April 16, 1940. W. P. PLACE 2,197,417

SIGNALING SYSTEM

Filed March 14, 1939 2 Sheets-Sheet 1

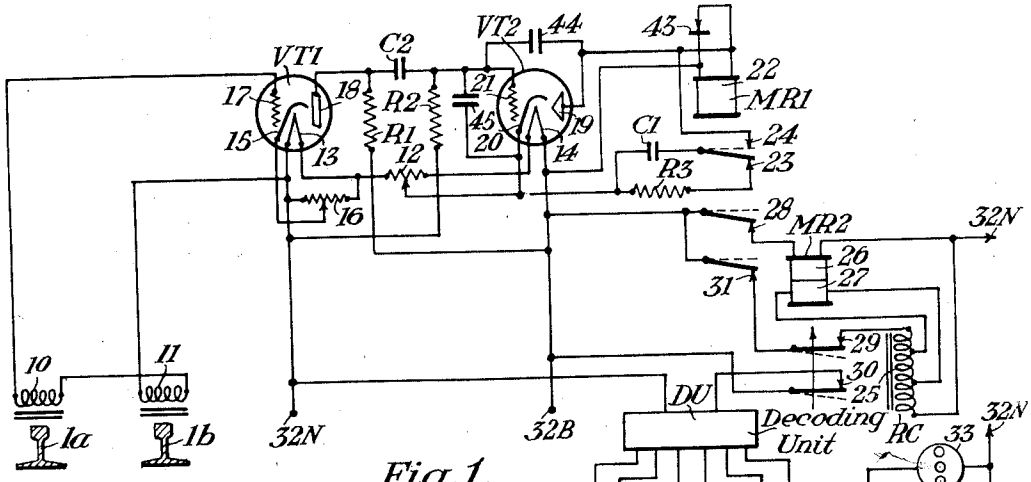



Fig.1.

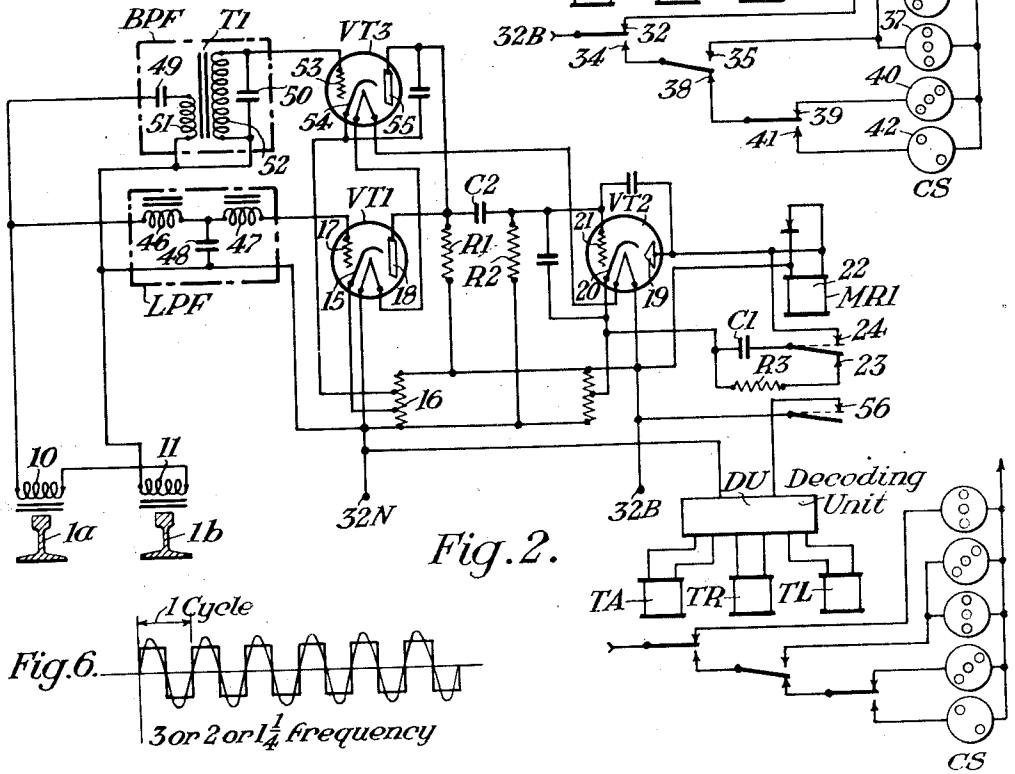



Fig.2.




Fig.6.

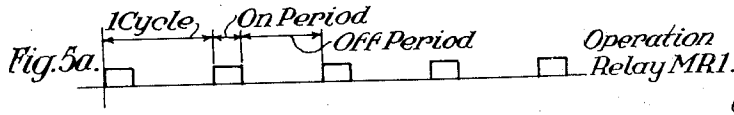



Fig.5a.

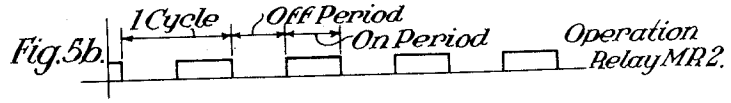



Fig.5b.

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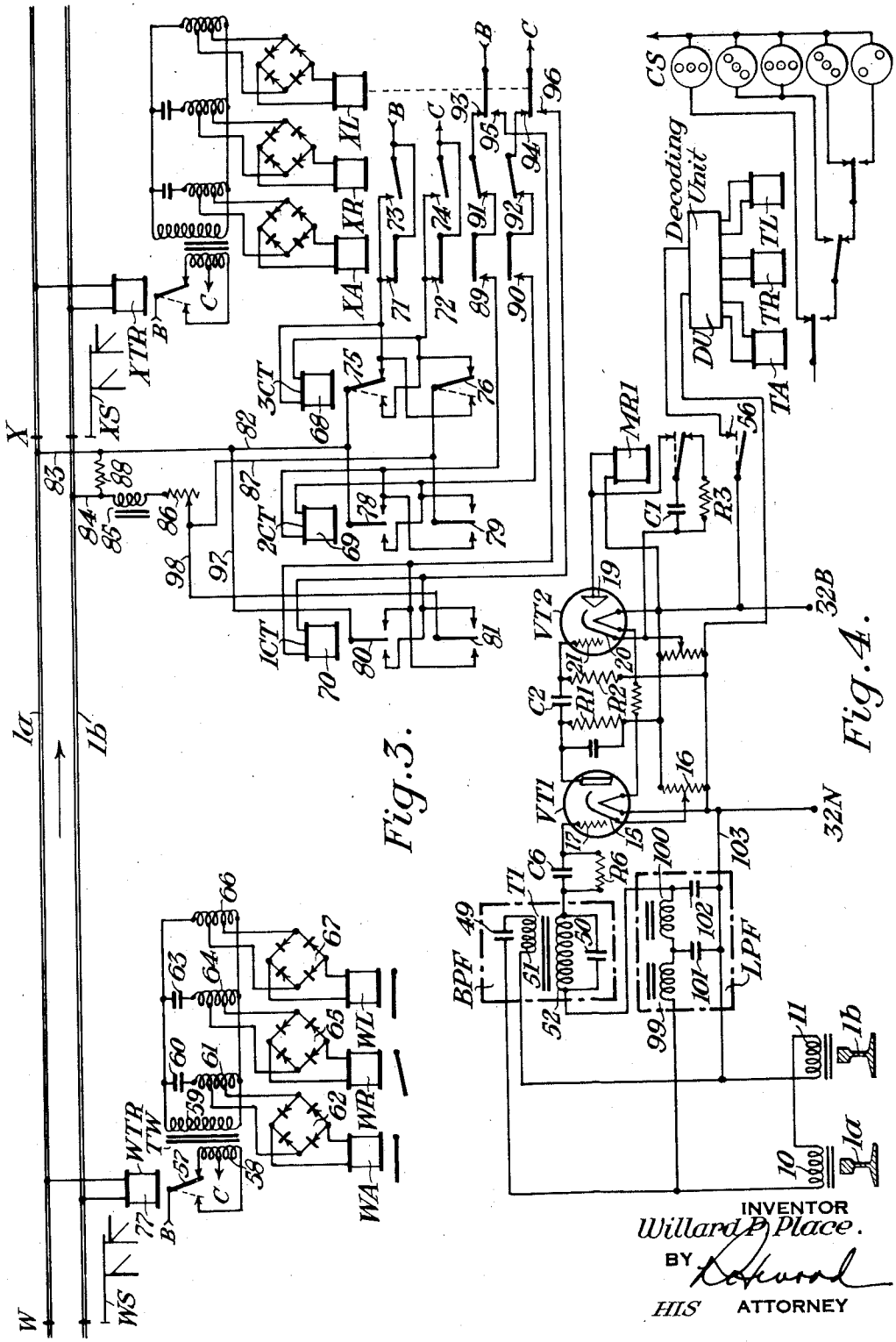



