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RAILWAY TRAFFIC CONTROLLING APPARATUS

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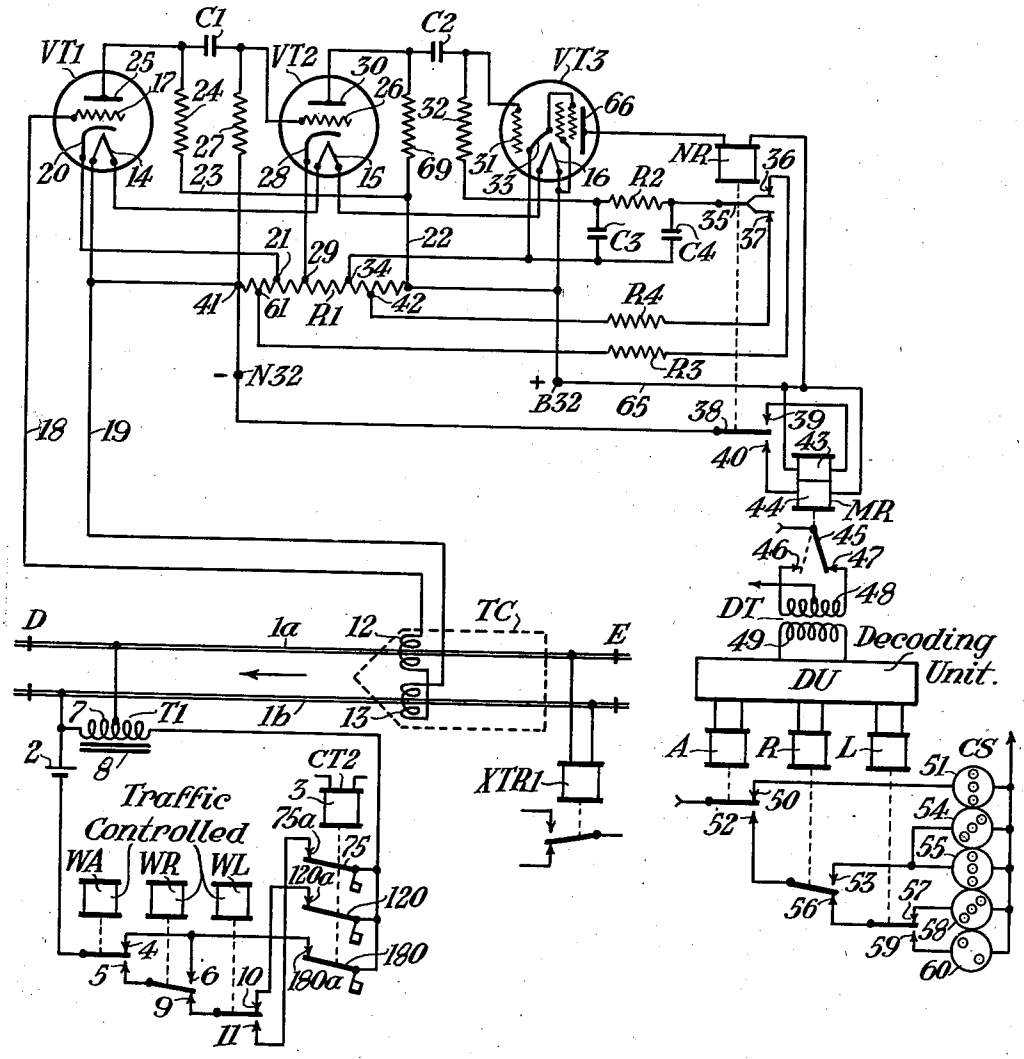

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RAILWAY TRAFFIC CONTROLLING APPARATUS

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9 Claims. (Cl. 246—63)

My invention relates to railway traffic controlling apparatus, and more particularly to train carried train control apparatus responsive to coded energy.

Railway traffic controlling apparatus using track circuits provided with code impulses of direct current has been proposed. Such impulses of direct current are supplied to a track circuit at different code rates according to different traffic conditions, and the code rates of 180, 120 and 75 impulses per minute to reflect clear, approach-medium and approach traffic conditions, respectively, may be employed. Each impulse of direct current is preferably of relatively high peak voltage and of short duration. The high peak voltage serves as an aid to the shunting sensitivity of the track circuit and the short duration serves to limit the energy output of the current source, which is ordinarily a battery, to a low energy level. The duration of such a current impulse is short as compared with the duration between successive impulses. In other words, the on period of the impulse during which current flows is small as compared with the off period during which no current flows. For example, under the 180 code rate a code cycle is of the order of .33 second and of the .33 second the duration of the impulse (on period) is preferably of the order of .05 second and the duration between successive impulses (off period) is of the order of .28 second.

