR releases and causes release of relay 1W.

When the train advances beyond transformer 2AGT the tube 2AT ceases to be conducting and relay 2ATR releases to initiate operation of the crossing signals XS2, while when the rear of the train clears joint 15 at crossing H1, energy is again supplied to transformer 1AGT and tube 1AT is rendered conducting so that relay 1ATR

picks up and discontinues operation of the crossing signals XS1.

When the train advances into section 8T relay 8TR is shunted and ceases to follow code so relays 8H and 8J release and cause signal 8S to display its stop indication, while the energy supplied to section 7T is changed from 180 to 75 code frequency. In addition, on release of relay 8H its contact 26 additionally interrupts the circuit of relay 2CR to insure that the crossing signals XS2 will be under the control of the auxiliary track circuit apparatus as long as section 8T is occupied.

When the train advances beyond the crossing H2 tube 2BT is rendered non-conducting and relay 2BTR releases.

When the train vacates section 7T coded direct current energy supplied at the exit end of the section feeds over the section rails to the track relay 7TR and operates it so that relay 7H is picked up, while feed-back energy is supplied to the section rails to operate relay K to pick up relay KH.

When relay 7H picks up it causes signal 7S to display its caution indication, while its contact 26 establishes the circuit of relay 1CR so that it picks up and establishes circuits for relays 1E and 1W and thus prevents operation of the crossing signals XS1. In addition, on picking up of relay 1CR the supply of energy to alternator 1TA is interrupted so that operation of the auxiliary track circuit apparatus associated with crossing H1 is discontinued.

When the rear of the train clears the insulated joint 15 at crossing H2, energy from transformer 2T again feeds to transformer 2AGT so that tube 2AT is rendered conducting and relay 2ATR is picked up and discontinues operation of the crossing signals XS2.

When the rear of the train passes beyond the transformer 2BGT the tube 2BT is rendered conducting and relay 2BTR is picked up.

When the train vacates section 8T coded direct current energy supplied at the exit end of the section feeds to track relay 8TR and operates it so that energy is supplied through the decoding transformer 8DT to pick up relay 8H. When relay 8H picks up its contact 26 completes the circuit of relay 2CR, assuming that section 7T is vacant so that relay KH is picked up, and on picking up of relay 2CR its contacts 27 and 28 establish circuits for relays 2E and 2W to maintain them picked up and thus prevent operation of the crossing signals XS2, while contact 35 of relay 2CR interrupts the circuit of alternator 2TA and thus discontinues operation of the auxiliary track circuit apparatus associated with crossing H2.

In addition, on picking up of relay 8H signal 8S is caused to display its caution indication, while the energy supplied to section 7T is changed from 75 to 180 code frequency so that signal 7S displays its clear indication.

If while the train under consideration is in section 8T, a second or following train enters section 7T, relay 7H will release and cause release of relay 1CR to cause operation of the auxiliary track circuit apparatus associated with crossing H1 and to place the crossing signals XS1 under the control of that apparatus.

In addition, presence of the second or following train in section 7T will cause relay KH to be released so that when the first train vacates section 8T and relay 8H picks up, the circuit of relay 2CR will not be established and it will remain released to continue operation of the auxiliary track circuit apparatus associated with crossing H2 and to continue control of the crossing signals XS2 by that apparatus.

Accordingly, as the second train proceeds through the track stretch the crossing signals XS1 and XS2 will be operated to warn users of the highways H1 and H2 of the approach of the train, while operation of the crossing signals for each intersection will be discontinued as soon as the train clears the intersection.

The modification shown in Fig. 11 also operates to provide proper control of the crossing signals in the event a train passes through the track stretch in the reverse of the normal direction.

When a train moving in the reverse direction enters section 8T the track relay 8TR ceases to follow code and relay 8H releases and causes release of relay 2CR so that the auxiliary track circuit apparatus associated with crossing H2 is placed in operation and the crossing signals XS2 are placed under the control of this apparatus to thereby prevent operation of the crossing signals XS2 until the train advances a predetermined distance towards the crossing H2.

When the train enters section 8T and relay 8H releases the coded energy supplied to section 7T is changed from 180 to 75 code frequency, but relay 7H remains picked up and maintains the circuit of relay 1CR to thereby prevent operation of the crossing signals XS1 and of the auxiliary track circuit apparatus associated with crossing H1.

When the train advances beyond transformer 2BGT the tube 2BT ceases to be conducting and relay 2BTR releases to initiate operation of the crossing signals XS2. When the train enters the portion of section 8T at the left of the insulated joint 15 tube 2AT ceases to be conducting and relay 2ATR releases.

When the train enters section 7T relay 7H releases and interrupts the circuit of relay 1CR to thereby initiate operation of the auxiliary track circuit apparatus associated with crossing H1 and prevent operation of the crossing signals H1. At this time the supply of feed-back energy over the rails of section 7T is cut off and relay KH releases so that its contact 105 additionally interrupts the circuit of relay 2CR.

