

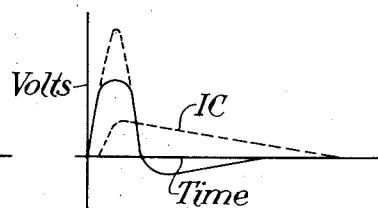
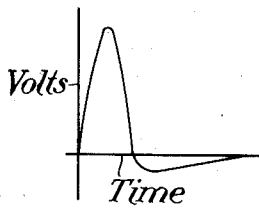
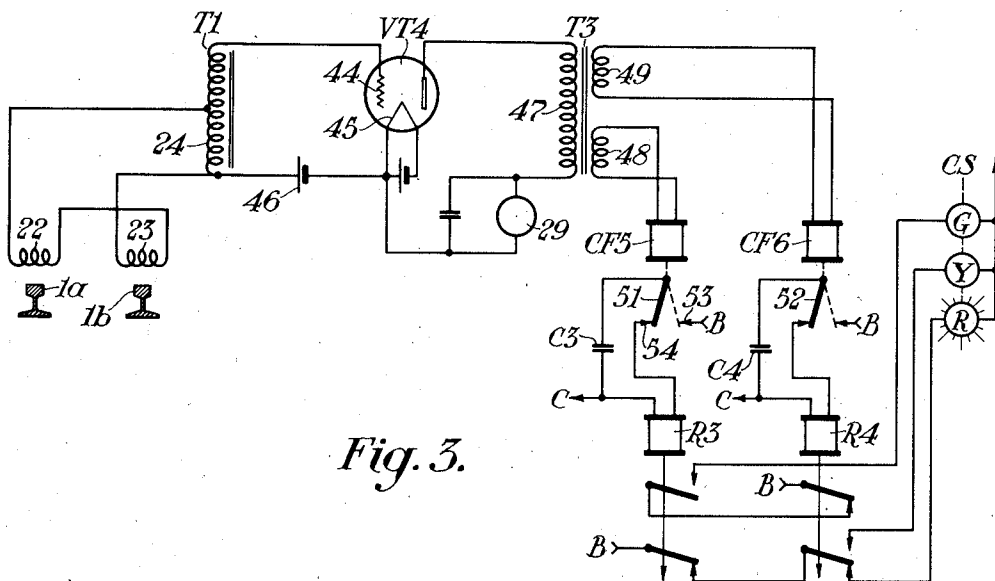
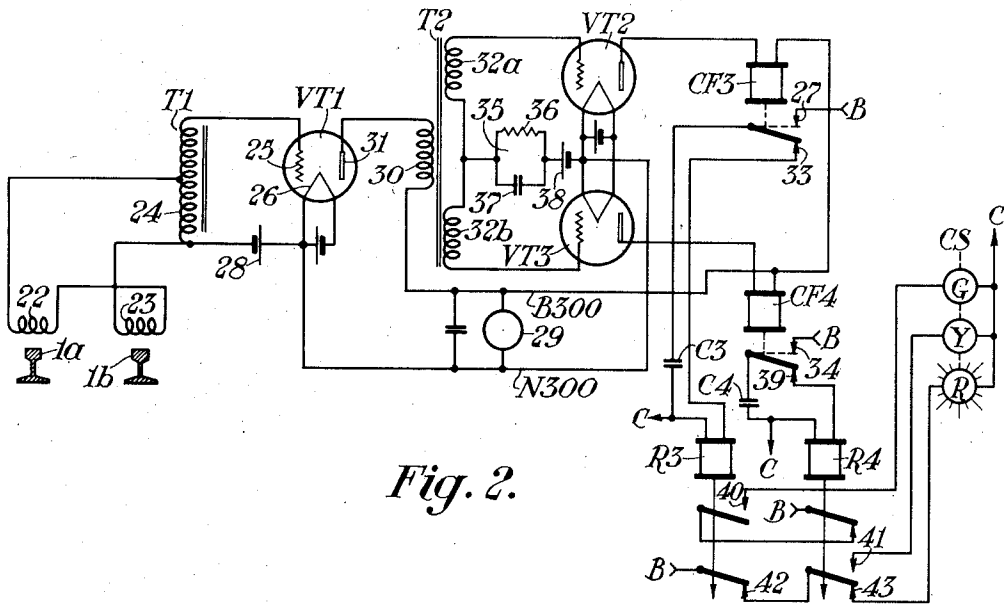
April 16, 1940.

W. P. PLACE
SIGNAL SYSTEM

2,197,415

Filed Nov. 8, 1938

4 Sheets-Sheet 2



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SIGNAL SYSTEM

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4 Sheets-Sheet 3

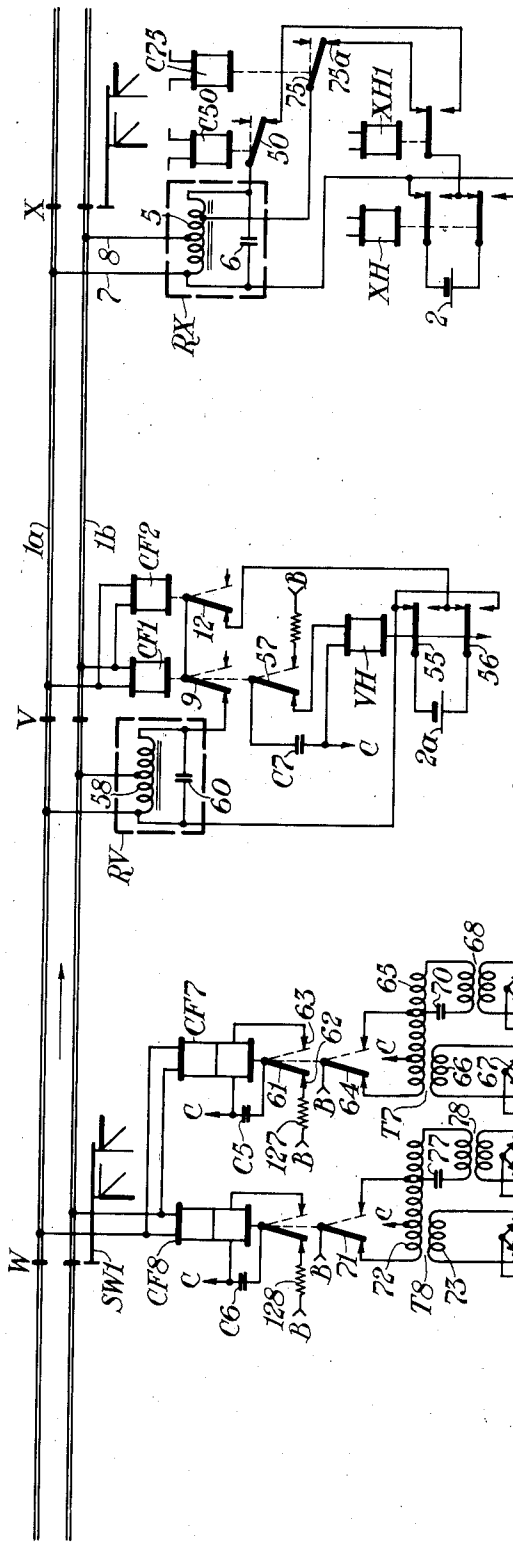


Fig. 4.

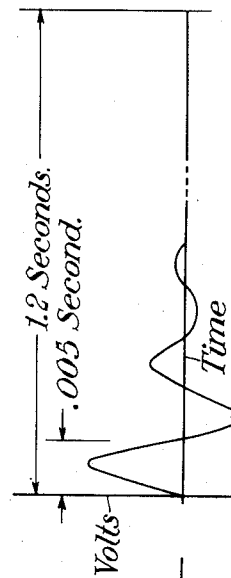


Fig. 8.

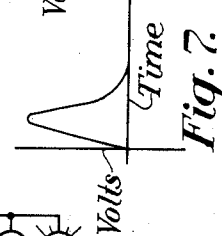


Fig. 7.

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2,197,415

SIGNAL SYSTEM

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Application November 8, 1938, Serial No. 239,523

24 Claims. (Cl. 246—63)

My invention relates to signal systems, and more specifically to signal systems for railways.

I shall describe several forms of apparatus embodying my invention, and shall then point out the novel features thereof in claims.

A feature of my invention is the provision in signal systems of the type here involved of novel and improved means selectively responsive to code current impulses. Another feature of my invention is the provision in signal systems of the type here contemplated of novel and improved means for prolonging the effects of a current impulse so that a relay or other electromagnetic device, which requires a relatively long interval for the building up of proper energization, is effectively energized in response to a current impulse of relatively short duration. When apparatus embodying my invention is used for railway signal systems, another feature of the invention is the provision of novel and improved means to provide substantially the same average energization of a track relay under all weather conditions, to increase the shunting sensitivity of a track circuit, and to provide when a track circuit is occupied by a train current surges of relatively high amperage as an aid in energy transfer between the track rails and train carried signal apparatus. Other features and advantages of my invention will appear as the specification progresses.

In the accompanying drawings, Figs. 1 and 2 when taken together are diagrammatic views of one form of apparatus embodying my invention when used with a railway signal system, Fig. 1 being the trackway portion of the apparatus and Fig. 2 being the train carried portion of the apparatus. Fig. 3 is a diagrammatic view of a modified form of the train carried apparatus of Fig. 2 which also embodies my invention. Figs. 4 and 5 when taken together are diagrammatic views of another form of apparatus embodying my invention when applied to a railway signal system, Fig. 4 being the trackway portion of the apparatus and Fig. 5 being the train carried portion of the apparatus. Fig. 6 is a diagrammatic view of a modification of the train carried apparatus of Fig. 5 which also embodies the invention. Figs. 7 and 8 are diagrams illustrating operating characteristics of the trackway apparatus of Fig. 1 and Fig. 4. Figs. 9 and 10 are diagrams illustrating operating characteristics of the train carried apparatus of Fig. 2. Figs. 11 and 12 are diagrams illustrating operating characteristics of the train carried apparatus of Figs. 5 and 6.

Similar parts are identified by like reference characters in each of the several views.

It is to be understood that I do not wish to limit my invention to signal systems for railways, and this one use will serve as an illustration of the many places where the apparatus is useful.

Referring to Fig. 1, the reference characters 1a and 1b designate the traffic rails of a railway over which traffic normally moves in the direction indicated by an arrow and which is formed by the usual insulated rail joints into consecutive track sections for signaling, a single section W—X and the adjoining ends of the two sections adjacent thereto only being shown for the sake of simplicity. Each track section is provided with a track circuit which comprises a source of coded current connected across the track rails at the exit end of the section and a receiving and decoding relay means connected across the rails at the entrance of the section. Looking at section W—X, the source of coded current comprises a battery 2, a code transmitter C50 and a reactance device RX. The connections of battery 2 are controlled by a control relay XH to be later described, the contact fingers 3 and 4 of relay XH serving to pole change the connections of battery 2 as will be readily understood by an inspection of Fig. 1.