Train carried train control apparatus is governed by such coded direct current through the medium of train carried inductors and an amplifier. The inductors are mounted on the train in inductive relation to the track rails to receive an electromotive force in response to each such current impulse, and are connected to the input terminals of the amplifier and the electromotive force thus received by the inductors is amplified to operate a code following relay connected to the output terminals of the amplifier, the relay being operated at a rate corresponding to the code rate of the track circuit current impulses. Two or more stages of amplification may be employed. The code following relay governs cab signals and brake control equipment through decoding means selectively responsive to the different code rates at which the code following relay is operated and indirectly selectively responsive to the different code rates of the track circuit current impulses. Most satisfactory operation of such decoding means is effected when the code following relay is operated at substantially equal on and off periods and when code distortion is avoided. Amplifiers for such train control apparatus preferably include electron tubes of the type that will restore themselves to an inactive condition once the controlling current ceases. In other words the amplifier tubes are preferably such that positive action on the part of some restoring device is not required in order for the amplifier to be restored to its inactive condition.

In view of the above conditions a feature of my invention is the provision in railway traffic controlling apparatus of a novel and improved amplifier of coded direct current.

Another feature of my invention is the provision of railway traffic controlling apparatus incorporating a novel and improved amplifier using high vacuum electron tubes which are continuously under the control of a grid potential and which automatically become inactive when the control current ceases.

Again a feature of my invention is the provision of train carried train control apparatus incorporating a novel and improved electron tube amplifier having an equalizing circuit which effects substantially equal on and off periods in the operation of a control relay and in turn of a code following relay in response to energy picked up from a track circuit supplied with code impulses of direct current when the duration of each such current impulse is short as compared to the duration between successive impulses.

Still another feature of my invention is the provision of an amplifier for railway traffic controlling apparatus incorporation novel means for automatically adjusting the grid bias voltage and code distortion caused by current and voltage variations of the source of supply and of the control energy received is avoided.

The above features, as well as other advantages of my invention, which will become apparent as the specification progresses, are attained according to my invention by providing a multiple stage amplifier each of which stages includes a high vacuum type of electron tube. The grid circuit for the final stage tube includes a condenser which is coupled to the next preceding stage tube and in turn is coupled to the track circuit to charge the condenser in response to each code impulse of direct current of the track circuit. This charge on the condenser renders the grid of the final stage tube negative in potential with respect to the cathode. This grid circuit is provided with a grid leak resistor through which the condenser discharges between successive impulses of the coded current. A neutral relay is interposed in the plate circuit of the

final stage tube and is operated by the changes in the plate circuit current due to the variations of the grid potential effected through the condenser. The neutral relay is provided with a contact member having overlapping front and back contacts, the adjustment of the relay being such that the contact member is held at a mid position where both front and back contacts are closed when the relay is energized by a predetermined normal value of plate circuit current. An equalizing circuit controlled by these contacts of the neutral relay is interposed in the grid circuit of the final stage tube to regulate the grid voltage of that tube. This equalizing circuit comprises two parallel circuit paths each of which preferably includes a resistor and a source of direct voltage, and a first one of these paths is connected into the grid circuit over the front overlapping contact of the neutral relay and the second path is connected to the grid circuit over the back overlapping contact of the neutral relay. The sources of direct voltage for these circuit paths are arranged so that the first path is effective to apply to the grid circuit a negative voltage and the second path a positive voltage. When both overlapping contacts are closed and both circuit paths are closed the resulting grid voltage effected for the final stage tube is such as to create the above-mentioned predetermined normal value of plate circuit current and the neutral relay is held at its mid position. When the plate circuit current is increased so that the energization of the neutral relay is increased a predetermined amount, the contact member of the neutral relay is picked up to open the associated back contact but leaving the front contact closed and the second one of the two parallel circuit paths is opened and a more negative grid voltage is applied to the tube through the first circuit path tending to reduce the plate circuit current back to its normal value. When the plate circuit current is reduced below such normal value so that the energization of the neutral relay is reduced a predetermined amount the contact member of the neutral relay is released to open the associated front contact but leaving the back contact closed and the first one of the two circuit paths is opened and a more positive grid voltage is applied to the tube through the second one of the circuit paths tending to increase the plate circuit current back to its normal value. A filter including a resistor and at least one condenser is interposed in the connection between the contact member of the neutral relay and the grid of the final stage tube to smooth out the abrupt voltage changes when the overlapping front and back contacts are opened and closed. The grid voltage effected through the equalizing circuit and the overlapping contacts of a neutral relay modifies the control effected through the condenser and tends to cause the neutral relay to remain about equal periods in its picked up and released positions, notwithstanding the code impulses of direct current of the track circuit which cause operation of the neutral relay are short in duration as compared with the duration between successive impulses. Furthermore, the equalizing circuit is effective to cause substantially equal on and off operation periods of the neutral relay notwithstanding variations of the charge on the condenser due to variations in the magnitude of the code impulses of direct current, variations of voltages of the current supply for the amplifier, variations of code rates of the current impulses and variations of temperature, with the net result that code distortion is largely avoided.