Fig. 3.

Fig. 4.

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2,197,417

# UNITED STATES PATENT OFFICE

2,197,417

## SIGNALING SYSTEM

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Application March 14, 1939, Serial No. 261,737

10 Claims. (Cl. 246—63)

My invention relates to signal systems, and more particularly 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 contemplated of novel and improved means for operating a code following relay or other electro-magnetic device in step with signaling currents of different code rates, each code rate being predetermined to reflect a given control condition. When apparatus embodying my invention is used for signal systems for railways, another feature of the invention is the provision of novel and improved train carried apparatus responsive both to the coded alternating current now in general use in cab signal systems by railways, and to alternating current of different low frequencies, such low frequencies being, for example, of the order of the code rates impressed upon the standard 100 cycle alternating current of the present day cab signal systems. Hence a train equipped with such apparatus can be used with either a first territory of a railway where the track circuits are supplied with alternating current of a given frequency such as 100 cycles per second coded at predetermined code rates or with a second territory of the railway where the track circuits are supplied with alternating currents of different frequencies which are equal to said code rates.

Still another feature of my invention is the provision of novel and improved means for signal systems of the type here involved, wherewith low voltage electron tubes may be used in the receiving apparatus. Again, when long track circuits are used a feature of the invention is the provision of novel and improved means wherewith code distortion is eliminated and broken rail protection to a greater degree is assured. Other features and advantages of my invention will appear as the specification progresses.

In the accompanying drawings, Fig. 1 is a diagrammatic view of one form of apparatus embodying my invention when used as the train carried apparatus of a low power current impulse type of railway cab signal system. Figs. 2 and 3 are diagrammatic views of another form of apparatus embodying my invention when used for a combined wayside and cab signal system for railways, Fig. 2 being the train carried portion of the apparatus and Fig. 3 being the trackway portion of the apparatus, and wherein the train carried apparatus of Fig. 2 is provided with two receiving channels one responsive to alternating current of say, for example, 100 cycles per second coded at different code rates and the other channel responsive to alternating currents of frequencies equal to said code rates. Fig. 4 is a diagrammatic view of a modified form of the train carried apparatus of Fig. 2, also embodying the invention. Figs. 5*a* and 5*b* are diagrams of operating characteristics of the apparatus of Fig. 1. Fig. 6 is a diagram of operating characteristics of the apparatus of Fig. 3.

In each of the several views like reference characters designate similar parts.

Referring to Fig. 1, the train carried apparatus includes as essential elements two inductors 10 and 11, an amplifying electron tube VT1, a detector electron tube VT2, two code following relays MR1 and MR2, a deionizing unit comprising a condenser C1 and a resistor R3, a reactance unit RC, a decoding unit DU and a cab signal CS, together with a suitable source of current.

The inductors 10 and 11 are mounted on the train in inductive relation with the track rails 1*a* and 1*b*, respectively, for inductively receiving energy in response to current impulses flowing in the rails, the track rails 1*a* and 1*b* being the rails of the track over which the train equipped with the apparatus of Fig. 1 is moving. Inductors 10 and 11 are connected in accordance with usual practice so that electromotive forces induced therein by current flowing in the rails in opposite directions are additive.

The amplifying tube VT1 is preferably of the high vacuum type adaptable of operation at low plate voltage. The detector tube VT2 is preferably of the controlled ionization type adaptable of operation at low plate or anode voltage. As here shown both tubes VT1 and VT2 are of the indirect heater type.

The reference characters 32B and 32N designate the positive and negative terminals, respectively, of a suitable source of direct current such as a battery or generator not shown, the voltage of the source being of relatively low voltage such as of the order of 32 volts.

The filaments 13 and 14 of the respective tubes VT1 and VT2 are serially connected in a circuit receiving current from the terminals 32B and 32N, a resistor 12 being interposed in this circuit to effect proper heating of the tubes. Inductors 10 and 11 which are connected together in the manner stated hereinbefore, are connected in a grid circuit for the first stage tube VT1, by virtue of the left-hand terminal of inductor 10 being connected with the grid 17 of tube VT1 and the left-hand terminal of inductor 11 being

connected to the negative side of filament 13 of the tube, and by the cathode 15 of tube VT1 being connected to a mid terminal of a resistor 16 connected in multiple with filament 13. This connection of cathode 15 provides a desired biasing potential of grid 17 with respect to the cathode 15. The plate circuit of tube VT1 extends from positive terminal 32B of the current source over a resistor R1, plate 18 of tube VT1, tube space to cathode 15, the left-hand portion of resistor 16 and then to the negative terminal 32N of the current source. The parts are preferably adjusted so that tube VT1 operates on the straight line portion of the grid-voltage plate current characteristic.

The detector tube VT2 is of the controlled ionization type having an anode 19, a cathode 20 and a control grid 21 as well as the filament 14 the latter of which is heated in the manner pointed out hereinbefore. The grid 21 of tube VT2 is electrostatically coupled with the plate circuit of tube VT1 through a coupling condenser C2 and a resistor R2 in the well known manner. The plate or anode circuit of tube VT2 involves terminal 32B, winding 22 of a code following relay MR1, anode 19, tube space to cathode 20, a mid terminal and left-hand portion of resistor 12, resistor 16 in multiple with filament 13 of tube VT1 and terminal 32N of the current source. The parts are so proportioned that the normal bias potential of grid 21 with respect to cathode 20 causes the anode circuit to be ineffective to create ionization for the tube VT2, so that the tube is non-conductive and code following relay MR1 is denergized and released.

A condenser C1 and a resistor R3 are associated with tube VT2 to form a deionizing unit for that tube. Resistor R3 is connected across condenser C1 over back contact 23 of relay MR1 and condenser C1 is connected across anode 19 and cathode 20 of tube VT2 over a front contact 24 of relay MR1. The manner of operating the code following relay MR1 when an electromotive force is periodically applied to the grid 21 of tube VT2, and the manner of deionizing the tube VT2 subsequent to each such electromotive force will be pointed out when the operation of the apparatus is explained.