When the train advances beyond transformer 1BGT the tube 1BT ceases to be conducting and relay 1BTR releases and initiates operation of the crossing signals XS1, while when the train enters the portion of section 7T at the left of joint 15 relay 1ATR releases.

When the rear of the train vacates the portion of section 8T at the right of insulated joint 15 energy is again supplied from transformer 2T to transformer 2BGT so that tube 2BT is rendered conducting and energy is supplied through the tube to pick up relay 2BTR and distinue operation of the crossing signals XS2.

When the train vacates section 8T coded energy supplied at the exit end of the section feeds to track relay 8TR and operates it so that relays 8H and 8J are picked up. On picking up of relay 8H the relay 2CR remains released as its circuit is interrupted by contact 105 of relay KH. Accordingly, the auxiliary track circuit apparatus associated with crossing H2 continues to operate and to control the crossing signals XS2.

When the rear of the train passes beyond transformer 2AGT energy from transformer 2T again feeds to transformer 2AGT and the tube

2AT is rendered conducting so that energy is supplied through the tube to relay 2ATR and its contact picks up.

When the rear of the train clears joint 15 at crossing H1 energy from transformer 1T is supplied to transformer 1BGT and the tube 1BT is rendered conducting so that energy is supplied through the tube to pick up relay 1BTR and discontinue operation of the crossing signals XS1.

When the rear of the train passes beyond transformer 1AGT energy is supplied to this transformer and the tube 1AT is rendered conducting so that relay 1ATR picks up.

When the train vacates section 7T coded energy supplied at the exit end of the section feeds over the section rails to track relay 7TR and operates it so that relays 7H and 7J are picked up, while feed-back energy is supplied over the section rails to operate relay K and pick up relay KH.

When relay 7H picks up it establishes the circuit of relay 1CR so that it picks up to discontinue operation of the auxiliary track circuit apparatus associated with crossing H1 and to establish circuits for relays 1E and 1W and thus prevent operation of the crossing signals XS1. Similarly, when relay KH picks up it establishes the circuit of relay 2CR so that it picks up to discontinue operation of the auxiliary track circuit apparatus associated with crossing H2 and to establish circuits for relays 2E and 2W to prevent operation of the crossing signals XS2.

This crossing signal control system is also applicable to track sections in which coded alternating current energy is employed in the track circuits and Fig. 12 is a diagram illustrating such a modification.

The system shown in Fig. 12 is similar to that shown in Fig. 1, but differs therefrom in that coded alternating current energy is employed in the track circuit. This energy is supplied by a track transformer 5TT from a suitable source, not shown, the terminals of which are designated BX and CX. This energy may be of any appropriate frequency, such as 60 cycles a second, and cab signal apparatus on locomotives operated in the track stretch may be constructed so as to respond only to energy of this frequency.

The secondary winding of the track transformer 5TT is connected across the section rails through a reactor 110 which limits the supply of energy to the track rails, while the primary winding of the track transformer is controlled by contact 10 of the coding relay 5CTM which is governed by traffic conditions in advance.

The track relay 5TR is shown as being of the direct current type and is connected across the section rails through a transformer and a rectifier.

A condenser 112 is connected in series with the reactor 16 which is connected around the joint 15 at the crossing. The condenser and reactor are proportioned so as to permit free flow of energy of 60 cycle frequency around the joint 15 and to substantially prevent flow of energy of 100 cycle frequency around the joint.

The equipment is shown in the condition which it assumes when the track stretch is vacant. At this time coded alternating current energy supplied at the exit end of the section feeds over the track rails and through the condenser 112 and reactor 16 to the track relay 5TR and operates it so that energy is supplied through the decoding transformer 5DT to relay 5H. The energy supplied from the transformer secondary winding to relay 5H is rectified by a contact of relay 5TR as explained in Letters Patent of the United States No. 2,237,788 to Frank H. Nicholson and Leslie R. Allison.

The filter included in the connection between the transformer BGT and the section rails prevents the supply of 60 cycle track circuit energy to this transformer. A filter is not required in the circuit of the transformer AGT since 60 cycle track circuit energy supplied to this transformer will not interfere with operation of the auxiliary track circuit apparatus.

As relay 5H is picked up its contact 26 establishes the circuit of relay CR so that its contacts are picked up to establish circuits for relays E and W and thus prevent operation of the crossing signals XS, and to interrupt the circuit of the alternator TA and thus prevent operation of the auxiliary track circuit apparatus.

When a train moving in the normal direction of traffic enters the section the track relay 5TR ceases to follow code and relay 5H releases and interrupts the circuit of relay CR so that it transfers control of the relays E and W to the auxiliary track circuit apparatus, while it establishes the circuit of the alternator TA so that the auxiliary track circuit apparatus functions and relays ATR and BTR are picked up and establish circuits for relays E and W and thus prevent operation of the crossing signals XS.