The neutral relay is provided with a second contact member having front and back contacts which are closed only when the neutral relay is picked up and released, respectively. A master code following relay is controlled over the second contact member of the neutral relay and hence such code following relay is operated in step with the operation of the neutral relay. This master code following relay is used to govern a decoding means which in turn governs a signal or other train controlling device according to the rate at which the code following relay is operated.

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

The accompanying drawing is a diagrammatic view showing one form of apparatus embodying my invention.

Referring to the drawing, the reference characters *1a* and *1b* designate the track rails of a stretch of railway over which traffic normally moves in the direction indicated by an arrow and which rails are formed by the usual insulated rail joints into a track section D—E which section may be one section of a series of consecutive sections of a signal system. The track section D—E is provided with a track circuit which comprises a source of coded direct current connected across the rails at the exit end of the section and a code following track relay connected across the rails at the entrance end of the section. The means for supplying coded direct current to the track circuit of section D—E may take different forms and may be that covered in my Letters Patent of the United States No. 2,197,414, granted April 16, 1940 for Signal systems, the specific form of track circuit being that shown in Fig. 10 of the above-mentioned patent. It is sufficient for this application to point out that the source of code impulses of direct current for the track section D—E comprises a battery **2**, a track transformer T**1** and a code transmitter CT**2**. The code transmitter CT**2** is of the relay type, the operating winding **3** of which is connected to a suitable source of current, not shown, and is effectively energized to operate three code contact members **75**, **120** and **180**, the arrangement being such that contact member **75** is operated to close contact **75**—**75***a* at the rate of 75 times per minute, contact member **120** is operated to close contact **120**—**120***a* at the rate of 120 times per minute, and contact member **180** is operated to close contact **180**—**180***a* at the rate of 180 times per minute.

Three relays indicated by the reference characters WA, WR and WL are controlled by traffic conditions in advance of section D—E. The apparatus by which these relays are governed by traffic conditions in advance is not shown since it forms no part of my invention, and may, for example, be that shown and described in my aforementioned Patent No. 2,197,414. It is sufficient for the instant application to point out that at such time as relay WA is picked up closing front contact **4** in response to the first traffic condition in advance, or when relay WA is released closing back contact **5** and relay WR is picked up closing front contact **6**, in response to a second traffic condition in advance, the battery **2** is connected across winding **7** of transformer T**1** over contact **180**—**180***a* of code transmitter CT**2** and current flows in winding **7** causing magnetic

energy to be stored in the magnetic core 6 of transformer T1, and when contact 180—180a is opened the flow of current in winding 7 is interrupted and the magnetic energy stored in the core of transformer T1 decays. At least a portion of winding 7 is connected across the track rails 1a and 1b and the parts are so proportioned that when contact 180—180a is closed the current builds up in winding 7 relatively slow and little or no electromotive force is applied to the track rails, at least the electromotive force applied to the rails at this time is so small it can be neglected. When contact 180—180a is opened the current is interrupted and an electromotive force is applied to the track rails which causes an effective current impulse of a prescribed polarity to flow in the track circuit. Hence under the traffic conditions which cause relay WA to be picked up or relay WA to be released and relay WR to be picked up, code impulses of direct current of the code rate of 180 impulses per minute are supplied to the track circuit. When relays WA and WR are released closing back contacts 5 and 9, respectively, and relay WL is picked up closing front contact 10 in response to a third traffic condition in advance, the battery 2 is connected to winding 7 of transformer T1 over contact 120—120a of code transmitter CT2 and current impulses of the code rate of 120 impulses per minute are supplied to the track circuit. Again, when relays WA, WR and WL are released closing back contacts 5, 9 and 11, respectively, in response to a fourth traffic condition in advance, the battery 2 is connected to winding 7 over contact 75—75a of code transmitter CT2 and current impulses of the code rate of 75 impulses per minute are supplied to the track circuit. The parts are further so proportioned that each such code impulse of current is of relatively high peak voltage and short duration, at least the duration of the impulse is short as compared with the interval between successive impulses. It is to be understood of course that my invention is not limited to the code rates of 180, 120 and 75 impulses per minute, but such are used for illustration since they are the code rates commonly employed in cab signal systems for railways.

A code following track relay XTR1 is connected across the rails of section D—E at the entrance end E of the section, and when the section is unoccupied, that is, when the train shown conventionally at TC does not occupy section D—E, code following relay XTR1 is operated at a rate corresponding to the code rate of the current impulse supplied to the track circuit. Relay XTR1 would be used to control the apparatus for the section next in the rear of section D—E, and which apparatus would include relays corresponding to the relays WA, WR and WL controlled by the section next in advance of section D—E. Such apparatus controlled by relay XTR1 is not shown since, as stated hereinbefore, such apparatus forms no part of my present invention and is not required for a full understanding of my present invention.

The train shown conventionally at TC is provided with train carried apparatus embodying my invention, and which apparatus comprises inductors 12 and 13, a three stage amplifier, a neutral relay NR, a master code following relay MR, a decoding unit DU and a train control means shown in the form of a cab signal CS. An equalizing circuit and voltage regulator, to be later referred to, for the amplifier together with a suitable source of current are also provided for the train carried apparatus.