The code transmitter C50 may be any one of several well-known types, and as here shown is of the relay type, the operating winding of which is permanently connected across a source of current whose terminals are B and C. Hence the code transmitter C50 is continuously energized to operate a code contact member 50 at a selected rate which may be, for example, 50 operations per minute. That is to say, the code transmitter C50 divides time into successive operation cycles of a selected interval each, the contact member 50 being operated once each cycle to break engagement with a stationary contact 50a.

The reactance device RX includes an inductor or transformer winding 5 and a condenser 6. The condenser 6 is connected across the winding 5 and the two in multiple are connected across the battery 2 over code contact member 50 and the pole changing contact fingers 3 and 4 of relay XH. The winding 5 is provided with taps and a selected portion of the winding is connected across the track rails over wires 7 and 8. The condenser 6 is preferably of relatively large capacity, and the parts are so proportioned that the circuit thus formed by the track rails and the reactance device is an oscillatory circuit, the

frequency or oscillation period of which is largely determined by the condenser 6 and inductor 5 and is determined to a small degree by the ballast resistance.

5 When relay XH is energized in a manner to appear later, current of one polarity is supplied to the reactance device during the period the code contact member 50 engages contact 50a, and energy is stored in the magnetic circuit of winding 5 and condenser 6 is charged. The parts
10 are preferably so designed with respect to the time constant of the circuit and with respect to the manner of closing contact 50—50a that energy in the reactance device R_X builds up rather slowly and no energy is transferred to the track rails during the storing of the energy in the reactance device, or at least the magnitude of the energy transferred to the rails at this time is so small that it can be neglected. Each time
15 code contact member 50 breaks engagement with contact 50a, the magnetic energy causes a high voltage to be impressed across the terminals of condenser 6 and by transformer action a proportional voltage to be impressed across the track
20 by way of wires 7 and 8. The condenser 6 and inductance of winding 5 form an oscillatory circuit damped by the ballast resistance of the track, and a current impulse is transferred to the track rails, the current impulse having a damped wave by virtue of the oscillatory nature
25 of the circuit. Under wet weather conditions and the ballast resistance is low, the oscillations are highly damped, and as illustrated in Fig. 7 the current wave consists of substantially one-half cycle only. Under dry weather conditions,
30 the ballast resistance is relatively high and the oscillations persist for several cycles before dying out. As illustrated in Fig. 8, the amplitude of each half cycle is materially larger than the amplitude of the half cycle immediately following it. The result of such current impulse and wave form therefore is that the average energization of a relay connected across the rails at the entrance of the section during dry weather
35 conditions is about equal to the average energization of the relay during wet weather conditions. It is to be observed from Figs. 7 and 8 that in any event the first half cycle of the wave form is the dominating half cycle. This first half cycle is of relatively high peak voltage and high shunting sensitivity of the track circuit is provided because the high peak voltage of the first half cycle of each current impulse aids in breaking down the film resistance of the track rails. Because of the high peak voltage of the first half cycle of each current impulse, a current surge of relatively high amperage is produced when the track rails are shunted by a train. Such high amperage of current, together
40 with the short duration of the impulse, results in a relatively high energy transfer being effected inductively between the rails and inductors mounted on the train. As illustrated in Figs. 7 and 8, the duration of the current impulse is only a small portion of the operation cycle interval of the code transmitter. Taking the cycle interval to be, as here assumed for the purpose of illustration, 1.2 seconds each or 50 cycles per minute, the first half cycle of the wave may be, for example, of the order of .005 second. Consequently, the energy output required of the battery 2 can be made relatively small.

When the control relay XH is released, the action is similar except the current impulse supplied to the track circuit is opposite in polarity

to that supplied when the relay XH is picked up. To aid in understanding the invention, I shall assume the connections are such that with relay XH picked up, the first half cycle of each current impulse supplied to the track circuit is of positive polarity so that the rail 1a is positive and the rail 1b is negative. When the relay XH is released, the first half cycle of each current impulse supplied to the track circuit is of negative polarity, and rail 1b is positive and rail 1a is negative. It follows, therefore, that the track circuit for section W—X is supplied with current of the polarity code type, the frequency of the impulses being the same under each code, and being, as here assumed for the purpose of illustration, 50 cycles per minute. From the foregoing description it is to be seen that the coded current impulses supplied to the track rails effect substantially the same average energization of the track relay under all weather conditions. Also, the first half cycle of the damped wave of each current impulse is of relatively high peak voltage and high shunting sensitivity of the track circuit is assured. Because the first half cycle is of relatively high peak voltage and short duration, a correspondingly high energy transfer is effected between the rails and train carried apparatus to be later described. Since each current impulse persists for only a small portion of each operating cycle, the energy consumed from the battery 2 can be made relatively low.

The receiving and decoding relay means connected across the rails of the entrance of section W—X include two code following relays CF¹ and CF², two decoding relays S¹ and S², and two condensers C¹ and C².

The code following relays CF¹ and CF² are preferably of the quick acting polar type. The operating windings of relays CF¹ and CF² are connected in multiple across the track rails but with opposite polarity. That is, the left-hand terminal of the winding of the relay CF¹ and the right-hand terminal of the winding of relay CF² are connected with the rail 1a, while the right-hand terminal of the winding of relay CF¹ and the left-hand terminal of the winding of relay CF² are connected with rail 1b. The relays CF¹ and CF² are provided with polar contact members 9 and 12, respectively, and these polar contact members are biased to seek a selected position when the winding of the relay is deenergized. Thus polar contact member 9 of relay CF¹ seeks under the influence of the bias the left-hand position, closing normal polar contact 9—10 when the relay is deenergized, is retained at the same left-hand position when the relay is energized by current flowing through the winding of the relay from the right-hand terminal to the left-hand terminal, and the contact member 9 is operated to the right-hand position, closing reverse polar contact 9—11 when the relay winding is energized by current flowing from the left-hand terminal to the right-hand terminal. The polar contact member 12 of relay CF² seeks under the influence of its bias the left-hand position, closing normal polar contact 12—13, is retained at this left-hand position when the relay is energized by current flowing in its winding from the right-hand terminal to the left-hand terminal, and is operated to the right-hand position closing reverse polar contact 12—14 when the relay is energized by current flowing in its winding from the left-hand to the right-hand terminal.

It follows that when a current impulse of posi-

tive polarity is supplied to the track rails of section W—X and rail 1a is positive and rail 1b is negative, the relay CF1 is operated and relay CF2 remains inactive. When a current impulse of negative polarity is supplied to the track rails and rail 1b is positive and rail 1a is negative, the relay CF2 is operated and relay CF1 remains inactive. Since the duration of each current impulse supplied to the rails of section W—X is relatively short and the impulse persists for only a small portion of the operating cycle into which time is divided by the code transmitter, the period the contact member 9 or 12 is held at the right-hand position when the respective relay is operated, is short, and is only a small fraction of the time the contact member 9 or 12 is held at the left-hand position. Furthermore, it is to be observed that when the current impulse is of positive polarity the relay CF2 is energized during the first half cycle at a polarity which tends to retain the polar contact member 12 at its biased or left-hand position. The second half cycle of the current impulse tends to energize relay CF2 at a polarity to operate the contact member 12. However, the magnetic field built up in the relay CF2 during the first half cycle of the current impulse is relatively large and, because the duration of the second half cycle is short, the magnetic field built up during the first half cycle does not die away to zero and build up in the opposite direction to any extent and hence the net effect is that the contact member 12 remains firmly held at its biased position. In other words, the resultant energization of relay CF2, when the track circuit current impulse is of positive polarity, is of the polarity that causes contact member 12 to remain under the influence of its bias. When the track circuit current is of negative polarity, the action with respect to relay CF1 is similar to that just described for relay CF2 when the track circuit current impulse is of positive polarity. That is, the resultant energization of relay CF1, when the track circuit current impulse is of negative polarity, is of the polarity that causes its contact member 9 to remain under the influence of its bias.

Decoding relays S1 and S2 are preferably neutral relays provided with slow release characteristics, relay S1 being controlled by code following relay CF1 through the medium of the condenser C1, and relay S2 being controlled by code following relay CF2 through the medium of the condenser C2. When relay CF1 is operated, closing its reverse polar contact 9—11, the condenser C1 is connected across the B and C terminals of a convenient source of direct current (not shown) and the condenser is charged. When relay CF1 closes its normal polar contact 9—10, condenser C1 is connected across the winding of relay S1 and discharges to energize relay S1. Hence, when relay CF1 is periodically operated at the code frequency of 50 cycles per minute, condenser C1 is charged each time contact 9—11 is closed and discharges through the winding of relay S1 each time contact 9—10 is closed, with the result that relay S1 is energized and picked up, and is retained picked up due to its slow release characteristics. Likewise, when relay CF2 is operated closing its contact 12—14, the condenser C2 is connected across the terminals B and C of the current source and is charged. Condenser C2 then discharges through the winding of relay S2 to energize that relay when contact 12—13 of the code following relay CF2 is closed. With relay CF2 operated

at the code frequency of 50 cycles per minute, the condenser C2 is charged each time contact 12—14 is closed and discharges through the winding of relay S2 each time contact 12—13 is closed, with the result that relay S2 is energized and picked up and is retained picked up by virtue of its slow release period.

As stated above, the interval the relay CF1 or CF2 is operated to close reverse polar contact 9—11 or 12—14 is short due to the short duration of the track circuit current impulse, but such interval is sufficient to charge condenser C1 or C2. During the relatively long remaining portion of each cycle interval the condenser C1 or C2 is connected with the winding of the decoding relay S1 or S2, with the result that the energizing of relay S1 or S2 is of ample duration to pick up that relay, whereas the duration of the current impulse of the track circuit current, while sufficient to operate the quick acting polar relay CF1 or CF2, might not be sufficient to properly energize the slow acting electromagnetic device or relay S1 or S2. In other words, the receiving and decoding relay means of section W—X is operative to effect in response to a current impulse of short duration a relatively long period of energization of the slow acting decoding relay.

Decoding relays S1 and S2 are used to control the operating circuits of a wayside signal SW for section W—X, and to govern a control relay WH, which latter relay governs the connections of battery 2 for the track circuit of the track section next in the rear of section W—X in the same manner that relay XH controls the connections of battery 2 for the track circuit of section W—X. Furthermore, relay XH is governed by the decoding relays (not shown) for the track circuit for the section next in advance of section W—X in the same manner that relay WH is controlled by decoding relays S1 and S2.