Another or second code following relay MR2 is governed over the back contact 28 of code following relay MR1, and a reactance unit RC. The unit RC preferably consists of a winding 25 mounted on a magnetic core and is controlled over back contact 31 of code following relay MR1. The code following relay MR2 is provided with a first or top winding 26 and with a second or lower winding 27. At such time as relay MR1 is released closing back contact 28, the relay MR2 is energized and picked up by virtue of a circuit including terminal 32B, back contact 28, top winding 26 of relay MR2 and terminal 32N. The winding 25 of reactance unit RC is energized over a circuit involving terminal 32B, back contact 31 of relay MR1, front contact 29 of relay MR2, winding 25 and terminal 32N. A portion of winding 25 is connected across the lower winding 27 of relay MR2 to cause, as will shortly appear, a delay in the picking up of relay MR2 when relay MR1 is being operated.

The code following relay MR2 controls frequency decoding unit DU which may be of standard type, the input side of the decoding unit DU being controlled over a circuit receiving current from terminals 32B and 32N and which circuit includes front contact 30 of relay MR2. Hence, current impulses are supplied to the decoding units DU at a rate corresponding to the rate at which the code following relay MR2 is operated.

In accordance with usual practice a relay TA connected with the output side of decoding unit DU is effectively energized and picked up only when the relay MR2 is operated at a predetermined code rate which I shall assume for illustration to be 180 cycles per minute or 3 cycles per second. A relay TR connected with the output side of decoding unit DU is effectively energized and picked up only when code following relay MR2 is operated at a different predetermined code rate which I shall assume for illustration to be 120 cycles per minute or 2 cycles per second. Also, a relay TL connected with the output side of unit DU is effectively energized and picked up when code following relay MR2 is operated at either of the code rates of 2 or 3 cycles per second and also when relay MR2 is operated at a third predetermined code rate which latter code rate I shall assume for illustration to be 75 cycles per minute or 1¼ cycles per second.

The relays TA, TR and TL govern the operating circuits of a cab signal CS here shown as of the position light type. When relay TA is picked up closing front contact 32 a circuit for lamp 33 is closed and lamp 33 is illuminated so that signal CS displays a clear signal indication. When relay TA is released closing back contact 34 and relay TR is picked up closing front contact 35, the two lamps 36 and 37 of signal CS are illuminated to display an approach medium indication. When both relays TA and TR are released closing the respective back contacts 34 and 38, and relay TL is picked up closing front contact 39, a lamp 40 of signal CS is illuminated to display an approach signal indication. Again, when all three relays TA, TR and TL are released closing respective back contacts 34, 38 and 41, a lamp 42 of signal CS is illuminated to display a slow speed signal indication.

As stated hereinbefore, the train carried apparatus of Fig. 1 is adaptable of use with a low power current impulse signal system, such as, for example, described in my copending application Serial No. 222,833, filed August 3, 1938 for Signal systems. Specifically, the train carried apparatus of Fig. 1 is adaptable of cooperating with the trackway apparatus of Fig. 10 of my aforementioned copending application Serial No. 222,883, and by which trackway apparatus the track rails 1*a* and 1*b* of a track section of a stretch of railway is supplied with impulses of direct current at the code rates of 180, 120 and 75 cycles per minute according to different traffic conditions in advance of the section. A single current impulse of direct current is supplied to the track rails each code cycle, each current impulse being of relatively high peak voltage and of short duration, the duration of the impulse being only a small portion of the code cycle. Reference is made to said copending application Serial No. 222,883 for a full description of such trackway apparatus and it is sufficient for the instant application to point out that under either clear traffic conditions or approach medium traffic conditions in advance of a track section the track rails 1*a* and 1*b* of that section are supplied with current impulses of 180 code rate. When approach traffic conditions exist in advance of that section the track rails are supplied with current impulses of the 120 code rate,

and when the section immediately in advance of the section is occupied the track rails are supplied with current impulses of the 75 code rate, and when a train already occupies the track section the current impulses are shunted by the leading train.

In describing the operation of the apparatus of Fig. 1, I shall first assume that direct current impulses of the code rate of 180 are supplied to the track rails 1a and 1b, which is the code rate used to reflect clear traffic conditions. Each direct current impulse induces electromotive forces in inductors 10 and 11, which electromotive forces add their effects and the resultant electromotive force is applied to the grid of the amplifying tube VT1 so that the wave form of the electromotive force is reproduced on an enlarged scale in the plate circuit of tube VT1. Since each current impulse is in effect a single surge of direct current, the induced electromotive force has a single cycle wave form, the first half cycle of which is of relatively large amplitude and the second half cycle of which is of relatively small amplitude. The connections are such that the first half cycle of the wave form of the electromotive force as reproduced in the plate circuit of tube VT1, causes the grid 21 of tube VT2 to be more positive in potential with respect to cathode 20 with the result that tube VT2 ionizes and becomes conductive. When tube VT2 becomes conductive and current flows in its anode circuit the code following relay MR1 is energized and picked up. With relay MR1 picked up closing front contact 24 condenser C1 is connected directly across the anode 19 and cathode 20. The anode current which has been flowing through the tube VT2 is diverted and for an instant flows through condenser C1. During this instant the potential of anode 19 with respect to the cathode 20 is reduced to substantially zero and tube VT2 deionizes and is restored to its nonconductive condition. When condenser C1 has been fully charged current ceases to flow and relay MR1 is deenergized and released, closing back contact 23 to connect resistor R3 across condenser C1. Condenser C1 is quickly discharged through resistor R3 and made ready for the next operation of relay MR1 in response to the next electromotive force caused by the next current impulse flowing in the rails 1a and 1b. A rectifier 43 may be connected in shunt across winding 22 of relay MR1 to dissipate the energy stored in the magnetic circuit of that relay when current is flowing and thereby prevent voltage surges which might otherwise tend to cause tube VT2 to again ionize when the current flow is being diverted by condenser C1. Condensers 44 and 45 may be provided and connected across the elements of tube VT2 in the manner shown in Fig. 1 to improve the operation of the tube. It should be noted that since there is no current flow in tube VT2 until a breakdown begins, condensers 44 and 45 do not make the circuits unstable, condensers 44 and 45 being effective to insure that once conduction of tube VT2 is started it is carried on to completion. However, condensers 44 and 45 may not be needed. It should also be noted that the second half cycle of the wave form of the induced electromotive force as reproduced in the plate circuit of tube VT1 increases the negative potential of grid 21 of tube VT2 with respect to its cathode 20 and hence tends to prevent ionization of that tube by the second half cycle of the electromotive force.

It follows that code following relay MR1 is operated once for each current impulse supplied to the track rails 1a and 1b, the time relay MR1 is picked up being, however, only a small portion of the code cycle interval of the track circuit current. In Fig. 5a this operating characteristic of code following relay MR1 is illustrated, the period relay MR1 is picked up during each code cycle being indicated as the "on" period of the relay and the period the relay is released during each code cycle being indicated as the "off" period for the relay.

When the current impulses supplied to the rails 1a and 1b are of either the 120 or 75 code rate, the operation of the apparatus of Fig. 1 is similar to that thus far explained in connection with the code rate of 180 except the "on" period of the relay MR1 is a somewhat smaller portion of each code cycle because the time required to deionize tube VT2 and deenergize relay MR1 is the same under each code.

Consequently, the code following relay MR1 is operated at a code rate which corresponds to the code rate of the current impulses supplied to the track rails of the section occupied by the train but with unequal "on" and "off" periods. It should be noted that because both the normal grid bias potential and anode voltage of tube VT2 are derived from the same source of current, operation of tube VT2 is immune to a reasonable amount of variation in the voltage of the current source.