When the train enters section 5T, the locomotive cab signal apparatus responds to the coded 60 cycle energy in the track rails to provide an appropriate indication of traffic conditions. The locomotive cab signal apparatus is unaffected by 100 cycle energy supplied to the track rails to operate the auxiliary track circuit apparatus, since the cab signal apparatus is proportioned to respond only to energy of 60 cycle frequency. Furthermore, the 100 cycle energy for the auxiliary track circuit apparatus is not coded, and therefore will not operate the cab signal equipment which will respond only to coded energy. In addition, the 100 cycle auxiliary track circuit apparatus is of very small value so it will not interfere with the 60 cycle cab signal equipment.

At this time energy of both 60 and 100 cycle frequency is supplied to transformer AGT, but the difference between the two frequencies is such that there are frequently recurring periods in which the tube AT is rendered conducting, and enough energy is supplied through the tube to keep the contacts of relay ATR picked up.

When the train advances beyond transformer AGT energy ceases to be supplied to this transformer and tube AT ceases to be conducting so that relay ATR releases and initiates operation of the crossing signals.

When the train advances beyond the joint 15 the supply of energy from the transformer T to the transformer BGT is cut off and the tube BT ceases to be conducting and relay BTR releases.

When the train vacates the portion of the track section at the left of joint 15, energy from the transformer T feeds to the transformer AGT so that tube AT becomes conducting and relay ATR picks up to discontinue operation of the crossing signals XS.

The reactor 16 and condenser 112 prevent the train from exerting substantial shunting effect on the 100 cycle energy supplied to the portion of the track at the left of joint 15 so that operation of the crossing signals is discontinued promptly when the train clears the intersection.

When the train vacates the portion of the track section at the left of the joint 15, energy from the transformer T will feed to the transformer associated with the track relay. The value of this energy is such that it is ineffective to operate the track relay. If it is found that too much of the 100 cycle auxiliary track circuit energy feeds through the primary winding of the transformer for the track relay, so that insufficient energy is supplied to transformer AGT to properly control the tube AT, a filter may be included in the connection between the track relay transformer and the track rails to prevent flow of 100 cycle energy to the transformer while permitting flow of 60 cycle energy thereto.

When the rear of the train passes beyond transformer BGT energy is again supplied thereto and the tube BT becomes conducting so that relay BTR picks up.

When the train vacates the section coded 60 cycle energy supplied at the exit end of the section feeds to the entrance end of the section and operates the track relay 5TR so that relay 5H picks up and establishes the circuit of relay CR. Accordingly, relay CR picks up and interrupts the circuit of the alternator TA to thereby discontinue operation of the auxiliary track circuit apparatus, while relay CR establishes circuits for relays E and W to prevent operation of the crossing signals.

The equipment operates in a similar manner on movement of a train through the track stretch in the reverse direction.

This crossing signal control system is also applicable to track stretches in which the track sections are provided with track circuit apparatus operated by coded direct current, and on which is superimposed coded alternating current for operation of locomotive cab signal apparatus, and Fig. 13 is a diagram showing such a modification.

The system shown in Fig. 13 is similar to that shown in Fig. 12, but differs therefrom in that direct current is employed to operate the track relay, while coded alternating current cab signal energy is supplied to the section rails only when the section is occupied.

The cab signal energy is supplied from a suitable source of energy of appropriate frequency, such as 60 cycles, and is supplied to the track through a track transformer 5T the secondary winding of which is connected in series with the track battery 5TB. The circuit of the primary winding of the track transformer is controlled by contact 116 of an approach relay 5AR. This contact when picked up short circuits the transformer primary winding to reduce the impedance of the secondary winding, and when released establishes the circuit to supply alternating current to the transformer.

A reactor 16 is connected around the joint 15 at the crossing and is proportioned to permit coded direct current to freely flow around the joint 15, but to substantially prevent flow of alternating current of either 60 or 100 cycle frequency around the joint 15.

A reactor 16A and a condenser 112 are connected in series around the joint 15, and are proportioned to freely pass energy of 60 cycle frequency and to substantially prevent flow of energy of 100 cycle frequency.

A stick relay SR is located at the crossing and when picked up its contact 120 establishes a shunt circuit around the joint 15. The relay SR is controlled by the relays E and W so that

the pick-up circuit for relay SR is established only when relays E and W are both picked up, and so that the stick circuits for relay SR are interrupted only when relays E and W are both released.

The equipment is shown in the condition which it assumes when the track section is vacant. At this time relay 5CTM is operated at a rate determined by traffic conditions in advance and causes coded energy to be supplied from the track battery 5TB to the section rails. This energy feeds over the section rails and through the shunt circuit including front contact 120 of relay SR to the track relay 5TR and operates it so that energy is supplied through the decoding transformer 5DT to relay 5H.

As relay 5H is picked up its contact 26 establishes the circuit of relay CR with the result that its contacts are picked up and its contact 115 establishes the circuit of relay 5AR and thus prevents the supply of alternating current to transformer 5TT.