When track section W—X is occupied and its track circuit shunted, both code following relays CF1 and CF2 are inactive so that decoding relays S1 and S2 are both deenergized and released. The R lamp of signal SW is illuminated over an operating circuit including back contacts 15 and 16 of relays S1 and S2, respectively, to display a stop signal indication. Relay WH is now deenergized and the battery 2 for the track circuit of the section next in the rear is connected so as to supply that track circuit with impulses of negative polarity to reflect approach traffic conditions for the section next in the rear because of track section W—X being occupied. When the section next in advance of the section W—X is occupied and section W—X is unoccupied so that current impulses of negative polarity are supplied to the track circuit of section W—X, the code following relay CF2 is operated in the manner explained hereinbefore to energize the decoding relay S2. The Y lamp of signal SW is illuminated over an operating circuit including back contact 15 of relay S1 and front contact 17 of relay S2 to display an approach signal indication. Relay WH is now energized over front contact 18 of relay S2 and the connection of battery 2 for the track section next in the rear is such that current impulses of positive polarity are supplied to the track circuit of that section to reflect clear traffic conditions. When the section next in advance of section W—X and section W—X are both unoccupied and relay XH is picked up so that current impulses of positive polarity are supplied to the track circuit of sec-

tion W—X, the code following relay CF1 is operated and the decoding relay S1 is picked up but relay S2 is released. The G lamp of signal SW is illuminated over an operating circuit including back contact 19 of relay S2 and front contact 20 of relay S1 to display a clear signal indication. Relay WH is now energized over front contact 21 of relay S1, and current impulses of positive polarity are supplied to the track circuit of the section next in the rear to reflect clear traffic conditions.

It is to be understood that each track circuit of each section of the railway comprises trackway apparatus similar to that described for the section W—X.

Referring to Fig. 2, the train carried apparatus includes an inductor comprising two windings 22 and 23 mounted on the train in inductive relation with the track rails 1a and 1b, respectively. Windings 22 and 23 are connected across a portion of the winding 24 of an input transformer T1, the connections of windings 22 and 23 being preferably such that the electromotive forces induced therein by current flowing in opposite directions in rails 1a and 1b add their effects. The full winding 24 of transformer T1 is connected across the grid 25 and filament 26 of an electron tube VT1, a biasing battery 28 being preferably interposed in this grid circuit. The tube VT1 is provided with a plate circuit which can be traced from terminal B300 of a generator 29 over primary winding 30 of a coupling transformer T2, plate 31 of tube VT1, tube space to filament 26, and to terminal N300 of generator 29. The generator 29 is driven by any convenient source of power not shown, and supplies a suitable voltage, say, 300 volts.

The secondary winding of coupling transformer T2 is constructed with two portions 32a and 32b which are preferably alike and are connected with the grids of two electron tubes VT2 and VT3 in a push-pull arrangement. The connection of the central terminal of the two portions of the secondary winding 32a—32b is connected with the filaments of tubes VT2 and VT3 over a biasing battery 33 and an auxiliary biasing unit 35 in series, the unit 35 comprising a resistor 36 and a condenser 37 in multiple. The plate circuit of tube VT2 includes generator 29 and the winding of a code following relay CF3, and the winding of a code following relay CF4 as will be readily understood by inspection of Fig. 2.

The code following relays CF3 and CF4 are preferably of the neutral type and are constructed with quick acting characteristics.

The tubes VT2 and VT3 are normally biased by virtue of biasing battery 38 to practically complete cut-off of plate current. That is to say, when no electromotive force is applied to the grids of tubes VT2 and VT3 through the coupling transformer T2, the biasing of battery 38 renders the grids of tubes VT2 and VT3 negative in potential with respect to the filaments to a degree where the plate current of each tube is substantially zero.

The code following relays CF3 and CF4 govern two decoding relays R3 and R4 in substantially the same manner the code following relays CF1 and CF2 of Fig. 1 govern the associated decoding relays S1 and S2. When relay CF3 is picked up closing front contact 27. A condenser C3 is charged from a source of direct current whose terminals are B and C, and when the relay CF3

is released closing back contact 33, the condenser C3 discharges through the winding of relay R3 to energize and pick up that relay. Likewise, when relay CF4 is picked up closing front contact 34, a condenser C4 is charged, and when relay CF4 is released closing back contact 39, the condenser C4 discharges through the winding of relay R4 to energize and pick up that relay. Relays R3 and R4 are slow releasing in character, and hence, when relay CF2 or CF4 is operated at the code frequency of 50 cycles per minute, the relay R3 or R4 is retained picked up.

Relays R3 and R4 are used to control the operating circuits of a cab signal CS of the color light type capable of displaying three different indications. The operating circuits for cab signal CS are similar to the circuits for wayside signal SW of Fig. 1, and it is thought the operating circuits of signal CS need no further description.

Assuming the train on which the apparatus of Fig. 2 is mounted is moving in the normal direction of traffic through the track section W—X of Fig. 1 under clear traffic conditions so that code current impulses of positive polarity are supplied to the track circuit, the operation of the apparatus of Fig. 2 is as follows: The first half cycle of each such rail current impulse induces electromotive forces in windings 22 and 23 which add their effects. The wave form of the electromotive force is substantially that illustrated in Fig. 9. That is, the wave form of the induced electromotive force has a first half cycle of relatively high peak voltage, while the second half cycle is of relatively low voltage. I have found that under usual operating conditions only the first half cycle of the track circuit current impulse induces in the windings 23 and 22 an electromotive force of appreciable amplitude. That is to say, the electromotive force induced in windings 22 and 23 due to the oscillations of the track circuit current impulse other than the first half cycle is so small in magnitude that it can be neglected. The electromotive force induced in windings 22 and 23 due to the first half cycle of each current impulse creates in the secondary winding 32a—32b of transformer T2 an electromotive force of substantially the same wave form, except it is amplified by the tube VT1. The connections are arranged so that the top terminal of secondary winding 32a—32b is first positive and the lower terminal is negative when the track circuit current impulse is of positive polarity. The grid of tube VT2 is made positive with respect to its filament due to the crest of the wave form. Looking at Fig. 10, the dotted crest portion of the electromotive force wave represents that portion during which the grid of tube VT2 is made positive in potential with respect to the filament of the tube. That is to say, the dotted crest portion of the wave form represents that portion of the induced electromotive force sufficient to overcome the normal bias voltage of battery 38 and the grid of tube VT2 is made positive with respect to its filament. This causes plate current to flow through the tube VT2 and the code following relay CF3 is picked up. Furthermore, this crest voltage causes grid current to flow in the tube VT2 and condenser 37 is charged to a voltage equal to the difference between the peak voltage and the voltage just sufficient to overcome the normal bias voltage of battery 38. The voltage thus built up on condenser 37 is illustrated by the dotted curve IC of Fig. 10, and increases the normal negative

bias on the grid of tube VT3 so that the immediate negative half cycle of the induced electromotive force which tends to render the grid of tube VT3 positive with respect to its filament is canceled and no current flows in the plate circuit of tube VT3. The charge on condenser 37 leaks away through resistor 36 during the interval between successive impulses so that the above described operation of the apparatus is repeated each impulse of the track circuit current.

It is to be noted that device 35 enables tubes VT2 and VT3 to operate properly over a wide range of track current. If the crest voltage of the first half cycle is only sufficiently strong to cause, say, VT2 to operate relay CF3 but not sufficiently strong to cause grid current to flow, the immediately following half cycle is not strong enough to cause VT3 to operate CF4 and no increased bias is needed. If the voltage is considerably higher, a higher voltage is built up across the terminals of condenser 37, the immediate negative half cycle is cancelled, and no plate current flows in tube VT3.

It follows that the code following relay CF3 is operated at a rate corresponding to the code frequency of the track circuit current impulses. The period the relay CF3 is picked up to close front contact 27 is short but is sufficient to charge condenser C3, which condenser then by discharging through the winding of relay R3 over the back contact 33 of relay CF3 causes relay R3 to be energized for a sufficient interval to pick up that relay. Relay R3 is retained picked up from one impulse to the next by virtue of its slow release period. Hence the impulse which operates the code following relay CF3 is in effect prolonged sufficiently to operate the decoding relay R3.

With the decoding relay R3 picked up closing front contact 40, the G lamp of the cab signal CS is illuminated to display a clear signal indication.

With approach traffic conditions existing while the train occupies the track section W—X, the code current impulses of the track circuit are of negative polarity and the electromotive force induced in windings 22 and 23 is of opposite polarity to that induced under clear traffic conditions. This time the lower terminal of the secondary winding 32a—32b is first positive and the upper terminal is negative so that the grid of the tube VT3 is made positive in potential with respect to the filament of that tube during the upper crest portion of the wave form of the induced electromotive force. Plate current flows for the tube VT3 and the code following relay CF4 is operated. Condenser 37 is charged in the same manner as described before and increases the negative grid bias of tube VT2 so that the immediate following half cycle of the induced electromotive force which tends to render the grid of tube VT2 positive is canceled and no plate current flows for the tube VT2. Hence relay CF4 is picked up each current impulse of the track circuit current and relay R4 is energized because the condenser C4 is charged during the brief interval the front contact 34 of relay CF4 is closed and then discharges through the winding of relay R4 during the longer interval the back contact 39 of relay CF4 is closed. With relay R4 picked up closing front contact 41 and relay R3 released closing back contact 42, the Y lamp of cab signal CS is illuminated to display an approach signal indication.

If the track section W—X is already occupied

by a train when the train on which the apparatus of Fig. 2 is mounted enters that track section, no electromotive force is induced in the windings 22 and 23 and both code following relays CF3 and CF4 are inactive so that the decoding relays R3 and R4 are deenergized and released. The R lamp of signal CS is now illuminated over a circuit including back contacts 42 and 43 of relays R3 and R4, respectively, to display a slow speed cab signal indication.

In the train carried apparatus of Fig. 3, the winding 24 of the input transformer T1 is connected across grid 44 and filament 45 of an electron tube VT4, a biasing battery 46 being preferably interposed in the circuit. The plate circuit for tube VT4 includes generator 29 and the primary winding 47 of an output transformer T3, transformer T3 being provided with two secondary windings 48 and 49. Winding 48 is connected with the winding of a code following relay CF5, and winding 49 is connected with the winding of a code following relay CF6. The code following relays CF5 and CF6 are preferably of the quick acting polar type having polar contact members biased to seek a selected position when the relay is deenergized similar to the relays CF1 and CF2 of Fig. 1. Thus polar contact member 51 of relay CF5 seeks its left-hand position when the relay is deenergized, is retained at that position when the relay is energized by current of negative polarity, and is operated to the right-hand position when the relay is energized by current of positive polarity. Contact member 52 of relay CF6 is biased to seek its left-hand position when the relay is deenergized, is retained at that position when the relay is energized by current of negative polarity, and is operated to the right-hand position when the relay is energized by current of positive polarity.

Decoding relays R3 and R4 of Fig. 3 are governed by the code following relays CF5 and CF6, respectively, in substantially the same manner as decoding relays R3 and R4 of Fig. 2 are governed by the associated code following relays CF3 and CF4. That is, condenser C3 is charged when polar contact member 51 of relay CF5 is operated to its right-hand position, closing reverse polar contact 51—53, and condenser C3 discharging through the winding of relay R3 to energize relay R3 when normal polar contact 51—54 of relay CF5 is closed, so that operation of relay CF5 at the selected code frequency causes decoding relay R3 to be retained picked up. Similarly, condenser C4 is charged when the polar contact member 52 of relay CF6 is operated to its right-hand position, and condenser C4 discharges through the winding of relay R4 to energize relay R4 when polar contact member 52 is moved back to its left-hand position, so that operation of relay CF6 at the code frequency causes decoding relay R4 to be picked up. Decoding relays R3 and R4 of Fig. 3 govern the operating circuits of the cab signal CS the same as in Fig. 2.