Since the operation of a decoding unit of the standard forms in present day use is most satisfactory when the "on" and "off" periods of the impulses supplied thereto are substantially equal, I provide the second code following relay MR2 and reactance unit RC for controlling the impulses supplied to unit DU. With relay MR1 released closing back contact 28 relay MR2 is energized and picked up causing winding 25 of unit RC to be energized and magnetic energy stored in the reactance unit RC. When relay MR1 is picked up for a brief period in response to ionization of tube VT2 because of a current impulse flowing in the track rails, the circuits to the top winding 26 of relay MR2 and to the winding 25 of reactance unit RC are both opened. The decay of the magnetic energy stored in reactance unit RC causes current to flow in the lower winding 27 of relay MR2. The connection of winding 27 is such that the flux set up in relay MR2 by the current flowing in winding 27 due to the decay of magnetic energy in unit RC opposes the flux set up by the current flowing in winding 26 of the relay so that relay MR2 is quickly released. When relay MR1 is shortly released in response to the deionization of tube VT2 the top winding 26 of relay MR2 is reenergized but the building up of flux in relay MR2 by current flowing in winding 26 is at first opposed by the flux created by the current flowing in winding 27. The current supplied to winding 27 gradually falls to zero due to the dying away of the energy stored in the reactance device RC so that after a brief period the flux created by winding 26 prevails and relay MR2 is again picked up. The parts are so proportioned that the delay thus effected in the picking up of relay MR2 provides substantially equal "on" and "off" periods in the operation of relay MR2 with the result that the current impulses supplied to the coded unit DU over front contact 30 of relay MR2 have substantially equal "on" and "off" periods. This operation of relay MR2 with respect to the operation of relay MR1 is illustrated by Fig. 5b. It should

be noted that when relay MR1 is operated at the lower code rate of 120 and 75 cycles per minute the magnetic energy stored in the reactance unit RC is within limits built up to a higher level than at the higher code rate of 180 cycles per minute and as a consequence the energization of winding 27 effected during the decay of the stored magnetic energy in unit RC is able to hold relay MR2 released a longer time at the lower code rates so that substantially equal "on" and "off" periods in the operation of relay MR2 occur at each of the code rates of 180, 120 and 75 cycles per minute.

From the foregoing description of the operation of the apparatus of Fig. 1, it is clear that relay TA is picked up and a clear signal is displayed by the cab signal CS in response to current impulses of the code rate of 180 cycles per minute flowing in rails 1a and 1b and which code rate is used to reflect clear traffic conditions. Relay TR is picked up and an approach medium signal is displayed by the signal CS in response to current impulses of 120 cycles per minute and which code rate is used to reflect approach medium traffic conditions. Relay TL is also picked up in response to current impulses of the code rate of 75 cycles per minute so that an approach signal is displayed by the signal CS. Again, when the current impulses supplied to the track rails are shunted by a train in advance and all three relays TA, TR and TL are released a slow speed signal is displayed by the signal CS.

It is to be observed that in the event the energy level of the current impulses supplied to the track rails 1a and 1b is relatively high the first stage amplifying tube VT1 may not be needed and the inductors 10 and 11 may be connected directly with the grid 21 and cathode 20 of tube VT2.

Referring to Fig. 2, the train carried apparatus comprises two receiving channels one effectively influenced by coded alternating current of 100 cycles per second, such as, for example, disclosed in United States Letters Patent No. 1,773,472, granted August 19, 1930 to P. N. Bossart, for Railway traffic controlling apparatus, such coded alternating current being widely used in present day cab signal systems for railways, and the other channel is effectively influenced by low frequency alternating currents such as supplied by the trackway apparatus of Fig. 3 to be described later, the low frequencies being of the order of the code rates of the standard coded alternating current. That is, when the code rates of the standard alternating current of 100 cycles per second are that of 180, 120 and 75 cycles per minute or 3, 2 and 1¼ cycles per second, the second channel is effectively influenced by low frequency alternating currents of the frequencies of 3, 2, and 1¼ cycles per second.

Looking at Fig. 2, the train carried inductors 10 and 11 mounted in inductive relation with the track rails 1a and 1b, are interposed in the grid circuit of the amplifying tube VT1 the same as in Fig. 1, except a low pass filter LPF is included in this grid circuit. The specific form of the low pass filter LPF is immaterial and as here shown it consists of two inductors 46 and 47 and a condenser 48. The parts of the filter LPF are so proportioned that it has a cut off frequency of the order of 3 cycles per second. Hence alternating current of 100 cycles per second is not passed to the tube VT1 but alternating currents of the low frequencies of 3, 2 and 1¼ cycles per second are passed to the tube VT1 with little attenuation. The other receiving channel which is responsive to coded alternating current of 100 cycles per second includes an electron tube VT3 and a band pass filter BPF. The tube VT3 is preferably a high vacuum amplifying tube similar to tube VT1. The band pass filter BPF comprises condensers 49 and 50 and a transformer T1. The condenser 49 and primary winding 51 of transformer T1 are serially connected across the inductors 10 and 11 in multiple with the grid circuit of tube VT1. The condenser 50 is connected across the secondary winding 52 of transformer T1 and the two in multiple are connected across the grid 53 and cathode 54 of tube VT3, to form a grid circuit for that tube, the cathode 54 of tube VT3 being connected to a mid terminal of resistor 16 to provide a desired grid bias potential for the tube VT3. Tube VT3 is preferably biased for substantially normal zero plate current. The parts of filter BPF are tuned sharply to resonance at 100 cycles per second. Hence, electromotive forces induced in inductors 10 and 11 in response to coded alternating current of 100 cycles per second are applied across the grid and cathode of tube VT3 but are blocked by filter LPF from tube VT1, whereas electromotive forces induced in the inductors 10 and 11 by alternating currents of the low frequencies of 3, 2 and 1¼ cycles per second are applied to the tube VT1 but are blocked from the tube VT3.

The plate circuit for tube VT3 extends from terminal 32B, over resistor R1, plate 55 of tube VT3, tube space, cathode 54, a portion of resistor 16 and to terminal 32N. The grid circuit of detector tube VT2 of Fig. 2 is coupled with the plate circuit of tube VT1 through condensers C2 and resistor R2 the same as in Fig. 1, and consequently it is also coupled with the plate circuit of tube VT3 through the same elements because of the parallel arrangement of the plate circuits of the two tubes VT1 and VT3. The winding 22 of the code following relay MR1 is included in the anode circuit of tube VT2, and the deionizing unit consisting of condenser C1 and resistor R3 is associated with tube VT2 in the same manner as in Fig. 1.

In Fig. 2, the input side of the decoding unit DU is controlled over a front contact 56 of code following relay MR1. The relays TA, TR and TL connected with the output side of decoding unit DR are responsive to the code rates of 180, 120 and 75 cycles per minute or 3, 2 and 1¼ cycles per second the same as described in Fig. 1, and the relays TA, TR and TL govern the operating circuits of cab signal CS the same as in Fig. 1.