In addition, as relay CR is picked up its contacts 27 and 28 establish circuits for relays E and W so that they are picked up to prevent operation of the crossing signals XS, while contact 35 of relay CR interrupts the circuit of the alternator TA and thus prevents operation of the auxiliary track circuit apparatus.

As relays E and W are both picked up energy is supplied to relay SR over its pick-up circuit which includes front contact 121 of relay E and front contact 122 of relay W, while energy is also supplied to relay SR over its stick circuits which include its own front contact 124 and either front contact 125 of relay E or front contact 126 of relay W. Accordingly, relay SR is energized and its contact 120 establishes the circuit shunting the joint 15.

When a train moving in the normal direction of traffic enters section 5T the relay 5TR ceases to follow code and relay 5H releases and interrupts the circuit of relay CR so that it releases and its contact 115 interrupts the circuit of relay 5AR. Accordingly, relay 5AR releases and establishes the circuit to supply energy to track transformer 5TT so that coded alternating current as well as coded direct current is supplied to the section rails.

On release of relay CR its contact 35 establishes the circuit of the alternator TA and thus causes operation of the auxiliary track circuit apparatus so that relays ATR and BTR are picked up and establish circuits to maintain relays E and W picked up to thereby prevent operation of the crossing signals, and to also maintain the supply of energy to relay SR so that it maintains the circuit shunting the joint 15.

As relay SR maintains the circuit shunting the joint 15, coded alternating current cab signal control energy supplied at the exit end of the section may flow freely to the portion of the track rails at the left of the joint 15, and ample energy will be present in this portion of the section rails to insure reliable operation of the cab signal apparatus on the locomotive present in the track section.

When the train advances beyond the transformer AGT the supply of energy to this transformer is cut off and tube AT ceases to be conducting and relay ATR releases and interrupts the circuit of relay E to thereby initiate operation of the crossing signals XS.

On release of relay E its contact 121 interrupts the pick-up circuit of relay SR, while its contact

125 interrupts one stick circuit for the relay SR. However, at this time relay SR is maintained picked up by energy supplied over the stick circuit established by front contact 126 of relay W. Accordingly, relay SR maintains the circuit shunting the joint 15 so that cab signal control energy is freely supplied to the portion of the track section at the left of the joint 15.

As the train approaches the intersection it exerts gradually increasing shunting effect through the circuit shunting joint 15 on the 100 cycle auxiliary track circuit energy supplied to the portion of the track section at the right of joint 15. As a result the energy supplied to the transformer BGT will be reduced to a value ineffective to maintain conductivity of the tube BT before the train reaches the joint 15, and the relay BTR will release and interrupt the circuit of relay W.

On release of relay W its contact 126 interrupts the stick circuit for relay SR and relay SR releases and additionally interrupts its own stick circuit, while its contact 120 interrupts the circuit shunting the joint 15. On this interruption of the circuit shunting the joint 15, alternating current cab signal control energy is supplied to the portion of the track section at the left of joint 15 through the resonant circuit provided by condenser 112 and reactor 16A. This circuit will have somewhat greater impedance than the shunt circuit provided by contact 120 of relay SR so there will be some reduction in the value of the cab signal control energy supplied to the portion of the section rails at the left of the joint 15.

However, the joint 15 is located at an intermediate point in the track section and the total cab signal energy present in this portion of the track section is substantially greater than that present at the entrance end of the section even when the circuit shunting the joint 15 is established. The value of the cab signal energy supplied to the track rails must be high enough to operate the locomotive cab signal equipment when the locomotive first enters the section, and the value of this energy will be such as to operate the cab signal equipment when the locomotive approaches the intersection even though at that time the value of the cab signal energy is reduced somewhat due to release of relay SR and interruption of the circuit shunting the joint 15.

On release of relay SR and resultant interruption of the circuit shunting the joint 15, the shunting effect of the train on the 100 cycle auxiliary track circuit energy supplied to the portion of the track section at the right of the joint 15 is reduced, and sufficient energy will again be supplied to the transformer BGT to render the tube BT conducting and relay BTR will pick up and establish the circuit of relay W.

On this picking up of relay W the crossing signals XS continue to operate since relay E is released while relay SR remains released since its own contact 124 interrupts the relay stick circuit, and the pick-up circuit of the relay is interrupted by contact 121 of relay E. Accordingly, once relay SR is released it will remain released until relays E and W both are picked up. The control of relay SR, therefore, is such as to eliminate "pumping" or continued releasing and picking up of the relay which would occur if a train should stop before passing the intersection.

When the train under consideration advances beyond the joint 15 the transformer BGT is shunted and tube BT cease sto be conducting so relay BTR releases and interrupts the circuit of relay W.

When the train vacates the portion of the track section at the left of joint 15, auxiliary track circuit energy feeds to transformer AGT and energy is supplied through the tube AT to relay ATR and it picks up and establishes the circuit of relay E to thereby discontinue operation of the crossing signals XS.