In Fig. 3 the parts are so proportioned that tube VT4 is biased to a straight line point of its grid voltage-plate current characteristics, and a steady value of current normally flows in the plate circuit, which, of course, induces no electromotive forces in the secondary windings 48 and 49. If the grid 44 of tube VT4 is made more positive in potential with respect to filament 45, the plate current will increase and such change in the plate current induces electromotive forces in the secondary windings 48 and 49. The parts are so proportioned that the wave form of the electro-

motive force induced in the windings 48 and 49 is in each case substantially that shown in Fig. 9, the first half cycle of the wave form being of relatively high peak voltage while the second half cycle is of relatively low voltage. If the grid 44 is rendered more negative in potential with respect to filament 45, the plate current is reduced and such reduction of plate current induces electromotive forces in the windings 48 and 49 the same as before, except the electromotive forces are opposite in polarity.

The connections are so arranged that the electromotive force induced in secondary winding 48 when the grid 44 is made more positive and the plate current is increased causes current of positive polarity to flow in the winding of relay CF5 and that relay is operated. The electromotive force induced in the winding 49 when grid 44 is made more negative in potential and the plate current is reduced causes current of positive polarity to flow in the winding of relay CF6 and that relay is operated. It should be pointed out that the energization of relay CF6, because of the second half cycle of the electromotive force induced in winding 49 when the plate current is increased, is not sufficient to operate its contact member 52, and likewise the energization of relay CF5, because of the second half cycle of the electromotive force induced in winding 48 when the plate current is reduced, is not sufficient to operate contact member 51.

Assuming the train on which the apparatus of Fig. 3 is mounted is moving in the normal direction of traffic through the track section W—X of Fig. 1 under clear traffic conditions, each impulse of the track circuit current of positive polarity induces in windings 22 and 23 an electromotive force which causes the top terminal of winding 24 of transformer T1 to be first positive and the bottom terminal of winding 24 to be negative. This causes the grid 44 of tube VT4 to be more positive in potential with respect to filament 45, the plate current is increased and relay CF5 is operated so that decoding relay R3 is picked up, and a clear cab signal indication is displayed by the signal CS. If approach traffic conditions exist for the track section W—X, then each current impulse of the track circuit is of negative polarity and the electromotive force induced in the windings 22 and 23 of Fig. 3 causes the lower terminal of winding 24 to be positive and the top terminal to be negative. This time the grid 44 is made more negative in potential with respect to filament 45, the plate current is reduced, and relay CF6 is operated so that decoding relay R4 is picked up and an approach cab signal is displayed. If the track section W—X is already occupied when the train on which the apparatus of Fig. 3 is mounted enters section W—X, then no electromotive force is induced in the windings 22 and 23, both relays CF5 and CF6 are inactive, and both decoding relays R3 and R4 are released so that a slow speed cab signal indication is displayed.

Referring to Fig. 4, the track rails 1a and 1b of a railway over which traffic normally moves in the direction indicated by an arrow are formed into consecutive track sections the same as in Fig. 1, a single section W—X and the ends of the adjacent sections only being shown. In Fig. 4 the track section W—X is provided with a so-called cut section subdividing the section into two subsections W—V and V—X.

Each track section of Fig. 4 is provided with a track circuit the same as in Fig. 1. The track

circuit for section W—X of Fig. 4 comprises a source of coded current connected across the rails at the exit of the section and a receiving and decoding relay means connected across the rails at the entrance of the section, the same as in Fig. 1, and includes in addition a code repeating means connected across the rails at the cut section location V. In Fig. 4 the trackway apparatus is adaptable of supplying coded current of four different codes for a four block five indication signal system.

Looking at the exit of the section W—X of Fig. 4, the source of coded current comprises a battery 2, two code transmitters C50 and C75, and reactance device RX. The code transmitter C75 is preferably the same as code transmitter C50 except it is adjusted to operate its code contact member 75 at the code frequency of 75 operations per minute, whereas the code transmitter C50 operates its code contact member 50 at the code frequency of 50 cycles per minute. The reactance device RX of Fig. 4 comprises inductor winding 5 and a condenser 6 the same as in Fig. 1, and a selected portion of winding 5 is connected across the rails 1a and 1b over wires 7 and 8. The connection of battery 2 is pole changed by control relay XH the same as in Fig. 1, while selection between the code transmitter C50 and code transmitter C75 is made by a second control relay XH1.

When both relays XH and XH1 are picked up in a manner to appear later to reflect clear traffic conditions for section W—X, the track rails of subsection V—X are supplied with a current impulse of positive polarity each time the code transmitter C75 operates its contact member 75 to break engagement with contact 75a, the current impulse having a damped wave the same as explained in connection with Fig. 1. Hence the first half cycle of the current impulse flowing in the track rails of subsection V—X is of positive polarity and the current impulses have a code frequency of 75 cycles per minute.

When control relay XH is released and control relay XH1 is picked up to reflect approach restricting traffic conditions for the section W—X, as will shortly appear, the current impulses supplied to the rails of subsection V—X are of negative polarity and of the 75 code frequency. When both relays XH and XH1 are released to reflect approach traffic conditions for the section W—X, the track rails of subsection V—X are supplied with current impulses of negative polarity at the code frequency of 50 cycles per minute. Again, when relay XH is picked up and relay XH1 is released to reflect restricting traffic conditions for the section W—X, the track rails of subsection V—X are supplied with current impulses of positive polarity at the code frequency of 50 cycles per minute. The stop or slow speed traffic condition for section W—X is reflected when the track circuit is shunted. Preferably the full winding 5 of reactance device RX is used when the code transmitter C50 is active, while only a portion of the winding is used when the code transmitter C75 is active.

The code repeating means at location V includes a battery 2a, two code following relays CF1 and CF2, a control relay VH, and a reactance device RV. Relays CF1 and CF2 are preferably quick acting polar relays the same as in Fig. 1, the windings of the two relays being connected across the rails of the subsection V—X in multiple and the connections being so arranged that relay CF1 is operated by current impulses of positive polarity and relay CF2 is operated by current

impulses of negative polarity. The control relay VH is controlled over a polar contact member 57 of relay CF1 through the medium of a condenser C7 as will be understood by an inspection of Fig. 4. The reactance device RV is substantially the same as the reactance device RX and is provided with a winding 58 and a condenser 60 of relatively large capacity. A selected portion of winding 58 is connected across the rails of subsection W—V. The connections of battery 2a with the reactance device RV are pole changed by contact fingers 55 and 56 of relay VH and are governed by polar contact members 9 and 12 of relays CF1 and CF2, respectively.

When clear traffic conditions exist for the section W—X and current impulses of positive polarity and of a 75 code frequency are supplied to the rails at location X, the code following relay CF1 at location V is operated at the same frequency and relay VH is picked up. With relay VH picked up and contact member 9 of relay CF1 operated at the code frequency of 75, current impulses of positive polarity and of the 75 code frequency are supplied to the rails of subsection W—V. That is to say, the code of the current impulses flowing in the rails of subsection V—X is repeated for the current impulses supplied to the rails of the subsection W—V. Under approach restricting traffic conditions for the section W—X and current impulses of negative polarity and 75 code frequency are supplied to the rails at location X, the code following relay CF2 is operated at the corresponding code frequency, control relay VH being now deenergized and released. With relay VH released and contact member 12 operated at the code frequency of 75 cycles per minute, current impulses of negative polarity and the code frequency of 75 are supplied to the rails of the subsection W—V. Under approach traffic conditions and current impulses of negative polarity and of the 50 code frequency are supplied to the rails at location X, the code following relay CF2 is operated at the corresponding code frequency, relay VH is released and the current impulses supplied to the rails of subsection W—V are of negative polarity and of the code frequency of 50 cycles per minute. Under restricting traffic conditions and code impulses of positive polarity and of 50 cycles per minute are supplied to the rails at location X, the relay CF1 is operated and control relay VH is picked up, with the result that this code is repeated for the current impulses supplied to the rails of subsection W—V. If the subsection V—X is occupied, both code following relays CF1 and CF2 are inactive and no current impulses are supplied to the rails of the subsection W—V.

The receiving and decoding means of Fig. 4 comprises two code following relays CF7 and CF8, two decoding transformers T7 and T8, and four decoding relays S3, S4, S5 and S6.

The code following relays CF7 and CF8 are preferably biased polar relays similar to relays CF1 and CF2, except relays CF7 and CF8 are each provided with a lower or holding winding and have associated therewith condensers C5 and C6, respectively, for equalizing the "on" and "off" periods of the relay in order to provide sufficient time when relay CF7 or CF8 is operated for the associated decoding relays to be effectively energized. The relays CF7 and CF8 have their top or operating windings connected in multiple across the track rails at reversed polarity, the arrangement being such that relay CF7 is operated by track circuit current impulses of positive

polarity and relay CF8 is operated by current impulses of negative polarity.

Normally the condenser C5 is charged from a direct current source over normal polar contact 61—62 of relay CF7, and discharges through the holding winding of relay CF7 when that relay is operated, closing its reverse polar contact 61—63. This discharge of condenser C5 acts to retain relay CF7 at its operated position for an appreciable instant after the impulse of current which operated the relay ceases to flow in the operating winding of the relay. Similarly, condenser C6 is normally charged and discharges through the holding winding of relay CF8 when that relay is operated to retain the relay in its operated position for an appreciable instant after the impulse which operated the relay ceases to flow in the operating winding of relay CF8. The charge built up in condenser C5 or C6 when connected across the source of direct current depends upon the interval the connection is completed and also upon the resistor 127 or 128 interposed in the respective connections. When the code frequency for the current impulses is 75 cycles per minute, the interval between successive current impulses and during which interval the relay CF7 or CF8 is retained at its biased position, is of a correspondingly short interval. Consequently the condenser C5 or C6 acquires only a relatively small charge and the subsequent discharge through the holding winding of relay CF7 or CF8 is effective to hold that relay at its operated position for only a corresponding interval. On the other hand, if the code frequency for the current impulses is 50 cycles per minute, condenser C5 or C6 acquires a greater charge and the subsequent discharge through the holding winding of the associated relay is effective to hold that relay at its operated position for a correspondingly longer interval. By properly proportioning the parts, the time during which relays CF7 and CF8 are retained at their operating position ("on" period) can be made approximately equal to the time the relays are retained at their biased position ("off" period) for both the 50 and 75 code frequencies.