In Fig. 3 there is shown trackway apparatus for supplying to the rails of a track section alternating currents of the low frequencies of 3, 2 and 1¼ cycles per second. Looking at Fig. 3, the track rails 1a and 1b of a section of railway over which traffic normally moves in the direction indicated by an arrow are formed into consecutive track sections by the usual insulated rail joints, and of which track sections only the one section W—X and the ends of the two sections adjacent thereto are shown for the sake of simplicity. Each track section is provided with a track circuit consisting of means for creating different low frequency alternating currents, the track rails and a track relay. Referring to section W—X, the means for creating low frequency alternating currents includes a suitable source of direct current whose terminals are indicated at B and C, three code transmitters 1CT, 2CT and 3CT, and a reactance device 35 together with the necessary circuit connections with the track

rails. The track relay for section W—X is a polar code following relay WRT whose winding 77 is connected across the rails of section W—X, and whose polar contact member 57 is biased to remain at the position to which it was last operated when the relay is deenergized. When the relay WTR is energized alternately by current of positive and negative polarity so as to operate its contact member 57, direct current is alternately supplied to the two half portions of the primary winding 58 of a transformer TW so that electromotive forces of a frequency corresponding to the rate at which the relay WTR is operated are induced in the secondary winding 59 of transformer TW. The secondary winding 59 is connected with decoding circuits, a first one of which includes a condenser 60 and an inductor 61 and which circuit is tuned to resonance at the frequency corresponding to that of the electromotive force produced in the secondary winding 59 when the relay WTR is operated at the rate of 3 cycles per second. A relay WA is connected through a rectifier 62 across a portion of the inductor 61 of this decoding circuit and hence relay WA is effectively energized and picked up only when relay WTR is being operated at the code rate of 3 cycles per second. A second decoding circuit includes condenser 63 and an inductor 64 and this decoding circuit is tuned to resonance at a frequency corresponding to that of the electromotive force produced in the secondary winding 59 when relay WTR is operated at 2 cycles per second. A relay WR is connected across a portion of inductor 64 through a rectifier 65 and hence relay WR is effectively energized and picked up only when relay WTR is being operated at the code rate of 2 cycles per second. A third decoding circuit including an inductor 66 is connected with the secondary winding 59 of transformer TW and this third circuit is non-tuned so that current is passed through a rectifier 67 to a relay WL when relay WTR is operated at either the code rate of 3 or 2 cycles per second, and also when relay WTR is operated at the third code rate of 1¼ cycles per second. The relays WA, WR and WL are used to control the supply of current to the track circuit not shown for the section next in the rear of section W—X, and also to govern the operating circuits of a wayside signal WS for section W—X. The control effected by the relays WA, WR and WL will be shortly explained.

The three relays XA, XR and XL shown at the right-hand end of Fig. 3 are associated with the track circuit for the section next in advance of section W—X in substantially the same manner that the respective relays WA, WR and WL are associated with the track circuit for the section W—X. That is to say, the relays XA, XR and XL are controlled by the code following track relay XTR for the section next in advance of section W—X through decoding circuits so that relays XA and XL are effectively energized and picked up when the code following track relay XTR is operated at the code rate of 3 cycles per second, relays XR and XL are effectively energized and picked up when relay XTR is operated at the code rate of 2 cycles per second, and relay XL is effectively energized and picked up when relay XTR is also operated at the code rate of 1¼ cycles per second.

The relays XA, XR and XL are used for governing the supply of current to the track circuit for the section W—X and to govern the operating circuits for the signal XS for the section next in advance. The operating circuits for signal XS as well as the operating circuits for the signal WS are not shown in order to not unduly complicate the drawing, since such operating circuits form no part of my present invention and they may be of any one of the standard arrangements now in present day use.

I shall next explain the manner of supplying alternating current to the track circuit for the section W—X, the means for thus supplying this alternating current being as stated hereinbefore a source of direct current, three code transmitters and a reactance device together with the necessary circuit connections. The code transmitters 1CT, 2CT and 3CT are each preferably of the well known oscillating relay type and each is provided with pole changing contact members which are normally biased to a center position. The code transmitter 3CT is adjusted so that when its winding 68 is supplied with direct current the pole changing contact members 75 and 76 are operated between right-hand and left-hand positions at the rate of 3 cycles per second. The code transmitter 2CT is adjusted so that when its winding 69 is energized its pole changing contact members 78 and 79 are operated at the rate of 2 cycles per second, and code transmitter 1CT is adjusted so that when its winding 70 is energized its pole changing contact members 80 and 81 are operated at the rate of 1¼ cycles per second.

When clear traffic conditions exist in advance of section W—X and the relay XA is picked up closing front contacts 71 and 72, or when approach medium traffic conditions exist in advance and relay XR is picked up closing front contacts 73 and 74, the winding 68 of code transmitter 3CT is connected across the terminals B and C of the source of direct current over a circuit easily traced so that the code transmitter 3CT is energized to operate its contact members 75 and 76 at the code rate of 3 cycles per second. Each time the contact members 75 and 76 are closed to the right as viewed in Fig. 3, current of positive polarity is supplied to the track circuit of section W—X, the circuit being traced from terminal B over either front contact 71 or 73, contact member 75 toward the right, wire 82, track lead wire 83, track rail 1*a*, winding 77 of track relay WTR or train shunt if section W—X is occupied, rail 1*b*, track lead wire 84, winding of reactance device 85, adjustable resistor 86, wire 87, contact member 76 toward the right, front contact 72 or 74 and to terminal C of the current source. Each time the contact members 75 and 76 are closed toward the left current of negative polarity is supplied to the track circuit, the circuit being made up of the same elements as traced above except it is now closed at the left-hand contacts of the pole changing contact members 75 and 76. Consequently for each operating cycle of code transmitter 3CT the track circuit of section W—X is supplied with current the polarity of which is positive during substantially the first half of the cycle and is negative during substantially the second half of the cycle. This condition is illustrated by the flat top curve of Fig. 6. The resistor 86 is interposed in the connection to the track rails of the track circuit so that the amplitude of the current is limited during periods when the track section W—X is occupied by a train. The reactance device 85 is used to smooth out the wave form of the track circuit current so that the wave form of the track circuit current is substantially that illustrated by the si-

nusoidal curve of Fig. 6. It is to be observed that if the section W—X is relatively long the impedance of the track rails 1*a* and 1*b* may be sufficient to effect a substantially sinusoidal wave form of the current and the unit 35 may not be needed. A resistor 88 may be connected across the track lead wires 83 and 84 to reduce sparking at the contacts of the pole changing contact members 75 and 76. It follows, therefore, that when either clear traffic conditions or approach medium traffic conditions exist in advance of section W—X, a track circuit current which in effect is an alternating current of the code frequency of 3 cycles per second is supplied to the track circuit for section W—X and by proper proportioning of parts the wave form of the current is substantially free from distortion.

When approach traffic conditions exist in advance of section W—X and relays XA and XR are released and relay XL is picked up so that back contacts 89 and 90 of relay XA, back contacts 91 and 92 of relay XR and front contacts 93 and 94 of relay XL are all closed, the winding 69 of code transmitter 2CT is energized and that code transmitter operates its pole changing contact members 78 and 79. Each time contact members 78 and 79 are closed toward the right, current of positive polarity is supplied to the track circuit of section W—X, the circuit comprising terminal B, front contact 93, back contacts 91 and 89, contact member 78 toward the right, wires 82 and 83, rail 1*a*, winding 77 of relay WTR or train shunt if the section is occupied, rail 1*b*, wire 84, winding of reactance device 85, resistor 86, wire 87, contact member 79 toward the right, back contacts 99 and 92, front contact 94 and terminal C. Each time contact members 78 and 79 are closed to the left current of negative polarity is supplied to the track circuit over this same circuit since the circuit is pole changed by the contact members 78 and 79. Since code transmitter 2CT operates at 2 cycles per second the current of the track circuit of section W—X is effectively an alternating current having a frequency of 2 cycles per second, the wave form of the track circuit current being substantially that shown by the sinusoidal curve in Fig. 6. It follows that under approach traffic conditions in advance of section W—X, alternating current of the low frequency of 2 cycles per second is supplied to the track circuit for section W—X to reflect approach medium traffic conditions for that section.