The inductors 12 and 13 are mounted on the train in inductive relation to rails 1a and 1b, respectively, for inductively receiving electromotive forces in response to each code impulse of direct current supplied to the rails in the manner explained hereinbefore. The inductors 12 and 13 are connected together so that the electromotive forces induced therein due to current flowing in opposite directions in the rails are additive and the inductors are connected to the input terminals of the first stage of the amplifier.

The three stage amplifier includes electron tubes VT1, VT2 and VT3, each such tube, together with its associated circuit, serving as one stage of amplification. Each of these tubes is preferably of the high vacuum indirect heater type. As will be apparent from an inspection of the drawing, the filaments 14, 15 and 16 of tubes VT1, VT2 and VT3 respectively, are connected in series across the positive terminal B32 and the negative terminal N32 of a suitable source of current such as the usual 32 volt train carried generator or battery, not shown. Hence each electron tube is normally heated and in an active condition.

A voltage regulator in the form of a potentiometer type resistor R1 is connected across terminals B32 and N32 of the current source as will be apparent from an inspection of the drawing, to provide suitable control voltages for the several circuits of the amplifier as will appear as the specification progresses.

A grid or input circuit is provided for the first stage tube VT1 by connecting its control grid 17 to one terminal of the inductor 12—13 over wire 18, connecting the other terminal of inductor 12—13 to the negative terminal 41 of resistor R1 over wire 19 and by connecting the cathode 20 of tube VT1 to a selected terminal 21 of resistor R1. The negative terminal 41 of resistor R1 is connected directly to the negative terminal N32 of the current source and grid 17 of tube VT1 is thus provided with a negative bias voltage equal to the voltage drop in that portion of resistor R1 between terminal 21 and its negative terminal 41. A plate circuit for tube VT1 can be traced from positive terminal B32 of the current source over wires 22 and 23, a resistor 24, plate 25 of tube VT1, intervening tube space to cathode 20, terminal 21 of resistor R1, that portion of resistor R1 between the terminals 21 and 41 and to the negative terminal N32 of the current source.

The control grid 26 of the second stage tube VT2 is coupled to the plate circuit of the first stage tube VT1 through the well-known resistor coupling type of circuit and which coupling circuit includes a condenser C1 and a grid leak resistor 27. The cathode 28 of tube VT2 is connected to a selected terminal 29 of resistor R1 to provide a predetermined negative grid bias voltage for tube VT2. The plate circuit of tube VT2 involves positive terminal B32, wire 22, a resistor 69, plate 30 of tube VT2, intervening tube space to cathode 28, terminal 29 of resistor R1 and that portion of resistor R1 between terminal 29 and terminal 41 to the negative terminal N32 of the current source.

The control grid 31 of the third and final stage tube VT3 is resistance coupled to the plate circuit of tube VT2, this coupling including a condenser C2 and a grid leak resistor 32.

The cathode 33 of tube VT3 is connected to a presented terminal 34 of resistor R1. An equalizing circuit to be shortly explained is interposed in the grid circuit of tube VT3 to regulate the potential of grid 31 with respect to cathode 33. The plate circuit of tube VT3 extends from positive terminal B32 of the current source over wire 65, winding of neutral relay NR, plate 66 of tube VT3, intervening tube space to cathode 33, terminal 34 of resistor R1 and that portion of resistor R1 between terminals 34 and 41 to the negative terminal N32 of the current source.

The relay NR is a neutral relay and is provided with a contact member 35 having overlapping front and back contacts 36 and 37 respectively, the arrangement being such that when relay NR is energized by current of a predetermined intermediate or normal value, contact member 35 is held at a mid position where it is in engagement with both front contact 36 and back contact 37 as shown in the drawing. When the energization of relay NR is increased a predetermined amount above the intermediate value, then contact member 35 is raised to a picked up position where it is out of engagement with back contact 37 and is in engagement only with front contact 36. When the energization of relay NR is reduced a predetermined amount below the aforementioned intermediate value, contact member 35 is released and becomes disengaged from front contact 36 and remains only in engagement with back contact 37. Relay NR is also provided with a second contact member 38 which is adjusted to engage an associated front contact 39 only when the energization of the relay is increased the predetermined amount above said intermediate value and which contact member engages back contact 40 when the energization of the relay is reduced the predetermined amount below said intermediate value. At the intermediate energization of relay NR contact member 38 is out of engagement with both front contact 39 and back contact 40 as shown in the drawing.