When relay CF7 is operated, direct current is reversibly supplied over polar contact member 64 to two portions of primary winding 65 of the decoding transformer T7. A secondary winding 66 of transformer T7 is connected with the winding of relay S5 through a full wave rectifier 67. A portion of winding 65 of transformer T7 is connected with the winding of relay S6 through a rectifier 69 and a filter comprising a condenser 70 and a transformer 68. The filter including condenser 70 and transformer 68 is proportioned to pass electromotive forces of the frequency corresponding to the 75 code frequency of the track circuit current impulses. Hence, when relay CF7 is operated at either the 50 or 75 code frequency, relay S5 is picked up, and, when relay CF7 is operated at the code frequency of 75, the relay S6 is also picked up. In like fashion, relay CF8 reversibly applies direct current over its polar contact member 71 to two portions of the primary winding 72 of decoding transformer T8. A secondary winding 73 of transformer T8 is connected with the winding of relay S3 through a full wave rectifier 74. A portion of winding 72 is connected with the winding of relay S4 through a full wave rectifier 76 and a filter comprising a condenser 77 and a transformer 78. The filter including condenser 77 and transformer 78 is proportioned to pass electromotive forces of the frequency corresponding to the code frequency of 75. It fol-

lows that when relay CF8 is operated at either the 75 or 50 code frequency relay S3 is picked up and relay S4 is also picked up when the relay is operated at the 75 code frequency.

5 The relays S3, S4, S5 and S6 are used to control the operating circuits of a wayside signal SW1 which in Fig. 4 is shown as a color light signal capable of displaying five different indications. The relays S3, S4, S5 and S6 are also
10 used to govern two control relays WH and WH1, which latter relays in turn control the track circuit for the section next in the rear of section W—X in the same manner that relays XH and XH1 control the track circuit for the section
15 W—X. Furthermore, relays XH and XH1 are governed by the decoding relays (not shown) for the track section next in advance of section W—X in the same manner that relays WH and WH1 are governed by the decoding relays for section
20 W—X.

Under clear traffic conditions for section W—X and the code of the track circuit current impulses is that of positive polarity and 75 cycles per minute, relays S5 and S6 are picked up in the manner explained hereinbefore. Lamp G of the top
25 group of lamps of signal SW1 is illuminated over front contacts 76 and 80 of relay S6, and lamp R of the bottom group of lamps is illuminated over front contact 79 of relay S6 and front contact 81 of relay S5, and signal SW1 displays a
30 green light over a red light for a clear signal indication. Relay WH is now energized over front contact 82 of relay S6, and relay WH1 is energized over front contact 82 of relay S6 and front
35 contact 83 of relay S5 so that clear traffic condition is established for the track circuit for the section next in the rear of section W—X.

Under approach restricting traffic conditions and the code for the track circuit current impulses of section W—X is that of negative polarity and 75 cycles per minute, relays S3 and S4
40 are picked up in the manner explained hereinbefore. The Y lamp of the top group of lamps of signal SW1 is illuminated over front contact 84 of relay S3, and the G lamp of the bottom group of lamps is illuminated over front contact
45 85 of relay S4 so that signal SW1 displays a yellow lamp over a green lamp for an approach restricting signal indication. Relay WH1 is now energized over front contact 86 of relay S3 and
50 relay WH is energized over front contact 87 of relay S4 so that clear traffic conditions are still established for the section next in the rear.

Under approach traffic conditions for the section W—X and the code of the track circuit current impulses is that of negative polarity and 50
55 cycles per minute, the relay S3 is picked up while relays S4, S5 and S6 are all released. The Y lamp of the top group of lamps is illuminated as before, while the R lamp of the bottom group of lamps is illuminated over back contacts 88
60 and 89 of relays S4 and S5, respectively, and signal SW1 displays a yellow light over a red light for an approach signal indication. Relay WH1 is energized over front contact 86 of relay S3 as
65 before but relay WH is deenergized and hence an approach restricting traffic condition is established for the track section next in the rear.

Under restricting traffic conditions and the code for the track circuit current impulses of section W—X is that of positive polarity and 50
70 cycles per minute, relay S5 is picked up but relays S3, S4 and S6 are released. The R lamp of the top group of lamps is illuminated over back
75 contact 92 of relay S3, front contact 90 of relay

S5 and back contact 96 of relay S6, while the Y lamp of the bottom group of lamps is illuminated over back contact 92 of relay S3, front
contact 93 of relay S5 and back contact 94 of relay S6, so that signal SW1 displays a red light
5 over a yellow light for a restricting signal indication. Both relays WH and WH1 are now released to establish approach traffic conditions for the section next in the rear.

With the track section W—X occupied, both
10 code relays CF1 and CF8 are inactive and the associated decoding relays are all deenergized. Under this condition of the relays the R lamp of the top group of lamps is illuminated over
back contacts 92, 95 and 96 of relays S3, S5 and S6, respectively, while the R lamp of the bottom
15 group of lamps is illuminated over back contacts 88 and 89 of relays S4 and S5, respectively. Signal SW1 now displays a red light over a red light for a stop signal indication. Relay WH is now
20 energized over back contacts 97, 98 and 99 of relays S5, S4 and S3, respectively, while relay WH1 is released with the result that restricting traffic condition is established for the section next
25 in the rear.

It will be understood, of course, that the track
section W—X of Fig. 4 need not include a cut section and the code following relays CF1 and CF8 may be operated directly by the code current
30 impulses supplied to the rails at location X. Furthermore, it will be understood that each track section of the system is provided with trackway apparatus substantially the same as described for section W—X of Fig. 4.

Referring to Fig. 5, the train carried apparatus
35 operatively associated with the trackway apparatus of Fig. 4 includes inductor windings 22 and 23, an input transformer T1, a first stage amplifier tube VT1, coupling transformer T2, two
40 amplifier tubes VT2 and VT3, code following relays CF3 and CF4, decoding transformers T9 and T10, decoding relays R5, R6, R7 and R8, and a cab signal CS1. The inductor windings 22 and 23, input transformer T1 and the first stage
45 amplifier tubes VT1 are the same as in Fig. 2 and need no further description. The grid circuits of tubes VT2 and VT3 are connected with the secondary winding 32a—32b of transformer
50 T2, the same as in Fig. 2 except for the fact the biasing battery 38 and auxiliary biasing unit 35 are replaced by two individual control units 100 and 103. In Fig. 5 the control unit 100 comprises
55 a condenser 101 and a resistor 102 in multiple, the control unit 100 being interposed between the grid of tube VT2 and the top terminal of the secondary winding 32a—32b. Likewise, the control unit 103 comprises a condenser 105 and
60 a resistor 104, and the control unit 103 is interposed between the grid of tube VT3 and the lower terminal of the secondary winding 32a—32b.

The parts are proportioned so that normally
the grids of tubes VT2 and VT3 are substantially of the same potential as the filaments of the tubes, and a relatively large steady flow of plate
65 current flows to both tubes VT2 and VT3, with the result that the code following relay CF3 interposed in the plate circuit of tube VT2 and the code following relay CF4 interposed in the plate
70 circuit of tube VT3 are both energized and picked up. This operating characteristic of the apparatus of Fig. 5 is illustrated by Fig. 11. The code
following relays CF3 and CF4 are neutral relays, the same as in Fig. 2. Relays CF3 and CF4 of
75 Fig. 5 govern the decoding relays R5, R6, R7 and

R8 through the medium of decoding transformers T9 and T10 together with associated filters and rectifiers which are similar to the filters and rectifiers associated with the decoding transformers T7 and T8 of Fig. 4, and it is thought a description thereof need not be repeated except to point out that decoding relay R6 is picked up only when code following relay CF4 is operated at the code frequency of 75 cycles per minute, relay R5 is picked up when relay CF4 is operated at either the 50 or 75 code frequency, relay R8 is picked up only when code following relay CF3 is operated at the 75 code frequency, and relay R7 is picked up when relay CF3 is operated at either the 50 or 75 code frequency. The operating circuits governed by the decoding relays for controlling the cab signal CS1 are similar to the operating circuits for signal SW1 of Fig. 4 and these operating circuits of Fig. 5 will be described as the operation of the apparatus of Fig. 5 is pointed out.

Assuming the train on which the apparatus of Fig. 5 is mounted is moving in the normal direction of traffic through the track section W—X of Fig. 4 under clear traffic conditions so that the track circuit is supplied with current impulses of positive polarity and the code frequency of 75, each impulse of track circuit current induces an electromotive force in the windings 22 and 23, which electromotive force is duplicated on an enlarged scale in the secondary windings 32a—32b of transformer T2. The wave form of the electromotive force induced in the secondary windings 32a—32b by each track circuit current impulse is illustrated by the solid line curve of Fig. 12, and this wave form is similar to that illustrated in Fig. 10 in connection with the apparatus of Fig. 2. The connections of transformer T2 of Fig. 5 are so arranged that the top terminal of winding 32a—32b is first positive in potential with respect to the lower terminal during the first half cycle of the induced electromotive force when the track circuit current impulse is of positive polarity. This tends to drive the grid of tube VT2 positive in potential with respect to the filament of that tube, and to drive the grid of tube VT3 negative in potential with respect to the filament of tube VT3. When the grid of tube VT3 is made negative in potential with respect to its filament, the plate circuit of tube VT3 is decreased and the energization of relay CF4 tends to reduce. Since the current impulse lasts for a brief time only (of the order of .005 second), the grid potential returns to zero and the plate current is restored before the code following relay CF4 is released. As stated above, the same half cycle of induced electromotive force drives the grid of tube VT2 positive, so that a grid current flows. This grid current causes a relatively large voltage drop at the control unit 100 comprising resistor 102 and condenser 101, with the result the grid of tube VT2 is made positive in potential with respect to its filament by only a small amount. Condenser 101 is, however, charged due to the flow of grid current. The plate current of tube VT2 is increased correspondingly when the grid of tube VT2 is driven positive in potential, but this only increases energization of relay CF3. When the half cycle of induced electromotive force ceases, the charge on condenser 101 applies a relatively large negative grid potential to tube VT2, and since the charge on condenser 101 can only leak away through resistor 102 the negative potential of the grid of tube VT2 persists for a relatively

long interval. This action of condenser 101 is illustrated by the dotted curve 120 of Fig. 12. The negative grid potential of tube VT2 causes the plate current to be reduced to a value low enough and for an interval long enough that code following relay CF3 is released. The condenser 101 is fully discharged so that the plate current is restored to its normal value and relay CF3 is again picked up before the next impulse of the track circuit current. It follows, therefore, that the above described operation of tube VT2 and the associated code following relay CF3 is repeated for each impulse of the track circuit current, the code following relay CF4 remaining inactive. Operation of relay CF3 at the code frequency of 75 cycles per minute causes relays R7 and R8 to be picked up. By properly proportioning the parts of the control unit 100 and the associated circuits, the interval relay CF3 is released ("on" period) and the interval relay CF3 is picked up ("off" period) during each code cycle of track circuit current are substantially equal. In other words, the effect of the current impulse of relatively short duration is prolonged through the medium of the control unit 100 and tube VT2 to provide satisfactory periods for energizing the decoding transformers and relays. Lamp G of the top group of lamps of signal CS1 is illuminated over front contacts 106 and 107 of relay R8, and lamp R of the bottom group of lamps is illuminated over front contacts 106 and 108 of relays R8 and R7, respectively, so that signal CS1 displays a clear signal indication.