When the section next in advance of section W—X is occupied so that relay XL is released closing back contacts 95 and 96, the winding 70 of code transmitter 1CT is energized and operates the contact members 80 and 81 at the rate of 1¼ cycles per second. Each time the contact members 80 and 81 are closed toward the right current of positive polarity is supplied to the track circuit for section W—X, the circuit involving the elements, terminal B, back contact 95, contact member 80 toward the right, wires 97 and 83, rail 1*a*, winding 77 or train shunt, rail 1*b*, wire 84, winding of reactance device 85, resistor 86, wire 98, contact member 81 toward the right, back contact 96 and terminal C. Each time contact members 80 and 81 are closed toward the left current of negative polarity is supplied to the track circuit of section W—X over the circuit traced above except as to the position of the pole changing contact members 80 and 81. Thus, when the track section next in advance of section W—X is occupied the track circuit for section W—X is supplied with current which in effect is an alternating current of the low frequency of 1¼ cycles per second to reflect approach traffic conditions for that section. Alternating current is supplied to the track circuit for the section next in the rear of section W—X in substantially the same manner as just described for supplying alternating current to the track circuit of section W—X, the alternating current supplied to the circuit for the section next in the rear being controlled by relays WA, WR and WL.

If a train equipped with the apparatus of Fig. 2 occupies track section W—X of Fig. 3 under clear traffic conditions and alternating current of the low frequency of 3 cycles per second is supplied to the track circuit of that section in a manner explained hereinbefore, the electromotive forces induced in the inductors 10 and 11 add their effects and the resultant electromotive force is applied through the low pass filter LPF to the grid of tube VT1 but such electromotive force is blocked by the band pass filter BPF from the tube VT3. After amplification of such induced electromotive force by the tube VT1 it is applied to the grid of tube VT2 through the coupling condenser C2. The wave form of this induced electromotive force is similar to that of the track circuit current, that is, the induced electromotive force has a sinusoidal wave form substantially the same as that of the track circuit current which is illustrated by the sinusoidal curve of Fig. 6. During one half cycle of each cycle of the wave form of the induced electromotive force the grid 21 of tube VT2 is driven more positive in potential with respect to cathode 20 so that the tube VT2 is ionized and made conductive, with the result that the code following relay MR1 is energized and picked up by the current passed by the tube VT2. With relay MR1 picked up closing front contact 24 the condenser C1 is connected directly across anode 19 and cathode 20 and the current which was flowing through the tube is momentarily diverted to the condenser, with the result that tube VT2 deionizes and restores to its non-conducting condition. When condenser C1 is fully charged current ceases to flow with the result that the code following relay MR1 is released, closing back contact 23 and connecting resistor R3 across the condenser C1. Condenser C1 now discharges through resistor R3 and is prepared for being charged when the tube VT2 is next ionized, which will be during the corresponding half cycle of the next cycle of the induced electromotive force. It is clear therefore that during one half cycle of each cycle of the track circuit current the tube VT2 is ionized so that relay MR1 is energized and picked up, and during the interval of the other half cycle of each cycle of the track circuit current the tube VT2 is deionized and restored to its non-conductive condition and relay MR1 is deenergized and released, relay MR1 being operated therefore at a rate corresponding to the frequency of the track circuit current. While the other half cycle of each cycle of the induced electromotive force is not used by the train carried apparatus both half cycles of the track circuit current are used to operate the code following track relay of Fig. 3 in the manner explained hereinbefore.

With code following relay MR1 operated at the code rate of 3 cycles per second current impulses at the rate of 3 impulses per second are supplied to the input side of the decoding unit DU over

front contact 56 of relay MR1 with the result that relays TA and TL connected with the output side of the unit DU are energized and picked up. When relay TA of Fig. 2 is energized and picked up a clear indication is displayed by signal CS.

If approach medium traffic conditions exist for section W—X and alternating current of 2 cycles per second is supplied to the track circuit of the section the operation of the train carried apparatus of Fig. 2 is similar to that described under clear traffic conditions except for the fact that the relay MR1 is now operated at the rate of 2 cycles per second. Current impulses at the rate of 2 impulses per second are now supplied to the decoding unit DU and relays TR and TL are picked up with the result that signal CS displays an approach medium indication. Again under approach traffic conditions and alternating current of 1¼ cycles per second is supplied to the track circuit of section W—X, the operation of the train carried apparatus of Fig. 2 is similar to that described above except for the fact that relay MR1 is now operated at the code rate of 1¼ cycles per second. This time current impulses as the rate of 1¼ impulses per second are supplied to the decoding unit DU and relay TL only is picked up causing signal CS to display an approach indication. With section W—X already occupied by a train when the train on which the apparatus of Fig. 2 is mounted enters the track section the leading train shunts the track circuit current so that the code following relay MR1 is inactive and all of the relays TA, TR and TL are released, with the result that signal CS displays a slow speed signal.

In the event the train equipped with the apparatus of Fig. 2 is moving through a stretch of railway provided with track circuits using alternating current of 100 cycles per second coded at the standard code rates of 180, 120 and 75 cycles per minute or 3, 2 and 1¼ cycles per second such as disclosed in the aforementioned Bossart Patent No. 1,773,472, the electromotive force induced in inductors 10 and 11 during each "on" period of the coded alternating current of 100 cycles per second will be an alternating electromotive force of 100 cycles per second and will be passed by the band pass filter BPF to the tube VT3 with the result that current will flow in the plate circuit of that tube during each "on" period of the track circuit current and the plate current will cease during each "off" period of the track circuit current because tube VT3 is biased for substantially normal zero plate current. The change in the voltage drop across resistor R1 thus effected by the plate circuit current of the tube VT3 causes an electromotive force to be applied to the grid 21 of tube VT2 which periodically drives the grid 21 more positive in potential with respect to cathode 20 at a rate corresponding to the code rate of the alternating current. Each time grid 21 is driven more positive in potential the tube VT2 ionizes and becomes conductive so that relay MR1 is energized and picked up. Tube VT2 is deionized and rendered non-conductive through the medium of condensers C1 subsequent to each period of ionization, with the result that relay MR1 is operated at a rate corresponding to the code rate of the alternating track circuit current. With relay MR1 thus operated the signal CS is made to display an indication corresponding to the code rate of the coded alternating track circuit current through the medium of the decoding unit DU and relays TA, TR and TL in the same manner as explained hereinbefore.

It follows from the foregoing description that the train carried apparatus of Fig. 2 is operated by either the standard coded alternating current of 100 cycles per second as supplied to a track circuit by the trackway apparatus of the aforementioned Bossart Patent No. 1,773,472, or by alternating current of the low code frequency of 3, 2 and 1¼ cycles per second as supplied to a track circuit by the trackway apparatus of Fig. 3 and which low frequencies correspond to the code rate of the standard 100 cycle alternating current.

In the event more equal on and off periods for the impulses supplied to the decoding unit DU of Fig. 2 is desired, the second code following relay MR2 and reactor R3 of Fig. 1 may be added to the apparatus of Fig. 2, relay MR2 and reactor R3 being governed over back contacts of relay MR1 and the impulses supplied to the decoding unit DU being governed over a front contact of relay MR2, the same as shown in Fig. 1.