When the rear of the train advances beyond the transformer BGT the tube BT is rendered conducting and relay BTR picks up and establishes the circuit of relay W. When relay W picks up and relay E is picked up, the pick-up circuit for relay SR is complete and it picks up so that its contact 129 establishes the circuit shunting the insulated joint 15, while its contact 124 establishes the relay stick circuits.

When the train vacates the track section coded direct current energy supplied at the exit end of the section feeds over the section rails and through the shunt circuit around joint 15 to the track relay 5TR and operates it so that relay 5H picks up. When relay 5H picks up its contact 25 establishes the circuit of relay CR so that relay CR picks up to cut off the supply of energy to the alternator TA and thereby discontinue operation of the auxiliary track circuit apparatus, while relay CR also establishes circuits for the relays E and W so that they remain picked up to prevent operation of the crossing signals and to maintain the supply of energy to relay SR so that it maintains the circuit shunting the joint 15.

In addition, on picking up of the relay CR its contact 115 establishes the circuit of relay 5AR so that its contact 116 picks up and cuts off the supply of energy to the track transformer 5TT.

If on movement of a train through the track section, a portion of the auxiliary track circuit apparatus is defective, one or both of the relays E and W will remain released when the train vacates the section, and the relay SR therefore will remain released and will not establish the circuit shunting the joint 15. The reactor 16 provides a circuit around the joint 15 through which coded direct current may flow to operate the track relay 5TR and thereby cause relay 5H to be picked up and establish the circuit of relay CR to discontinue operation of the crossing signals and of the auxiliary track circuit apparatus. In addition, on picking up of relay 5H the coded energy supplied to the section in the rear may be changed, while the aspect displayed by the wayside signal for section 5S, if such a signal is provided, will be changed.

If this method of operation is not required, the reactor 16 may be omitted and if the auxiliary track circuit apparatus is defective, the crossing signals will continue to operate and relay 5H will remain released after movement of a train through the track section.

The auxiliary track circuit apparatus provided by this invention is not limited to use for the control of highway crossing signals, and may be employed for other purposes. Fig. 14 shows how the auxiliary track circuit apparatus may be employed to control locking of a track switch.

Referring to Fig. 14 there is shown therein a stretch of main track having track rails 1 and 2 which are divided by insulated joints 3 into track sections 1T, 2T and 3T, while each of these

sections is provided with track circuit apparatus for the control of wayside signals governing movement of traffic through the track stretch. As shown the track circuit apparatus is of the direct current type and includes a track battery connected across the section rails at one end of the section and a track relay connected across the section rails at the other end of the section. Reactors may be included in series with the track batteries and track relays to prevent flow of alternating current auxiliary track circuit energy therein. The means by which the track relays control the wayside signals is not a part of this invention and has been omitted in order to simplify the disclosure.

The track section 3T includes a track switch W which governs movement of traffic on the main track and also between the main track and a branch track. The switch W is controlled by an electric lock which is arranged to permit movement of the switch only when the winding of the lock is energized. The circuit of the switch lock is controlled by an approach relay AR, and by a suitable time element device, while the relay AR is controlled by auxiliary track circuit apparatus provided by this invention.

A transformer T has the terminals of its secondary winding connected to rail 2 on opposite sides of an insulated joint 120 which is located a predetermined distance, such as 1500 feet, in the rear of the distant signal for the switch. A condenser 121 is connected between rails 1 and 2 at a point on the left-hand side of joint 120, while the secondary winding of the transformer T is proportioned so that it has little resistance to flow of direct current therethrough.

A transformer 124 has its primary winding connected across the rails of section 3T and its secondary winding connected across the rails of section 2T. Similarly, a transformer 125 has its primary winding connected across the rails of section 12T and has its secondary winding connected across the rails of section 3T, while the primary winding of grid transformer WGT is connected across the rails of section 3T at a point adjacent the switch W. The grid transformer WGT controls the potential on the grid or control element of a tube WT in the manner explained in connection with Fig. 1, while energy is supplied to the tube anode circuit from a transformer WTT.

Alternating current is supplied to the primary winding of transformer T from a source of current the terminals of which are designated BX and CX. Accordingly, energy from the transformer secondary winding is supplied through the condenser 121 to the rails 1 and 2 of section 1T so that energy is supplied over the section rails to the primary winding of transformer 124. Energy from the transformer 124 is supplied over the rails of section 2T and through transformer 125 to the rails of section 3T and thence to the transformer WGT. As long as the track stretch between the joint 120 and the switch W is unoccupied, alternating current supplied at one end of this portion of the stretch feeds to the transformer at the other end of the stretch and causes a potential to be impressed on the grid of tube WT effective to render the tube conducting when energy is supplied to the tube anode circuit.

Energy may be supplied to transformer WTT from any appropriate source, which may or may not be the same source as that from which energy is supplied to the transformer T.

The manually controlled contact 127 is normally open so that energy is not supplied to transformer WTT, and energy therefore is not supplied through the tube WT to relay AR and its contact 128 is released and interrupts the circuit of the switch lock to prevent movement of the switch.