The equalizing circuit interposed in the grid circuit of tube VT3 comprises two parallel circuit paths which are controlled over the overlapping contacts 36 and 37 of relay NR to regulate the grid voltage of tube VT3 according to the position of relay NR. A first one of these circuit paths includes a resistor R3 and is connected between front contact 36 of relay NR and a terminal 61 of resistor R1, while the second one of the circuit paths includes a resistor R4 and is connected between back contact 37 of relay NR and a terminal 42 of resistor R1. Terminals 61 and 42 of resistor R1 are located at points preselected on opposite sides of terminal 34 of resistor R1 to which latter terminal cathode 33 of tube VT3 is connected. Hence the voltage drop in resistor R1 between the terminals 42 and 34 serves as a source of positive voltage for the second circuit path including resistor R4 and the voltage drop in resistor R1 between terminals 34 and 61 serves as a source of negative voltage for the first circuit path including resistor R3. The contact member 35 of relay NR is connected to grid 31 of tube VT3 over a resistor R2 and grid leak resistor 32. Two condensers C3 and C4 are connected to the opposite ends of resistor R2 and a common terminal of condensers C3 and C4 is connected to cathode 33 of tube VT3, resistor R2 and condensers C3 and C4 forming a filter the function of which will be referred to when the operation of the apparatus is described.

When neutral relay NR is energized at its intermediate value and contact member 35 engages both front contact 36 and back contact 37, both circuit paths of the equalizing circuit are connected to the grid circuit of tube VT3. The parts are so proportioned that the resultant voltage derived from the positive voltage supplied through the second circuit path and the negative voltage supplied through the first circuit path establishes a predetermined grid bias voltage for tube VT3 which is effective to cause the predetermined normal plate circuit current to flow and which in turn creates the intermediate energization of relay NR. If for any reason the plate circuit current of tube VT3 increases to a point where relay NR picks up contact member 35 and back contact 37 is opened, there is effected through the first circuit path of the equalizing circuit a negative grid voltage which tends to reduce the plate circuit current to its normal value. When the plate circuit current is reduced below that required to energize relay NR at its intermediate value and contact member 35 is released to open front contact 36, there is effected through the second circuit path of the equalizing circuit a positive grid voltage which tends to increase the plate circuit current back to its normal value.

The code following relay MR is a polar relay of the type whose polar armature remains in the position to which it was last moved when the relay is deenergized and this relay is provided with two windings 43 and 44 and the energization of which windings is controlled over contact member 38 of relay NR. When relay NR is energized by current of intermediate value and contact member 38 is out of engagement with both front contact 39 and back contact 40, code following relay MR is deenergized. When relay NR is picked up and contact 38—39 is closed the top winding 43 of relay MR is connected across terminals B32 and N32 of the current source and relay MR is energized at a polarity as required to operate its contact member 45 to the right-hand position to engage a normal polar contact 47, and when the energization of relay NR is reduced to release the relay so that contact member 38 engages back contact 40, the winding 44 of relay MR is connected across terminals B32 and N32 and relay MR is energized as required to operate polar contact member 45 to the left-hand position to engage reverse contact 46. Code following relay MR when operated to alternately close contacts 46 and 47 causes direct current to be alternately supplied to the two portions of primary winding 48 of a decoding transformer DT and an alternating electromotive force is induced in secondary winding 49 of transformer DT, secondary winding 49 being connected to the input terminals of the decoding unit DU.

The decoding unit DU may be any one of several well-known forms and may be the tuned circuit arrangement covered by Letters Patent of the United States No. 1,773,515, granted August 19, 1930 to C. C. Buchanan for Railway traffic controlling apparatus. It is sufficient for the instant application to point out that control relays A, R and L connected to the output side of decoding unit DU are selectively energized according to the frequency of the electromotive force applied to the input terminals of the decoding unit, the arrangement being such that relays A and L are effectively energized and picked up in response to an electromotive force of a frequency caused by operation of code following relay MR

at a rate corresponding to the 180 code rate of the track circuit current impulses, relays R and L are effectively energized and picked up and relay A is released in response to an electromotive force of a frequency caused by operation of relay MR at a rate corresponding to the 120 code rate of the track circuit current impulses, and relay L is effectively energized and picked up and relays A and R are released in response to an electromotive force of a frequency caused by operation of relay MR at a rate corresponding to the track circuit current impulses of the 75 code rate. Again, when relay MR is inactive, relays A, R and L are all released.

Relays A, R and L are used to govern the operating circuits of signal CS. These operating circuits are those commonly provided and it is to be noted that when relay A is picked up closing front contact 50, an operating circuit is closed for lamp 51 and that lamp is illuminated to cause signal CS to display a first or clear signal indication. When relay A is released, closing back contact 52, and relay R is picked up closing front contact 53, an operating circuit is formed for lamps 54 and 55 in multiple and these lamps are illuminated to cause signal CS to display a second or approach-medium signal indication. When relays A and R are released closing back contacts 52 and 56, respectively, and relay L is picked up closing front contact 57, an operating circuit is formed for lamp 58 and that lamp is illuminated to cause signal CS to display a third or approach signal indication. Again, when relays A, R and L are released closing back contacts 52, 56 and 59, respectively, an operating circuit is formed for lamp 60 and that lamp is illuminated to cause signal CS to display a slow speed signal indication.