It should be noted that with the train carried apparatus of Fig. 2 the tube VT2 need not be of the controlled ionization type, and a high vacuum low plate voltage tube can be used. In this latter case the tube VT2 would be normally biased to the straight line portion of the grid voltage plate current characteristic and relay MR1 would be governed through the medium of a transformer, the primary winding of which transformer would be interposed in the plate circuit of the tube and the secondary winding of the transformer would be connected with the winding 22 of relay MR1.

In Fig. 4 the train carried apparatus is provided with two receiving channels the same as in Fig. 2. In Fig. 4, however, the amplifying tube VT1 functions to amplify both the standard coded alternating current of 100 cycles per second and to amplify the low frequency alternating current. The low pass filter LPF of Fig. 4 consists of two inductors 99 and 100 and two condensers 101 and 102. The band pass filter BPF is the same as in Fig. 2. The primary winding 51 and condenser 49 of band pass filter BPF are serially connected across inductors 10 and 11. Inductors 10 and 11 are also connected with the grid 17 and cathode 15 of tube VT1 through the low pass filter LPF, the secondary winding 52 of transformer T2 of the band pass filter BPF, and a control unit consisting of a condenser C6 and a resistor R6 in multiple. The plate circuit of tube VT1 is coupled with the grid circuit of tube VT2 the same as in Fig. 2. Also, in Fig. 4, the code following relay MR1, the deionizing unit consisting of condenser C1 and resistor R3, decoding unit DU, relays TA, TR and TL, and the cab signal CS are associated with the tube VT2 in the same manner as in Fig. 2.

When energy is received by inductors 10 and 11 of Fig. 4 in response to coded alternating current of 100 cycles per second flowing in rails 1a and 1b as would be the case of a track circuit of the aforementioned Bossart Patent No. 1,773,472, such energy is blocked by the low pass filters LPF but is effective to induce an electromotive force in the secondary winding 52 of transformer T1 of the band pass filter BPF. The electromotive force thus induced in the secondary winding 52 is applied to the grid 17 of tube VT1 over a circuit which can be traced from the right-hand terminal of secondary winding 52, through condenser C6 and resistor R6 in multiple, grid 17, tube space to cathode 15, lower portion of re-

sistor 16, wire 103, condenser 102 and to the left-hand terminal of secondary winding 52. This electromotive force persists during the "on" period of the coded 100 cycle alternating current with the result that condenser C6 is charged and the grid 17 of tube VT1 rendered negative during this "on" period of the coded alternating current. This variation in the potential of the grid 17 with respect to cathode 15 causes a corresponding variation in the plate circuit corrent of tube VT1. The change in the voltage drop across resistor R1 effected by this change in the plate circuit current of tube VT1 causes a corresponding change in the potential of grid 21 with respect to cathode 20 of the tube VT2 so that tube VT2 is ionized periodically at a rate corresponding to the code rate of the alternating current flowing in the rails 1a and 1b. The tube VT2 is deionized subsequent to each period of ionization through the medium of condenser C1 in the manner already explained, with the result that the code following relay MR1 of Fig. 4 is operated at a rate corresponding to the code rate of the coded alternating current of 100 cycles. With code following relay MR1 thus operated impulses of current are periodically supplied over front contact 56 of relay MR1 to the decoding unit DU at a rate corresponding to the code rate of the track circuit current and the cab signal CS is made to display an indication corresponding to the code rate in the manner explained hereinbefore.

When energy is received by inductors 10 and 11 of Fig. 4 due to a low frequency alternating current such as effected by the track circuit apparatus of Fig. 3, the energy is passed by the low pass filter LPF and applied to the grid of tube VT1, the secondary winding 52 of transformer T1 and condenser C6 offering but little attenuation to the energy.

From this point on the operation of the apparatus of Fig. 4 in response to low frequency alternating current flowing in the track circuit is the same as that described for the apparatus of Fig. 2 and the description need not be repeated.

It follows that the apparatus of Fig. 4 is responsive either to coded alternating current of 100 cycles per second such as provided by the trackway apparatus of the aforementioned Bossart Patent No. 1,773,472, or to alternating current of low code frequencies such as provided by the trackway apparatus of Fig. 3.

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

Having thus described my invention, what I claim is:

1. In a signal system for a railway having its rails formed with a track section which is provided with trackway apparatus having successive operation cycles each of a predetermined interval and operative at times to supply to the rails of that section during each cycle a single effective current impulse the duration of which impulse is short and only a small portion of the operation cycle interval, the combination comprising, a train carried normally deenergized first code following relay, train carried receiving and amplifying means mounted on the train in inductive relation with the track rails and connected with a winding of said relay for energizing the relay during each such current impulse supplied to the rails whereby said relay is operated with unequal on and off periods, a second code following relay having a first and a second winding which are connected to produce opposing magnetic fluxes in that relay, a reactance device including a winding mounted on a magnetic core, a first energizing circuit for said second relay including a back contact of said first relay and said first winding of said second relay, another circuit including a back contact of said first relay and a front contact of said second relay and the winding of said device for storing magnetic energy in said device, a second energizing circuit of said second relay including a portion of the winding of said reactance device and said second winding of said second relay whereby said second relay is provided with slow pickup characteristic and is operated in response to the current impulses supplied to the track rails with substantially equal on and off periods, and signaling means controlled over a contact of said second relay.

2. In a signal system for railways having transmitting apparatus which is effective to divide time into successive operation cycles each of a predetermined interval and to supply during each cycle a single signaling current impulse the duration of which impulse is short and only a small portion of the operation cycle interval, the combination comprising, receiving circuit means for receiving energy from such transmitting apparatus, a first code following relay connected with said receiving circuit means effectively energized and picked up during the short interval of each said current impulse, a second code following relay having a first and a second winding connected to create opposing magnetic fluxes, a reactance device having a winding with a magnetic core, a first energizing circuit for said second relay including a back contact of said first relay and said first winding; another circuit including a back contact of said first relay, a front contact of said second relay and the winding of said device for storing magnetic energy in said device; a second energizing circuit for said second relay including a portion of the winding of said device and said second relay for delaying the picking up of said second relay for operating said second relay once each operation cycle of the transmitting apparatus with substantially equal on and off periods, and a signaling circuit controlled over a contact of said second relay.

3. Train carried signaling apparatus for use with either a first territory provided with track circuits supplied at times with alternating current of a given frequency coded at a predetermined rate or with a second territory provided with track circuits supplied at times with alternating current of a frequency equal to said predetermined code rate comprising, a receiver mounted on the train for receiving energy from such track circuits, a controlled ionization tube, a code following relay, a source of direct current, a reactance device, said relay and source of direct current connected across the anode and cathode of said tube to energize said relay when an impulse of electromotive force of positive polarity is applied to the grid of said tube causing the tube to ionize, said reactance device connected with the anode and cathode of the tube to deionize the tube subsequent to each such impulse of electromotive force, two parallel circuit channels for coupling said receiver with said grid and cathode, a selected one of said channels including a band pass filter tuned to resonance at said given frequency and operative to apply to said

grid an impulse of electromotive force of positive polarity in response to each on period of said coded alternating current of said given frequency for operating said code following relay at said code rate when the train traverses a track circuit of said first territory, the other of said circuit channels including a low pass filter tuned for a cut-off frequency equal to said code rate and operative to apply to said grid an impulse of electromotive force of positive polarity in response to each cycle of said alternating current of a frequency equal to said code rate for operating said code following relay at said code rate when the train traverses a track circuit of said second territory, and a signaling circuit including a contact of said code following relay effectively controlled when said relay is operated at said code rate.