When it is desired to move the switch W the contact 127 is closed to establish the circuit of transformer WTT, and if the approach zone leading to the switch is vacant so that energy is supplied to transformer WGT, energy will be supplied through the tube WT to relay AR and its contact 128 will be picked up to establish a circuit for the switch lock and cause it to unlock the switch and thus permit the switch to be moved.

If at the time contact 127 is closed the approach zone is occupied energy will not be supplied over the rails of the approach zone to the transformer WGT, and the tube WT will not be conducting so relay AR will remain released and the switch lock will prevent movement of the switch. A time element device having a normally open contact 130 which can be closed only after the expiration of a time interval, such as three minutes, may be provided for energizing the switch lock and thus permit the switch to be moved at times when the approach zone is occupied.

The auxiliary track circuit apparatus provides means for ascertaining occupancy of the approach zone leading to the track switch, and makes it unnecessary to subdivide the track sections even though the ends of the approach zone are located at intermediate points in the track sections. Furthermore, the auxiliary track circuit apparatus does not interfere with operation of the principal track circuit apparatus which governs traffic in the track stretch.

Although I have herein shown and described only several forms of train detecting 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 apparatus for controlling the signal at the intersection between a highway and a stretch of railway track having track rails divided by insulated joints into track sections each of which is provided with track circuit apparatus comprising a relay governed by energy supplied over the section rails, said track stretch including an approach zone which is traversed by a train approaching said intersection and at least one end of which is situated at a point in said stretch which is not a point of division between said track sections, in combination, a crossing signal, a first and a second transformer located at opposite ends of said approach zone and connected together in series over the rails of the portion of said stretch forming said approach zone, the relay of the track circuit for the track section which includes the highway intersection being effective when picked up to prevent operation of said crossing signal and when released to cause to be supplied to said first transformer energy which is incapable of operating said track relay, and means responsive to energy supplied from said first transformer through said second transformer for also preventing operation of said crossing signal.

2. In apparatus for controlling the signal at the intersection between a highway and a stretch

of railway track having track rails divided by insulated joints into track sections each of which is provided with track circuit apparatus comprising a relay governed by energy supplied over the section rails, said track stretch including an approach zone which is traversed by a train approaching said intersection and at least one end of which is situated at a point in said stretch which is not a point of division between said track sections, in combination, a crossing signal, a first and a second transformer located at opposite ends of said approach zone and connected together in series over the rails of the portion of said stretch forming said approach zone, a control relay effective when energized to prevent operation of said crossing signal, the relay of the track circuit for the track section which includes the highway intersection being effective when picked up to supply energy to said control relay and when released to supply to said first transformer energy which is incapable of operating said track relay, and means responsive to energy supplied from said first transformer through said second transformer for also supplying energy to said control relay.

3. In apparatus for controlling the signal at the intersection between a highway and a stretch of railway track having track rails divided by insulated joints into track sections each of which is provided with track circuit apparatus comprising a relay responsive to energy of a first type supplied over the section rails, said track stretch including an approach zone which is traversed by a train approaching said intersection and which includes a portion only of a track section, in combination, a crossing signal, a first and a second transformer located at opposite ends of said approach zone and connected together in series over the rails of the portion of said stretch forming said approach zone, means governed by traffic conditions in a portion of said track stretch which includes but extends beyond said approach zone for controlling said crossing signal and also controlling the supply of energy of a second type to said first transformer, and means responsive to energy supplied from said first transformer through said second transformer for also controlling said crossing signal.

4. In apparatus for controlling the signal at the intersection between a highway and a stretch of railway track having track rails divided by insulated joints into track sections each of which is provided with track circuit apparatus comprising a relay responsive to energy of one type supplied over the section rails, said track stretch including a first approach zone which is traversed by a train approaching said intersection in one direction and a second approach zone which is traversed by a train approaching said intersection in the other direction, at least one end of each of said approach zones being located at a point in said stretch which is not a point of division between said track sections, in combination, a crossing signal, means for each of said approach zones for supplying over a circuit which includes in series therewith the rails of said approach zone auxiliary energy of a distinctive type which is incapable of operating said track relays, the relay of the track circuit which includes the highway intersection being effective when energized to control said crossing signal and to cut off the supply of auxiliary energy to said approach zones and being effective when deenergized to cause auxiliary energy to be supplied to said approach zones, and means responsive to the supply of auxiliary energy over the rails of said approach zones for also controlling said crossing signal.

5. In combination, a section of railway track including an intersection with a highway and an approach zone which is traversed by a train approaching said intersection and which includes a portion only of said track section, a principal track circuit for said track section comprising a source of energy of a first type connected across the section rails at one end and a first device responsive only to energy of said first type connected across the section rails at the other end, means governed by said first device and controlling traffic in said track section, an auxiliary track circuit comprising a second device located at one end of said approach zone and responsive only to energy of a second type and means located at the other end of said approach zone and effective only when said first device is deenergized for supplying energy of said second type to said second device over a circuit which includes in series therewith the track rails of the portion of said track section forming said approach zone, a crossing signal for said intersection, and means governed by said first and second devices and controlling said crossing signal.