Under approach restricting traffic conditions and the current impulses supplied to the track circuit for section W—X are of negative polarity and of the 75 code frequency, the electromotive force produced in the secondary winding 32a—32b of transformer T2 is opposite in polarity to that described in connection with clear traffic conditions. This time the grid of tube VT3 is made positive in potential with respect to its filament and grid current flows to charge the condenser 105 of the control unit 103. At the termination of the current impulse, condenser 105 discharges slowly through the resistor 104 and provides during this discharge period a negative grid potential for the tube VT3, with the result that the code following relay CF4 is released for an interval. Again, the parts are so proportioned that relay CF4 is operated with substantially each equal "on" and "off" period in response to each code cycle of the track circuit current. With relay CF4 operated at the code frequency of 75 cycles per minute, relays R5 and R6 are picked up and relays R7 and R8 are released. The Y lamp of the top group of lamps is illuminated over front contact 109 of relay R5, and the G lamp of the bottom group of lamps is illuminated over front contact 110 of relay R6 and signal CS1 displays an approach restricting signal indication.

Under approach traffic conditions for the track section W—X, the code of the track circuit current is that of negative polarity and 50 cycles per minute. The relay CF4 is operated in response to each current impulse, the same as before, but this time it is operated at the frequency of 50 cycles per minute and only relay R5 is picked up, the relays R6, R7 and R8 being released. The Y lamp of the top group of lamps is now illuminated over front contact 109 of relay R5, and the R lamp of the bottom group of lamps is illuminated over back contacts 112 and 111 of relays R6 and R7, respectively, so that signal CS1 now displays an approach signal indication.

Under restricting traffic conditions for the section W—X the code of the track circuit current is that of positive polarity and 50 cycles per minute. Relay CF3 is operated in response to each impulse of the track circuit current in the manner explained hereinbefore but at the code frequency of 50 cycles per minute and only relay R7 is picked up, the relays R5, R6 and R8 being released. The R lamp of the top group of lamps is now illuminated over back contact 115 of relay R5, front contact 113 of relay R7 and back contact 119 of relay R8, and the Y lamp of the bottom group of lamps is illuminated over back contact 115 of relay R5, front contact 116 of relay R7 and back contact 117 of relay R8, so that signal CS1 displays a restricting signal indication.

In the event the track section W—X is already occupied and the track circuit is shunted by the leading train, then no electromotive force is induced in the windings 22 and 23 and the code following relays CF3 and CF4 are inactive so that the decoding relays are all deenergized and released. Under this condition of the decoding relays, the R lamp of the top group of lamps is illuminated over back contacts 115, 118 and 119 of relays R5, R7 and R8, respectively. The R lamp of the bottom group of lamps is now illuminated over back contacts 112 and 111 of relays R6 and R7 so that the signal CS1 displays a slow speed signal indication.

It is to be pointed out that when the track circuit current impulses are of relatively large magnitude the first stage amplifier tube VT1 of the apparatus of Fig. 2 and of the apparatus of Fig. 5 may be omitted and the primary winding 30 of transformer T2 connected directly with the inductor windings 22 and 23.

It is to be observed from the foregoing description of the apparatus of Fig. 5 that the most essential part of the electromotive force induced in the windings 22 and 23 by the current impulses of the track circuit is that part tending to drive the grid of tube VT2 or VT3 positive. When the polarity of the impulse is such that the grid of tube VT2 or VT3 is driven negative, the electromotive force is of no use so far as the useful operation of the apparatus is concerned, and is in fact somewhat harmful. It follows, therefore, that the amplifier ahead of tubes VT2 and VT3 is most useful if arranged to amplify most strongly only that part of the incoming electromotive force that tends to drive the grid of tube VT2 or VT3 positive in potential with respect to its filament. This advantageous condition is effected by the apparatus of Fig. 6.

Referring to the train carried apparatus of Fig. 6, the amplifier ahead of the tube VT2 and VT3 comprises two tubes VT5 and VT6 having their grid circuits connected to the secondary winding 121 of a transformer T11 in a push-pull arrangement, the primary winding 122 of transformer T11 being connected with the inductor windings 22 and 23. A resistor R9 is interposed in the grid circuit of tube VT6 and a resistor R10 is interposed in the grid circuit of tube VT5. The plate circuit of tubes VT6 and VT5 are connected with the generator 29 in parallel, a resistor 123 being interposed in the plate circuit of tube VT6 and a resistor 124 being interposed in the plate circuit of tube VT5. The plate circuit of tube VT6 is coupled with the grid of tube VT2 through a condenser C11, and the plate circuit of tube VT5 is coupled with the grid of tube VT3 through a condenser C12. A control unit comprising a condenser C13 and a resistor 125 is connected

between the grid and filament of tube VT2, and in like fashion a control unit comprising a condenser C14 and a resistor 126 is connected between the grid and filament of tube VT3. The code following relays CF3 and CF4 of Fig. 6 are interposed in the plate circuit of tubes VT2 and VT3, respectively, the same as in Fig. 5, and these code following relays govern the decoding relays R5, R6, R7 and R8 in the same manner as in Fig. 5. Also, the decoding relays of Fig. 6 govern the operating circuit for signal CS1, the same as in Fig. 5.

The parts are so proportioned that normally the grids of tubes VT2 and VT3 are of substantially the same potential as the filaments of the tubes, and a relatively large steady value of plate current flows in the respective plate circuits so that relays CF3 and CF4 are both energized and picked up.

Assuming the train on which the apparatus of Fig. 6 is mounted is moving in the normal direction of traffic through the track section W—X of Fig. 4 under clear traffic conditions so that current impulses of positive polarity and of the code frequency of 75 cycles per minute are supplied to the track rails, an electromotive force is induced in windings 22 and 23 which in turn induces an electromotive force in the secondary winding 121 of transformer T11. The connections are so arranged that this electromotive force thus induced in the secondary winding 121 causes during the first half cycle of the wave form of the induced electromotive force the lower terminal of winding 121 to be positive and the top terminal to be negative. I shall first consider the effect of tube VT5 and the associated tube VT3 in response to this electromotive force thus induced in the secondary winding 121. When the crest of the wave form of the electromotive force drives the grid of tube VT5 positive in potential with respect to the associated filament, electrons are attracted to the grid so that grid filament impedance of tube VT5 is lowered, which correspondingly lowers the total impedance of the grid circuit of tube VT5, with the result that the major portion of the impedance of the circuit is now found in the resistor R10 which is proportioned for relatively high voltage resistance. Current flows in the grid circuit and the voltage drop of resistor R10 accounts for the major portion of the voltage applied to the circuit. Therefore the potential of grid of tube VT5 becomes positive with respect to its filament by only a small amount. With the grid of tube VT5 made positive, the plate current on tube VT5 is increased so that the voltage drop of resistor 124 is increased and the potential applied to the plate of tube VT5 is lowered since the voltage of the generator 29 remains constant. This decrease in the potential of the plate of tube VT5 is applied to the grid of tube VT3 through the coupling condenser C12, the potential of the grid of tube VT3 being therefore rendered negative with respect to its filament. The plate circuit current of tube VT3 is in turn reduced. The reduction of the plate current of tube VT3 is small because the electromotive force is not amplified much by the tube VT5 due to the large voltage drop in resistor R10. The resultant reduction in the plate current of tube VT3 is not only relatively small but it lasts only for a short time because of the short duration of the current impulse of the track circuit, with the result that the code following relay CF4 is not released.

I shall now consider the effect of the induced

electromotive force in secondary winding 121 on the tube VT6 and its companion tube VT2. The grid of tube VT6 is rendered negative in potential with respect to its filament by substantially the full crest voltage of the first half cycle of the induced electromotive force because no current flows in the grid circuit of tube VT6. Hence there is a relatively large reduction in the plate circuit current of tube VT6. Since the voltage drop of resistor 123 is made smaller due to the reduction in the plate circuit current of tube VT6, the potential applied to the plate of tube VT6 is increased and a resultant potential of positive polarity is applied to the grid of tube VT2 through the coupling condenser C11. With the grid of tube VT2 rendered positive in potential with respect to its filament, grid current flows in the grid circuit of tube VT2 and condensers C11 and C13 are charged thereby. The positive potential thus applied to the grid of tube VT2 causes a corresponding increase in the plate circuit current of that tube which in turn increases the energization of the relay CF3, and no operation of that relay is at this time effected. When the half cycle of the induced electromotive force ceases, condensers C11 and C13 apply a negative potential to the grid of tube VT2 during the time of its discharge through the resistor 125. The negative potential thus applied to the grid of tube VT2 causes a reduction in the plate current of tube VT2 sufficient to cause the release of relay CF3 since the reduction persists during the discharge of the condensers C11 and C13. Condensers C11 and C13 are discharged and the apparatus restored to its normal condition prior to the expiration of the code cycle interval. It is clear therefore that the code following relay CF3 is operated for each impulse of the track circuit current. The control unit comprising condenser C13 and resistor 125 is so proportioned that substantially equal "on" and "off" periods in the operation of relay CF3 are effected. Since the code frequency of the track circuit current impulses is that of 75 cycles per minute, both relays R7 and R8 are picked up and the cab signal CS1 displays a clear signal indication.

In the event approach restricting traffic conditions exist so that the code of the track circuit current impulses of section W—X is that of negative polarity and 75 cycles per minute, the electromotive force induced in the secondary winding 121 is opposite in polarity to that previously described, and this time the top terminal of winding 121 is positive and its bottom terminal is negative. The positive potential thus applied to the grid of tube VT6 causes grid current to flow and the voltage drop of resistor R9 is large so that the resultant positive potential for the grid of tube VT6 is not large and the resultant increase in the plate circuit current of tube VT6 is not large. Hence the negative potential applied to the grid of tube VT2 through condenser C11 is not large and the resulting reduction of the plate current for tube VT2 is not sufficient to reduce the energization of that relay to a point where it releases, and the reduction lasts for only a brief interval. The negative potential applied to the grid of tube VT5 is amplified and causes a relatively large reduction in the plate circuit current of tube VT5, and a resultant large positive potential is applied to the grid of tube VT3 through condenser C12. Grid current flows for the tube VT3 and condensers C12 and C14 are charged thereby. At the ex-

piration of the current impulse the charge on condenser C14 renders the grid of tube VT3 negative with respect to its filament and the plate circuit current is reduced to a point where the relay CF4 is released, the reduction in the plate circuit current being effected for a relatively long interval during the discharge of condensers C12 and C14 through the resistor 126. It follows therefore that the relay CF4 is operated in response to each current impulse of the track circuit current and the decoding relays R5 and R6 are picked up to cause the cab signal CS1 to display an approach restricting signal indication.

In the event approach traffic conditions exist for the section W—X so that the code of the current impulses is that of negative polarity and a frequency of 50 cycles per minute, the action of the electron tubes is the same as described in connection with approach restricting traffic conditions except the code following relay CF4 is operated at the frequency of 50 cycles per minute and relay R5 only is picked up, with the result that signal CS1 displays an approach signal indication.

In the event restricting traffic conditions exist for the section W—X so that the code of the current impulses is that of positive polarity and a frequency of 50 cycles per minute, the action of the electron tubes is the same as that described under clear traffic conditions except the code following relay CF3 is operated at the frequency of 50 cycles per minute and relay R7 only is picked up with the result that the signal CS1 displays a restricting signal indication.