4. Train carried signaling apparatus for use with either a first territory provided with track circuits supplied at times with alternating current of a given frequency coded at a predetermined rate or with a second territory provided with track circuits supplied at times with alternating current of a frequency equal to said predetermined code rate comprising, a receiver mounted on the train for receiving energy from such track circuits, an electron tube detector, a code following relay connected with the output terminals of said detector, said relay normally deenergized and effectively energized when positive energy is applied to the input terminals of said detector, two parallel circuit channels for coupling said receiver with the input terminals of said detector, a selected one of said circuit channels including a band pass filter tuned to resonance at said given frequency and operative to apply to the input terminals of said detector an impulse of positive energy in response to each on period of said coded alternating current of said given frequency for operating said code following relay at said code rate when the train traverses a track circuit of said first territory, the other of said circuit channels including a low pass filter having a cut-off frequency equal to said predetermined code rate and operative to apply to the input terminals of said detector an impulse of positive energy in response to each cycle of said alternating current of a frequency equal to said code rate for operating said code following relay at said code rate when the train traverses a track circuit of said second territory, and signaling means including a contact of said relay effectively energized when the relay is operated at said code rate.

5. Train carried signaling apparatus for use with either a first territory provided with track circuits supplied at times with alternating current of a given frequency coded at a predetermined rate or with a second territory provided with track circuits supplied at times with alternating current of a frequency equal to said predetermined code rate comprising, a receiver mounted on the train for receiving energy from such track circuits, a controlled ionization tube, a code following relay, a source of direct current, a reactance device, said relay and source of direct current connected across the anode and cathode of said tube to energize said relay when an impulse of electromotive force of positive polarity is applied to the grid of said tube causing the tube to ionize, said reactance device connected with the anode and cathode of the tube to deionize the tube subsequent to each such impulse of electromotive force, a first and a second amplifier tube, a resistor common to the plate circuits of said amplifier tubes and coupled with the grid of said controlled ionization tube to apply an impulse of electromotive force of positive polarity to the grid of the last mentioned tube when a predetermined voltage change is effected across said resistor, a first circuit channel including a band pass filter tuned to resonance at said given frequency to connect said receiver with the grid of said first tube to effect said voltage change across said resistor in response to each on period of said coded alternating current for operating said code following relay at said code rate when the train occupies a track circuit of said first territory, a second circuit channel including a low pass filter tuned with a cut-off frequency equal to said code rate to connect said receiver with the grid of said second amplifier tube to effect said voltage change across said resistor in response to each cycle of said alternating current of a frequency equal to said code rate for operating said code following relay at said code rate when the train occupies a track circuit of said second territory, and signaling means including a contact of said relay effectively energized when the relay is operated at said code rate.

6. Train carried signaling apparatus for use with either a first territory provided with track circuits supplied at times with alternating current of a given frequency coded at a predetermined rate or with a second territory provided with track circuits supplied at times with alternating current of a frequency equal to said predetermined code rate comprising, a receiver mounted on the train for receiving energy from such track circuits, a controlled ionization tube, a code following relay, a source of direct current, a reactance device, said relay and source of direct current connected across the anode and cathode of said tube to energize said relay when an impulse of electromotive force of positive polarity is applied to the grid of said tube causing the tube to ionize, said reactance device connected with the anode and cathode of the tube to deionize the tube subsequent to each such impulse of electromotive force, an amplifier tube, a plate circuit for said amplifier tube coupled with the grid of said controlled ionization tube to apply an impulse of electromotive force of positive polarity to the grid of the last mentioned tube when a predetermined change of the plate circuit current of the amplifier tube is effected, a first circuit channel including a band pass filter tuned to resonance at said given frequency and a blocking condenser to connect said receiver with the grid of said amplifier tube to effect said change in its plate circuit current in response to each on period of said alternating current of said given frequency to operate said code following relay at said code rate when the train occupies a track circuit of said first territory, a second circuit channel including a low pass filter tuned for a cut-off frequency equal to said code rate to connect said receiver with the grid of said amplifier tube to effect said change in its plate circuit current in response to each cycle of said alternating current of a frequency equal to said code rate to operate said code following relay at said code rate when the train occupies a track circuit of said second territory, and signaling means including a contact of said relay effectively energized when the relay is operated at said code rate.

7. Receiving apparatus for use with a source

of periodic impulses of current which are of short duration as compared with the duration between successive impulses comprising, a controlled ionization tube having a grid coupled with said source of current impulses to effect ionization of the tube by each such impulse, a first code following relay and a source of direct current connected across the anode and cathode of said tube to energize said relay when the tube is made conductive, a condenser connected with said anode and cathode to deionize the tube subsequent to each said impulse of current, a second code following relay, an energizing circuit including a back contact of said first relay and a winding of said second relay to pick up said second relay when said first relay is released, means including a back contact of said first relay to effect a predetermined slow pick-up period for said second relay to cause said second relay to be operated at substantially equal on and off periods in response to said current impulses, and a signaling circuit including a contact of said second relay.

8. Receiving apparatus for use with a source of periodic impulses of current of different code rates and which current impulses are of short duration as compared with the duration between successive impulses comprising, a controlled ionization tube having a grid coupled with said source of current impulses to cause ionization of the tube by each such impulse, a first code following relay and a source of direct current connected across the anode and cathode of the tube to energize the relay when said tube is ionized, a condenser connected with said anode and cathode to deionize said tube subsequent to each such impulse whereby said first relay is operated at the code rate of the current impulse but with unequal on and off periods, a second code following relay having a first and a second winding, an energizing circuit including a back contact of said first relay and said first winding of said second relay to pick up the second relay when said first relay is released, a reactance unit including a winding a portion of which is connected with the second winding of said second relay, another circuit including a back contact of said first relay and said winding of said reactance unit to store energy in said unit to cause current to flow in the second winding of said second relay that modifies the energization of the second relay as effected by said energizing circuit to cause said second relay to be operated at the code rate of said current impulses with substantially equal on and off periods, and decoding means selectively responsive to said different code rates controlled over a front contact of said second relay.

9. Receiving apparatus for use with a source of periodic impulses of electromotive force connected with the grid of a controlled ionization tube for causing ionization of the tube by each such impulse of electromotive force comprising, a code following relay and a source of direct current connected in series across the anode and cathode of said tube to pick up said relay when the tube is ionized and made conductive, a condenser, circuit means including a front contact of said relay to connect one terminal of said condenser directly with the anode of the tube and the other terminal of the condenser directly with the cathode of the tube to divert the current flowing through said relay to said condenser when the relay is picked up to deionize the tube and to retain the relay picked up until the condenser is fully charged, a resistor, means including a back contact of said relay to connect said resistor across said condenser to discharge the condenser between successive impulses of said electromotive force, and signaling means including a contact of said code following relay effectively controlled when the relay is operated.

10. Receiving apparatus for use with a source of periodic impulses of electromotive force connected with the grid of a controlled ionization tube for causing ionization of the tube by each such impulse of electromotive force comprising, a code following relay and a source of direct current connected in series across the anode and cathode of said tube to pick up said relay when the tube is ionized and made conductive, a condenser, circuit means including a front contact of said relay to connect said condenser and said relay in series across said source of direct current to divert the current flowing in said relay to said condenser to deionize said tube when the relay is picked up and to retain said relay picked up until said condenser is fully charged, a resistor, means including a back contact of said relay to connect said resistor across said condenser to discharge the condenser between successive impulses of said electromotive force, and a signaling circuit including a front contact of said relay effectively energized when said relay is operated.

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