In describing the operation of the apparatus, I shall assume that the train TC on which the train carried apparatus is mounted occupies track section D—E as shown in the drawing. When the rails are shunted ahead of train TC and no current flows in the rails so that no electromotive force is received by the inductors 12 and 13, the grid bias voltage applied to tube VT3 through the equalizing circuit causes the predetermined normal plate circuit current for tube VT3 and the intermediate energization of relay NR is effected and its two contact members 35 and 38 are held at the mid position. Under such normal conditions code following relay MR is deenergized and inactive with the result that relays A, R and L are released and lamp 60 is illuminated so that the slow speed indication is displayed by the cab signal CS.

I shall next assume that traffic conditions in advance of section D—E are such as to cause either relay WA to be picked up or to cause WA to be released and relay WR to be picked up so that direct current impulses of the 180 code rate are supplied to the track rails of section D—E. Each such code impulse of direct current induces an electromotive force in inductors 12 and 13 which electromotive force is amplified at tubes VT1 and VT2 in the usual manner and a corresponding amplified electromotive force is applied to the grid circuit of the final stage tube VT3. The connections are such that this amplified electromotive force drives control grid 31 of tube VT3 positive in potential with respect to cathode 33 causing current to flow in the grid circuit and the plate circuit current to be increased. This increase in the plate circuit current causes relay NR to be picked up to open back contact 35—37 and to close front contact 38—39, front contact 35—36 remaining closed also. The closing of front contact 38—39 completes the circuit for the top winding 43 of relay MR and relay MR is energized to operate its contact member 45 to the right-hand position. The flow of current in the grid circuit charges condenser C2. The received electromotive force is of short duration and subsequent to such electromotive force the charge of condenser C2 drives control grid 31 of tube VT3 negative in potential with respect to cathode 33. Such negative potential of grid 31 is supplemented by the negative voltage applied through resistor R3 of the first circuit path of the equalizing circuit. The resultant negative grid voltage causes the plate circuit current to be decreased to a value where relay NR is released to open front contacts 35—36 and 38—39 and to close back contacts 35—37 and 38—40. The closing of back contact 38—40 completes the circuit of the lower winding 44 of relay MR and relay MR is energized to operate its contact member 45 to its left-hand position. The opening of front contact 35—36 and closing of back contact 35—37 changes the negative voltage applied through the first circuit path of the equalizing circuit to a positive voltage applied through the second path of the equalizing circuit, and this positive voltage opposes the negative voltage applied from condenser C2. The charge of condenser C2 is discharged through a circuit including resistor 29, that portion of resistor R1 between its positive terminal and terminal 42, resistor R4, back contact 35—37 of relay MR, resistor R2 and grid leak resistor 32. The time constant of condenser C2 and the above traced discharge circuit is such that the charge on condenser C2 leaks away relatively slow and after a predetermined time interval the positive grid voltage applied through the second circuit path of the equalizing circuit effects a less negative voltage for grid 31 and the plate circuit current of that tube is increased toward its normal value. The time constant of condenser C2 and its associated discharge circuit is such that the charge of condenser C2 is discharged during the interval between successive impulses of the track circuit current and hence condenser C2 is discharged and the above operation of charging condenser C2 is repeated for the next code impulse of the track circuit current.

I have found that when the amplified impulse of electromotive force is sufficient to cause relay NR to be released and remain in such released position for a certain length of time there is an accumulated effect built up so that after a few successive impulses the grid voltage changes produced by such impulses tend to cause neutral relay NR to be retained a substantially equal length of time in its picked up and released positions. In other words the equalizing circuit associated with the final stage tube VT3 is constantly seeking to so regulate the grid voltage of that tube as to cause neutral relay NR to be picked up and released for substantially equal periods of time. It follows that when neutral relay NR is thus operated with substantially equal on and off periods the code following relay MR is also operated for substantially equal on and off periods. That is code following relay MR is operated at substantially equal on and off periods notwithstanding the code impulses of direct current which cause the operation of relay MR are short as compared to the duration between successive impulses of current. The filter

comprising resistor R2 and condensers C3 and C4 function to smooth out the abrupt voltage changes which take place when contact member 35 is operated from one position to the other so that the voltage level for control grid 31 of tube VT3 is gradually changed to correspond to the new condition.

I have also found that the voltage regulation of tube VT3 effected through the equalizing circuit tends to produce substantially equal on and off operation periods for relay NR notwithstanding variations in the magnitude of the electromotive force produced by the coded impulses of direct current, variations in the voltage of the current source B32—N32, variations in the code rate and temperature.

It is apparent that when the traffic conditions in advance of section D—E are such as to cause current impulses of the code rate of either 120 or 75 to be applied to the track rails of section D—E, the operation of the apparatus carried on the train is substantially the same as that described above in connection with track circuit current impulses of the 180 code rate, except for the code rate at which neutral relay NR and in turn code following relay MR is operated.

It is clear that one stage of amplification of the apparatus carried on the train may be omitted when the code impulses of the track circuit current are of a relatively high energy level and also that additional stages of amplification may be included in the amplifier if desired.