It is obvious that in the event the track section W—X is already occupied and the track circuit shunted, no electromotive force is induced in the windings 22 and 23 of Fig. 6 and the code following relays CF3 and CF4 remain inactive and the decoding relays are all deenergized and released, with the result that the cab signal CS1 displays a slow speed signal indication.

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

Having thus described my invention, what I claim is:

1. A signal system comprising, a transmitting circuit, means including a code transmitter operative at times to supply to said circuit successive current impulses of unidirectional current and the successive impulses of which are separated by an interval longer than the impulse interval, receiving means receiving energy from said circuit and effectively influenced by each such current impulse, a relay including a contact member which is moved to a selected position in response to a predetermined condition of energization of the relay for a predetermined interval, means including capacitance associated with said receiving means and with said relay to store up energy during each current impulse interval and to give up such energy during the interval between successive current impulses to effect said predetermined condition of energization of said relay for said predetermined interval, and a signaling circuit controlled by said contact member.

2. A signal system comprising, a transmitting circuit, means including a code transmitter operative at times to supply to said circuit a signal current consisting of successive current impulses

of unidirectional current and the successive impulses of which are separated by an interval longer than the impulse interval, receiving means receiving energy from said circuit effectively influenced by each such current impulse, an electromagnetic device, energy storing means including capacitance, means to associate said energy storing means with said receiving means to store up energy in response to each of said current impulses, other means to associate said energy storing means with said electromagnetic device to effect energization of the device by the giving up of such stored energy during the interval between successive current impulses, and signaling means controlled by said electromagnetic device and operated to a selected position in response to such recurrent energization of the device.

3. A signal system comprising, a transmitting circuit, a source of unidirectional current, coding means operable to divide time into successive cycles of a selected interval, means to connect said source to said circuit and controlled by said coding means to supply to said circuit a single effective surge of current each cycle the duration of which surge is relatively short and only a small portion of the cycle interval, receiving means coupled with said circuit effectively influenced by each such current surge, a relay governed by said receiving means and requiring for effective energization a period greater than the duration of such surge of current, a condenser, means to associate said condenser with said receiving means and with said relay to charge the condenser during each current surge and to effect by discharging said condenser during substantially the remaining portion of each cycle interval energization of said relay, and a signal circuit including a contact of said relay.

4. A railway signal system comprising, a track section, a code transmitter having an operation cycle of a selected interval and operating to continuously repeat such cycle, a source of unidirectional current, means controlled by said transmitter to connect said source across the rails of said section to supply to the rails during each operation cycle a single effective current impulse the duration of which is relatively short and is only a small portion of the cycle interval, receiving means receiving energy from the track rails and effectively influenced by each such current impulse, an electroresponsive means including a contact member normally occupying a first position and operated to a second position in response to a predetermined change in the energization of the electroresponsive means, signaling means controlled by said contact member, and means including capacitance associated with the receiving means and with the electroresponsive means to receive a charge in response to each current impulse and to effect said change in the energization of the electroresponsive means by discharging during the remaining portion of each cycle interval.

5. A railway signal system comprising, a track section having a track circuit, a code transmitter having an operation cycle of a selected interval and operating to continuously repeat such cycle, a track battery, traffic controlled means cooperating with said code transmitter to supply from said battery to said track circuit during each said cycle a single effective surge of current of high peak voltage and short duration and which duration is only a relatively small portion of the cycle interval, receiving means receiving energy from the track circuit effectively

influenced by each such current surge, a slow acting relay controlled by said receiving means, a condenser, means to associate said condenser with said receiving means to charge the condenser during each current surge, other means to associate said condenser with said relay to cause energization of the relay during substantially the remaining portion of each cycle interval in response to the discharge of the condenser, and a signal circuit controlled by said relay.

6. A railway signal system comprising, a track section having a track circuit, a code transmitter having an operation cycle of a selected interval and operating to continuously repeat such cycle, a track battery, traffic controlled means cooperating with said code transmitter to supply from said battery to said track circuit during each said cycle a single effective surge of current of high peak voltage and short duration and which duration is only a relatively small portion of the cycle interval, receiving means receiving energy from the track circuit effectively influenced by each such current surge, a circuit controlling electromagnetic device governed by said receiving means and which device is characterized by requiring for effective energization a period greater than the duration of such surge of current, a condenser, means controlled by said receiving means for charging the condenser during each such current surge and for effecting energization of said device during the remaining portion of each cycle interval by discharging said condenser, and a signal circuit controlled by said electromagnetic device.

7. A signal system comprising, a transmitting circuit, a quick acting code following relay having a contact member biased to a first position and operated to a second position when the winding of the relay is effectively energized by a current impulse of a predetermined short duration, means to effectively couple the winding of said relay with said circuit, a condenser, a decoding relay which is picked up when effectively energized for a relatively long period, a source of direct current, means including said contact member at its second position to connect said condenser across said source to charge the condenser, means including said contact member at its first position to connect said condenser across the winding of said decoding relay to energize that relay by the discharge of the condenser, transmitting means including a code transmitter connected with said transmitting circuit and operative to supply at times recurrent current impulses which are of said predetermined short duration and are spaced apart by an interval substantially equal to said relatively long period to operate the code following relay for causing periodic energization of said decoding relay for said relatively long period, and signaling means controlled by said decoding relay.

8. A signal system comprising, a transmitting circuit, a polar code following relay having a polar contact member biased to a first position and operated to a second position only when the winding of said relay is energized by current of a selected polarity, means to effectively couple the winding of said relay with said circuit, a condenser, a decoding relay which is operated when energized for a relatively long period, a source of direct current, means including said contact member at its second position to connect said condenser across said source to charge the condenser, means including said contact member at its first position to connect said condenser across the winding of said decoding relay to energize

that relay by the discharge of the condenser, transmitting means including a code transmitter connected with said transmitting circuit and operative to supply recurrent current impulses of said selected polarity and short duration but which are spaced apart by an interval substantially equal to said relatively long period to operate the code following relay for periodically energizing said decoding relay for said relatively long period, and signaling means controlled by said decoding relay.

9. A signal system for railways comprising, a track section having a track circuit, a source of unidirectional current, traffic controlled coding means operative to divide time into successive cycles of a given interval and to supply under a given traffic condition from said source to said track circuit a single effective current impulse during each cycle, said impulses all of one polarity and each impulse of only a relatively small portion of the cycle interval, a polar code following relay having a polar contact member biased to a first position and operated to a second position only when the winding of the relay is energized by current of a selected polarity, means to couple the winding of said relay with said track circuit as required for operation of said contact member by each said current impulse, a condenser, a slow acting relay, means including the second position of said contact member to connect said condenser across a source of direct current to charge the condenser, means including the first position of said member to connect said condenser with the winding of said slow acting relay to energize that relay by the discharge of the condenser, and signaling means governed by said slow acting relay.

10. A railway signal system comprising, a track section, a source of unidirectional current, traffic controlled coding means operative to supply from said source to the rails of said section recurrent current impulses of one polarity under a first traffic condition and recurrent current impulses of the opposite polarity under a second traffic condition, a first and a second code following relay each provided with a contact member biased to a first position and operated to a second position when the winding of the associated relay is effectively energized, means to couple the windings of said relays with the track rails of said section as required to effectively energize said first relay only by the current impulses of said one polarity and to effectively energize said second relay only by the current impulses of said opposite polarity, a first and a second condenser, a first and a second decoding relay, a source of direct current, means to connect said first condenser across said direct current source over the second position of the contact member of said first code following relay and to connect said second condenser across that source over the second position of the contact member of said second code following relay, means to connect said first condenser with the winding of said first decoding relay over the first position of the contact member of said first code following relay and to connect said second condenser with the winding of said second decoding relay over the first position of the contact member of said second code following relay, and a signal having a first and a second indication selectively governed by said decoding relays.

11. A railway signal system comprising, a track section, trackway coding means operative at times to supply to the rails of said section coded

direct current of a given polarity, said coded current consisting of current impulses each of relatively high peak voltage and short duration and the successive impulses separated by an interval longer than the impulse duration, a train carried receiving circuit receiving energy from the track rails, a train carried electron tube provided with a plate circuit including a code following relay and having its grid circuit coupled with said receiving circuit as required to apply a positive potential to the grid in response to each of said current impulses, means for normally creating a negative bias on the grid of said tube to establish substantially zero plate current for effectively energizing said relay only during the interval energy is received by said receiving circuit in response to each of said current impulses, a condenser and a slow acting decoding relay mounted on the train, means to connect said condenser across a source of direct current over a front contact of said code following relay to charge the condenser during each of said current impulses, means to connect said condenser with said decoding relay over a back contact of the code following relay to energize the decoding relay by the discharge of the condenser during each interval between successive current impulses, and a signal controlled over a contact of said decoding relay.

12. A railway signal system comprising, a track section, trackway apparatus operative under one traffic condition to supply to the rails of said section a first code current and under another traffic condition to supply to the rails a second code current, said coded currents each consisting of recurrent current impulses of relatively short duration with the impulses of the first code all of positive polarity and the impulses of the second code all of negative polarity, a train carried receiving circuit inductively receiving energy from the track rails and including the primary winding of an input transformer, a first and a second electron tube having plate circuits with a first code following relay interposed in the plate circuit of the first tube and a second code following relay interposed in the plate circuit of the second tube, means to connect the grids of said tubes with a secondary winding of said transformer in a push-pull arrangement, a biasing battery interposed in the connection between the cathodes of said tubes and the center terminal of said secondary winding to create a negative bias for the grids of said tubes to effect substantially zero plate circuit current, said transformer windings disposed so that the first half cycle of the electromotive force induced in the secondary winding in response to each rail current impulse of positive polarity renders the grid of said one tube positive in potential with respect to its cathode to cause plate current to flow for that tube and operate said first relay in step with the first code current and the first half cycle of the electromotive force induced in the secondary winding in response to each rail current impulse of negative polarity renders the grid of said second tube positive in potential with respect to its cathode to cause plate current to flow for that tube and operate said second relay in step with the second code current, and train carried decoding and signaling means selectively controlled by such operation of said code following relays.

13. A railway signal system comprising, a track section, trackway apparatus operative under one traffic condition to supply to the rails of said section a first code current and under

another traffic condition to supply to the rails a second code current, said coded currents each consisting of recurrent current impulses of relatively short duration with the impulses of the

5 first code all of positive polarity and the impulses of the second code all of negative polarity, a train carried receiving circuit inductively receiving energy from the track rails and including the primary winding of an input transformer, a

10 first and a second electron tube having plate circuits with a first code following relay interposed in the plate circuit of the first tube and a second code following relay interposed in the plate circuit of the second tube, means to connect the grids of said tubes with a secondary

15 winding of said transformer in a push-pull arrangement, a biasing battery interposed in the connection between the cathodes of said tubes and the center terminal of said secondary winding to create a negative bias for the grids of said tubes to effect substantially zero plate circuit current, said transformer windings disposed so that the first half cycle of the electromotive

20 force induced in the secondary winding in response to each rail current impulse of positive polarity renders the grid of said one tube positive in potential with respect to its cathode to cause plate current to flow for that tube and operate said first relay in step with the first

25 code current and the first half cycle of the electromotive force induced in the secondary winding in response to each rail current impulse of negative polarity renders the grid of said second tube positive in potential with respect to its

30 cathode to cause plate current to flow for that tube and operate said second relay in step with the second code current, train carried decoding and signaling means selectively controlled by such operation of the code following relays, and

35 an auxiliary biasing unit including a condenser and a resistor in multiple connected in series with said biasing battery.