6. In combination, a section of railway track including an intersection with a highway and an approach zone which is traversed by a train approaching said intersection and which includes a portion only of said track section, a principal track circuit for said track section comprising a source of energy of a first type connected across the section rails at one end and a first device responsive only to energy of said first type connected across the section rails at the other end, means governed by said first device and controlling traffic in said track stretch, an auxiliary track circuit comprising a second device located at one end of said approach zone and responsive only to energy of a second type and means located at the other end of said approach zone and effective only when said first device is deenergized for supplying energy of said second type to said second device over a circuit which includes in series therewith the track rails of the portion of said track section forming said approach zone, a crossing signal for said intersection, and means effective to prevent operation of said crossing signal as long as either of said devices is energized.

7. In apparatus for controlling the signal at the intersection between a highway and a stretch of railway track having track rails divided by insulated joints into track sections each of which is provided with track circuit apparatus comprising a relay responsive to energy of a first type supplied over the section rails, said track stretch including a first approach zone which is traversed by a train approaching said intersection in one direction and a second approach zone which is traversed by a train approaching said intersection in the other direction, at least one end of each of said approach zones being located at a point in said track stretch which is not a point of division between said track sections, in combination, a crossing signal, and an auxiliary track circuit for each of said approach zones comprising a device located at the end of the zone remote from the intersection and means located at the end of said approach zone adjacent the intersection and effective when the relay of the track circuit for the track section which includes the intersection is released for supplying energy of a

second type to said device over a circuit which includes in series therewith the rails of said approach zone, and means governed by the relay of the track circuit of the track section which includes said intersection and by the devices of both of said approach zones and controlling said crossing signal.

8. In combination, a section of railway track including an intersection with a highway and an approach zone which is traversed by a train approaching said intersection and includes a part only of said track section, a principal track circuit for said track section comprising a track relay responsive only to current of a first type supplied over the section rails, an auxiliary track circuit for said approach zone which is governed by said track relay so as to be operative only when said track relay is released, said auxiliary track circuit comprising an electron tube of the controlled ionization type, a control relay, means including a source of current for connecting the winding of said control relay across the anode and cathode of said tube to energize the relay when the tube is ionized but normally ineffective to cause ionization, means at one end of said approach zone for supplying energy of a second type to the rails of said approach zone, means at the other end of said approach zone responsive only to energy of said second type supplied over the rails of said approach zone for establishing on the control element of said tube a potential effective to initiate ionization of said tube, and a crossing signal for said intersection governed by said track relay and said control relay.

9. In combination, a section of railway track including an intersection with a highway and a first approach zone which is traversed by a train approaching said intersection in one direction and a second approach zone which is traversed by a train approaching said intersection in the other direction, a principal track circuit for said section comprising a track relay responsive only to current of a first type supplied over the section rails, an auxiliary track circuit for each of said approach zones, each of said auxiliary track circuits being governed by said track relay so as to be operative only when said track relay is released, each of said auxiliary track circuits comprising an electron tube of the controlled ionization type, a control relay, means including a source of current for connecting the control relay winding across the anode and cathode of said tube to energize the relay when the tube is ionized but normally ineffective to cause ionization, means at the end of the approach zone adjacent said intersection for supplying energy of a second type to the rails of said approach zone, and means at the end of the approach zone remote from the intersection responsive only to energy of said second type supplied over the rails of said approach zone for establishing on the control element of the tube a potential effective to initiate ionization of said tube, and a crossing signal for said intersection governed by said track relay and by said control relay.

10. In combination, a stretch of railway track including an intersection with a first highway, an intersection with a second highway, a first approach zone traversed by a train approaching the first intersection and a second approach zone traversed by a train approaching the second intersection, said approach zones overlapping for a portion of their length, a first and a second transformer located at opposite ends of said first approach zone and connected together over a circuit which includes in series therewith the track rails of the portion of said track stretch forming said first approach zone and is arranged to permit alternating current of a first frequency only to be supplied from said first to said second transformer, a third and a fourth transformer located at opposite ends of said second approach zone and connected together over a circuit which includes in series therewith the track rails of the portion of said track stretch forming said second approach zone and is arranged to permit alternating current of a second frequency only to be supplied from said third to said fourth transformer, a first crossing signal for the first intersection, a second crossing signal for the second intersection, means responsive to energy supplied from said second transformer for controlling said first crossing signal, and means responsive to energy supplied from said fourth transformer for controlling said second crossing signal.