It is also to be observed that since tubes VT1, VT2 and VT3 are of a high vacuum type and always under the control of the corresponding grid voltage, the apparatus restores itself to an inactive condition whenever the code impulses received from the track circuit cease.

It is to be seen, therefore, that I have provided train carried train control apparatus incorporating a novel and improved multiple stage amplifier each of which stages includes a high vacuum type of electron tube and the final stage of which amplifier is provided with an equalizing circuit effective to cause substantially equal on and off operation periods of a code following relay associated with the plate circuit of the final stage tube, notwithstanding the code impulses of direct current are of short duration as compared with the duration between successive impulses of the current and notwithstanding variations in magnitude of such code impulses of current and voltage variations of the train carried source of current.

Although I have herein shown and described only one form of railway traffic controlling 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 railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising; an electron tube having a plate, a cathode and a control grid; a condenser, a grid leak resistor, a grid circuit including said condenser and grid leak resistor for said tube, means to couple said grid circuit to the track circuit to charge said condenser during each such code impulse of direct current for rendering said control grid negative in potential with respect to the cathode subsequent to each such current impulse, means including said grid leak resistor to discharge said condenser between successive code impulses of current, a neutral relay, a plate circuit including said relay and a current source for said tube to operate said relay in response to the variations of grid potential effected through said condenser, an equalizing circuit including two parallel paths and connected to said grid circuit over respective front and back contacts of said relay, means in said parallel paths to create a positive voltage in a selected one of said paths and a negative voltage in the other of said paths to modify the potential of the grid with respect to the cathode as effected by said condenser according as said relay is picked up or released, and a signal controlling device governed over contacts of said relay when operated.

2. In railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising; an electron tube having a plate, a cathode and a control grid; a condenser, a grid leak resistor, a grid circuit including said condenser and grid leak resistor for said tube, means to couple said grid circuit to the track circuit to charge said condenser during each such code impulse of direct current for rendering said control grid negative in potential with respect to the cathode subsequent to each such current impulse, means including said grid leak resistor to discharge said condenser between successive code impulses of current, a neutral relay, a current source, a plate circuit including said relay and current source for said tube to operate the relay in response to the variations of grid potential effected through said condenser, another resistor connected across said current source, an equalizing circuit including two parallel paths connected to said grid circuit over respective front and back contacts of said relay and to preselected mid terminals of said other resistor to apply to the control grid a positive bias voltage when said relay is released and a negative bias voltage when the relay is picked up, and a signal controlling device governed over contacts of said relay when operated.

3. In railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising; an electron tube having a plate, a cathode and a control grid; a condenser, a grid leak resistor, a grid circuit including said condenser and grid leak resistor for said tube, means to couple said grid circuit to the track circuit to charge said condenser during each such code impulse of direct current for rendering said control grid negative in potential with respect to the cathode subsequent to each such current impulse, means including said grid leak resistor to discharge said condenser between successive code impulses of current, a neutral relay having a contact member provided with overlapping front and back contacts, a current source, a plate circuit including said relay and current source for said tube to operate the relay in response to the variations of grid potential effected through said condenser, another resistor connected across said current source, an equalizing circuit including a first and a second circuit path in parallel and which are connected to said grid circuit over said overlapping front and back contacts respectively, said first and second circuit paths connected to preselected mid terminals of said other resistor to apply to said control grid a bias voltage according as said relay is at a mid position closing

both said overlapping contacts or is picked up closing only the front contact or is released closing only the back contact, another contact member for said relay having front and back contacts closed only when the relay is picked up and released respectively, and a code following relay operated over a circuit including said last mentioned front and back contacts.

4. In railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising; an electron tube having a plate, a cathode and a control grid; a condenser, a grid leak resistor, a grid circuit including said grid leak resistor for said tube, means including said condenser to couple said grid circuit to said track circuit to charge said condenser during each such code impulse of direct current for rendering said control grid negative in potential with respect to said cathode subsequent to each such current impulse, means including said grid leak resistor to discharge said condenser between successive code impulses of current, a neutral relay, a current source, a plate circuit including said neutral relay and current source for said tube to operate the relay in response to the variations of grid potential effected by said condenser, another resistor connected across said current source, a first and a second circuit path in parallel, said first circuit path connected between said control grid and a preselected mid terminal of said other resistor over a front contact of said neutral relay to apply to the grid a negative bias voltage, said second circuit path connected between said control grid and another preselected mid terminal of said other resistor over a back contact of said neutral relay to apply to the grid a positive bias voltage, and a code following relay controlled over a circuit including a contact of said neutral relay.