14. A signal system comprising, a first and a second polar code following relay each provided with a contact member biased to a first

45 position and operated to a second position only when the winding of the associated relay is energized with current of a selected polarity, decoding means controlled over said contact members for selectively operating a signal, an electron tube, an output transformer, a plate circuit for said tube including a source of current and the primary winding of said transformer, a first

50 secondary winding of said transformer connected with the winding of said first relay and poled to operate that relay when an electromotive force of normal polarity is induced in that winding, a second secondary winding of said transformer connected with the winding of said second relay

55 and poled to operate that relay when an electromotive force of reverse polarity is induced in that winding, an input transformer, a grid circuit for said tube including a winding of said input transformer, biasing means interposed in

60 said grid circuit to establish a potential of the grid of the tube with respect to the cathode effective to cause a selected value of plate circuit current so that an increase in grid potential increases the plate current and induces in said

65 secondary windings electromotive forces of normal polarity to operate said first relay and a decrease in grid potential decreases the plate current and induces in said secondary windings electromotive forces of reverse polarity to operate said second relay, and transmitting means

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coupled with a winding of said input transformer for at times supplying recurrent current impulses of a polarity as required to increase the grid potential and for at other times supplying recurrent current impulses of a polarity as required to decrease the grid potential.

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15. A railway signal system comprising, a track section, a source of direct current, coding means for reversibly coupling said source with the rails of the sections to supply a first or a second code

10 current according to a first or a second traffic condition, said first code current consisting of recurrent current impulses of relatively short duration and high peak voltage with the successive impulses separated by an interval longer

15 than the impulse duration and the impulses all of one polarity, said second current impulses consisting of such current impulses but all of the opposite polarity, a train carried receiving circuit receiving energy from the track rails, a first

20 and a second electron tube having their grid circuits coupled with said receiving circuit in a push-pull arrangement and having their plate circuits arranged in parallel with a first code following relay interposed in the plate circuit

25 of the first tube and a second code following relay interposed in the plate circuit of the second tube, said grid circuits normally conditioned to create grid potentials substantially equal to that of the cathodes to produce a steady value of

30 plate current for each tube, a first and a second control unit each comprising a condenser and a resistor in multiple, said first unit interposed in the grid circuit of the first tube adjacent the grid of that tube and said second unit interposed

35 in the grid circuit of the second tube adjacent the grid of that tube, said receiving and grid circuits poled as required to create a positive grid potential for the first tube during each rail current impulse of said one polarity to cause grid

40 current to flow to charge the condenser of said first unit and to create a positive grid potential for the second tube during each rail current impulse of said opposite polarity to cause grid current to flow to charge the condenser of said

45 second unit, said condensers when thus charged effective to create a negative grid potential for the respective tube and to discharge through the associated resistor during the interval between successive rail current impulses to cause an operation of the associated code following relay, and decoding means selectively controlled by such operation of the code following relays.

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16. A railway signal system comprising, a track section, a source of direct current, coding means for reversibly coupling said source with the rails of the sections to supply a first or a second code

55 current according to a first or a second traffic condition, said first code current consisting of recurrent current impulses of relatively short duration and high peak voltage with the successive impulses separated by an interval longer than the impulse duration and the impulses all of one polarity, said second current impulses

60 consisting of such current impulses but all of the opposite polarity, a first and a second electron tube mounted on a train having grid circuits of a push-pull arrangement and plate circuits with a first code following relay interposed in the plate circuit of the first tube and a second code following relay interposed in the plate circuit of

65 the second tube, said grid circuits normally conditioned to create grid potentials effective to produce a steady value of plate current for each tube, a first and a second control unit each com-

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prising a condenser and a resistor in multiple, said first unit interposed in the grid circuit of the first tube adjacent the grid of that tube and said second unit interposed in the grid circuit of the second tube adjacent the grid of that tube, train carried receiving means to inductively couple said grid circuits with the track rails and so arranged as to create positive grid potential for the first tube by the first half cycle of the electromotive force induced in the grid circuits by each current impulse of said first code current to charge the condenser of said first unit and to create positive grid potential for the second tube by the first half cycle of the electromotive force induced in the grid circuit by each current impulse of said second code current to charge the condenser of said second unit, said condensers when thus charged to create a negative grid potential for the respective tube and to discharge through the resistor of the same unit during the interval between successive impulses of code current to cause operation of the associated code following relay for each impulse of the code current, a slow acting decoding relay for each code following relay effectively energized when the respective code following relay is operated, and signaling circuits selectively governed by the decoding relays.

17. A railway signal system comprising, a track section, a source of direct current, coding means for reversibly coupling said source with the rails of the sections to supply a first or a second code current according to a first or a second traffic condition, said first code current consisting of recurrent current impulses of relatively short duration and high peak voltage with the successive impulses separated by an interval longer than the impulse duration and the impulses all of one polarity, said second current impulses consisting of such current impulses but all of the opposite polarity, a first and a second electron tube mounted on a train having grid circuits of a push-pull arrangement and plate circuits with a first code following relay interposed in the plate circuit of the first tube and a second code following relay interposed in the plate circuit of the second tube, said grid circuits normally conditioned to create grid potentials effective to produce a steady value of plate current for each tube, a first and a second control unit each comprising a condenser and a resistor in multiple, said first unit connected across the grid and cathode of the first tube and said second unit connected across the grid and cathode of the second tube, a train carried receiving circuit inductively receiving from the track rails in response to each current impulse of said code currents an electromotive force the first half cycle of which tends when the current is of the first code to create a positive potential for the grid of the first tube and a negative potential for the grid of the second tube and tends when the current is of the second code to create a positive potential for the grid of the second tube and a negative potential for the grid of the first tube, amplifying means interposed between said receiving and grid circuits effective to amplify at high gain only that portion of such electromotive forces that tends to create positive potential for said first or second tube, said first control unit effective in response to such recurrent periods of positive grid potential for the first tube to create negative grid potential during the interval between such recurrent periods to cause operation of the first code following relay in step with

the first code current, said second control unit effective in response to such recurrent periods of positive grid potential for the second tube to create a negative grid potential during the interval between such recurrent periods to cause operation of the second code following relay in step with the second code current, and decoding means selectively controlled by such operation of the code following relays.

18. In combination with a section of railway track, a reactance device including a winding mounted on a magnetic core and a condenser, means to connect a portion of said winding across the track rails to form an oscillatory track circuit for said section, a source of unidirectional current, means to periodically connect said source to said device to store up energy therein and to periodically disconnect said source from said device to cause current of a damped wave to flow in said circuit, and a relay connected with said rails effectively energized by such current wave.

19. In combination with a section of railway track, a track relay connected across the rails at one end of the section, a reactance device including a winding mounted on a magnetic core and a condenser connected across said winding, means to connect a selected portion of said winding across the rails at the other end of said section, said reactance device so proportioned as to form an oscillatory track circuit for said section, a source of unidirectional current, and means to periodically connect said source with said device to store up energy therein and to periodically disconnect said source from said device to cause current of a damped wave to flow in said track circuit to effect substantially the same average energization of the track relay for both dry and wet ballast conditions.

20. In combination with a section of railway track, a track relay connected across the rails at one end of the section, a reactance device including a winding mounted on a magnetic core and a condenser connected across said winding, means to connect a selected portion of said winding across the rails at the other end of said section, said reactance device so proportioned as to form an oscillatory track circuit for said section, a source of unidirectional current, and means to periodically connect said source with said device to store up energy therein and to periodically disconnect said source from said device to supply to said track circuit current impulses having high peak voltage and a damped wave to effect when the section is unoccupied substantially the same average energization of the track relay under all weather conditions and to break down the rail film resistance as an aid to shunting when the section is occupied.

21. In combination with a section of railway track, a track relay connected across the rails at one end of the section, a reactance device including a winding mounted on a magnetic core and a condenser connected across said winding, means to connect a selected portion of said winding across the rails at the other end of said section, said reactance device so proportioned as to form an oscillatory track circuit for said section, a source of unidirectional current, and means to periodically connect said source with said device to store up energy therein and to periodically disconnect said source from said device to supply to said circuit current impulses of high peak voltage and a damped wave to effect when the section is unoccupied substantially the

same average energization of the track relay under all weather conditions and to cause when the section is occupied by a train a current surge of relatively high amperage as an aid in inductively transferring energy to signaling apparatus carried on the train.

22. In combination with a section of railway track, a polar track relay having its winding connected across the rails at one end of the section and having its armature biased for operation only in response to current of a selected polarity flowing in its winding, a reactance device including a winding mounted on a magnetic core and a condenser connected across said winding, means to connect a portion of said winding across the rails at the other end of said section to form an oscillatory track circuit for said section, a source of unidirectional current, and means to periodically connect said source with said device to store energy therein and to periodically disconnect said source from said device to cause current of a damped wave to flow in said track circuit and the first half cycle of which current wave is of said selected polarity to operate the armature of the track relay when the section is unoccupied and is of relatively high peak voltage to effect when the section is occupied by a train a current surge of relatively high amperage to aid in inductive transfer of energy to train carried signal apparatus.

23. In combination with a section of railway track, a track relay having its winding connected across the rails at one end of the section and having a contact member biased to a first position and operated to a second position in response to energization of its winding, means including a code transmitter connected across the rails at the other end of the section to supply to the rails recurrent current impulses for periodically energizing the winding of said track relay, a condenser, a slow acting decoding relay, a source of direct current, means including said contact member at its second position to connect said condenser across said source to charge the con-

denser, and means including said contact member at its first position to connect said condenser across the winding of said decoding relay to effectively energize the decoding relay in response to the recurrent current impulses supplied to the track rails.

24. In combination, a first and a second track section, means including a source of unidirectional current and a coding mechanism connected to the rails at one end of said first section and operative to supply current of four different codes for four different traffic conditions respectively, said first code consisting of current impulses of positive polarity and a first code frequency, said second code consisting of current impulses of negative polarity and said first code frequency, said third code consisting of current impulses of negative polarity and said second code frequency and said fourth code consisting of current impulses of positive polarity and said second code frequency, a first and a second polar code following relay each provided with contact members biased to a first position and operated to a second position only when the winding of the associated relay is energized by current of a selected polarity, means to connect the windings of said relays with the rails of said first section so that said first relay is operated by current impulses of positive polarity and said second relay is operated by current impulses of negative polarity, a slow release control relay controlled over a contact member of said first relay, another source of unidirectional current; circuit means connected to the rails of said second section and including said other source, pole changing contacts of said control relay and a contact member of each of said first and second code following relays to supply to the rails of the second section current impulses of the same code as supplied to the rails of the first section; and receiving and decoding means connected to the rails of the second section selectively responsive to said four different codes.

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