11. In apparatus for controlling the signal at the intersection between a highway and a stretch of railway track having track rails divided by insulated joints into a first and a second track section each of which is provided with a track circuit comprising a track relay responsive only to energy of a first type supplied over the section rails, said track stretch including an approach zone which is traversed by a train approaching said intersection, a portion of said approach zone being located in the first track section and the remainder of the approach zone being located in the second track section, means at the junction between the first and second track sections for transmitting from the rails of one section to the rails of the other section energy of a second type only, supply means at one end of the approach zone for supplying to the rails of the track stretch energy of said second type, and means at the other end of said approach zone responsive to the supply of energy of said second type from said supply means over a circuit including in series therewith the track rails of the portion of said track stretch forming said approach zone and controlling a crossing signal for said intersection.

12. In means for controlling the signal at a highway intersection located intermediate the ends of a section of railway track provided with a track circuit comprising a track relay responsive to unidirectional energy supplied over the section rails, in combination, an insulated joint mounted in one track rail of said track section at said intersection, a connection around said insulated joint through which unidirectional energy may be supplied but through which flow of alternating current is substantially prevented, means for supplying alternating current to the rails of said track section at one side of said insulated joint and for also supplying alternating current to the rails of said track section at the other side of said insulated joint, means responsive to the supply of alternating current over a circuit including in series therewith the track rails of a portion of said track section at one side of said insulated joint for controlling a crossing signal for said intersection, and means responsive to the supply of alternating current over a circuit including in series therewith the track rails of a portion of said track section at the other side of said insulated joint for also controlling said crossing signal.

13. In means for controlling the signal at a highway intersection located intermediate the

ends of a section of railway track provided with a track circuit comprising a track relay responsive to unidirectional energy supplied over the section rails, in combination, an insulated joint mounted in one track rail of said track section at said intersection, a transformer having its secondary winding connected around said insulated joint and proportioned to have little resistance to flow of unidirectional energy therethrough, means for supplying alternating current energy to said transformer, and means responsive to the supply of energy from said transformer over a circuit including in series therewith the track rails of a portion of said track section at one side of said insulated joint for controlling a crossing signal for said intersection.

14. In means for controlling the signal at a highway intersection located intermediate the ends of a section of railway track provided with a track circuit comprising a track relay responsive to energy of a first type supplied over the section rails, in combination, an insulated joint mounted in one track rail of said track section at said intersection, means for supplying energy of a second type to the section rails on each side of said insulated joint, a first device responsive to the supply of energy of said second type over a circuit including in series therewith the track rails of a portion of said track section at one side of said insulated joint for controlling a crossing signal for said intersection, a second device responsive to the supply of energy of said second type over a circuit including in series therewith the track rails of a portion of said track section at the other side of said insulated joint for also controlling said crossing signal, and a connection between the portions of said one track rail on opposite sides of said insulated joint controlled by said first and second devices.

15. In means for controlling the signal at a highway intersection located intermediate the ends of a section of railway track provided with a track circuit comprising a track relay responsive to energy of a first type supplied over the section rails, in combination, an insulated joint mounted in one track rail of said track section at said intersection, means for supplying energy of a second type to the section rails on each side of said insulated joint, a first device responsive to the supply of energy of said second type over a circuit including in series therewith the track rails of a portion of said track section at one side of said insulated joint for controlling a crossing signal for said intersection, a second device responsive to the supply of energy of said second type over a circuit including in series therewith the track rails of a portion of said track section at the other side of said insulated joint for also controlling said crossing signal, means for periodically establishing a connection between the portions of said one track rail on opposite sides of said insulated joint through which energy of said first type may be supplied to the track relay of said track section, and means governed by the track relay for said track section for also establishing a connection between the portions of said one track rail on opposite sides of said insulated joint.

16. In combination, a section of railway track including an intersection with a highway and an approach zone which is traversed by a train approaching said intersection and at least one end of which is located at a point in said track stretch which is not an end of said track section, said track section being provided with a track circuit comprising a track relay responsive to energy of a first type supplied over the section rails, a crossing signal for said intersection, a control relay effective when energized to prevent operation of said crossing signal, an alternator effective when supplied with energy to supply current of a second type, an electron tube which permits flow of energy from its anode to its cathode when a predetermined potenial is applied to the tube grid, means for supplying energy from said alternator to the tube anode circuit, means responsive to the supply of energy from said alternator over a circuit including in series therewith the track rails of said approach zone for establishing said predetermined potential on the tube grid, means responsive to the supply of energy between the tube anode and cathode for supplying energy to said control relay, means effective when said track relay is energized to supply energy to said control relay, and means effective when said track relay is released to supply energy to said alternator.

17. In combination, a section of railway track including an approach zone which includes a portion only of said track section, a principal track circuit for said track section comprising a source of energy of a first type connected across the section rails at one end of the section and a first device connected across the section rails at the other end of the section and responsive only to energy of said first type, an auxiliary track circuit comprising a second device located at one end of said approach zone and responsive only to energy of a second type and means located at the other end of said approach zone and effective only when said first device is deenergized for supplying energy of said second type to said second device over a circuit which includes in series therewith the track rails of the portion of said track section forming said approach zone, means governed by said first and said second device for indicating occupancy of said approach zone, and means governed by said first device for indicating occupancy of said track section.

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