5. In railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising; an electron tube having a plate, a cathode and a control grid; a source of direct current, a first resistor connected across said current source, a grid leak resistor, a grid circuit for said tube and including said cathode connected to a mid terminal of said first resistor and said control grid connected through said grid leak resistor to two mid terminals of said first resistor on opposite sides of said first mentioned mid terminal over a first and a second circuit path in parallel, a condenser, means including said condenser to couple said grid circuit to said track circuit to charge said condenser in response to each such code impulse of direct current for rendering said grid negative in potential with respect to the cathode subsequent to each such current impulse, said grid circuit effective to discharge said condenser between successive code impulses of current, a neutral relay, a plate circuit including said relay and said current source for the tube to operate the relay in response to the variations of grid potential effected through said condenser, a front and a back contact of said neutral relay interposed in said first and second circuit paths respectively to modify the grid potential effected through said condenser by voltages derived from said first resistor to control the on and off operation periods of said relay, and a signaling device controlled over a contact of said relay.

6. In railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising; an electron tube having a plate, a cathode and a control grid; a source of direct current, a first resistor connected across said current source, a grid leak resistor, a grid circuit for said tube and including said cathode connected to a mid terminal of said first resistor and said control grid connected through said grid leak resistor to two mid terminals of said first resistor on opposite sides of said first mentioned mid terminal over a first and a second circuit path in parallel, a condenser, means including said condenser to couple said grid circuit to said track circuit to charge said condenser in response to each such code impulse of direct current for rendering said grid negative in potential with respect to the cathode subsequent to each such current impulse, said grid circuit effective to discharge said condenser between successive code impulses of current, a neutral relay having a contact member provided with overlapping front and back contacts, a plate circuit including said relay and said current source to operate the relay in response to the variations of grid potential effected through said condenser, said contact member interposed in said grid circuit with its front and back contacts included in said first and second circuit paths respectively to apply to the grid circuit a first, a second or a third voltage derived from said first resistor according as said relay is at a mid position, is picked up or is released for governing the on and off operation periods of said neutral relay; and a code following relay governed over other contacts of said neutral relay.

7. In railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising, a multiple stage amplifier including a first and a second electron tube, means to couple the grid of said first tube to said track circuit to amplify in its plate circuit the electromotive force derived from such code impulse of direct current, means including a condenser to couple the grid of said second tube to the plate circuit of the first tube to charge the condenser in response to each such amplified electromotive force to effect a negative grid voltage for the second tube subsequent to each such electromotive force, means including a grid leak resistor to discharge the condenser between successive electromotive forces, a neutral relay having a contact member provided with overlapping front and back contacts, a plate circuit for said second tube and including said neutral relay to operate the relay by the grid voltage derived through said condenser, an equalizing circuit including two parallel circuit paths which are connected to the grid of said second tube over said contact member with its front contact included in one path and its back contact included in the other path, means to apply a negative voltage to the grid of said second tube over said one path and a positive voltage over said other path to equalize the on and off operation periods of said relay, another contact member for said neutral relay and provided with a front and a back contact, and a code following relay controlled over the last mentioned front and back contacts.

8. In railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising, an amplifier including an electron tube,

means including a condenser to couple the grid of said tube to the track circuit to charge the condenser in response to each such current impulse to effect a negative grid voltage for the tube subsequent to each such current impulse, means including a grid leak resistor to discharge the condenser between successive impulses, a neutral relay having a contact member provided with overlapping front and back contacts, a plate circuit for said tube and including said neutral relay to operate the relay by the grid voltage derived through said condenser, an equalizing circuit including two parallel circuit paths which are connected to the grid of said tube over said contact member with its front contact included in one path and its back contact included in the other path, means to apply a negative voltage to the grid of said tube over said one path and a positive voltage over said other path to equalize the on and off operation periods of said relay, a filter comprising a resistor and at least one condenser and interposed in the connection between said contact member and said grid of the tube to smooth out the abrupt voltage changes when said front and back contacts are opened, another contact member for said neutral relay and provided with a front and a back contact, and a code following relay operated over a circuit including said last mentioned contact member and its front and back contacts.

9. In railway traffic controlling apparatus for use with a track circuit supplied with code impulses of direct current, the combination comprising; an electron tube having a plate, a cathode and control grid; a source of direct current, a first resistor connected across said current source, a grid circuit for said tube including the cathode connected to a preselected mid terminal of said resistor and said grid connected to said first resistor over another resistor, a condenser, means including said condenser to couple said grid circuit to said track circuit to apply to grid an electromotive force in response to each such code impulse of direct current, said electromotive force effective to cause grid circuit current to flow to change said condenser and render the grid negative in potential with respect to the cathode subsequent to each such electromotive force, circuit means to discharge said condenser between successive electromotive forces, a neutral relay, a plate circuit for said tube and including said relay and said current source to operate the relay in response to the variations of the grid potential effected through said condenser, an equalizing circuit including two parallel resistors and respective front and back contacts of said relay and interposed in the grid circuit between said other resistor and said one resistor with said two parallel resistors connected to said one resistor on opposite sides of said mid terminal to apply a positive or a negative bias voltage to said tube according as said relay is released or picked up, and a railway traffic controlling device controlled over a contact of said neutral relay when operated.

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