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RAILWAY TRAFFIC CONTROLLING APPARATUS

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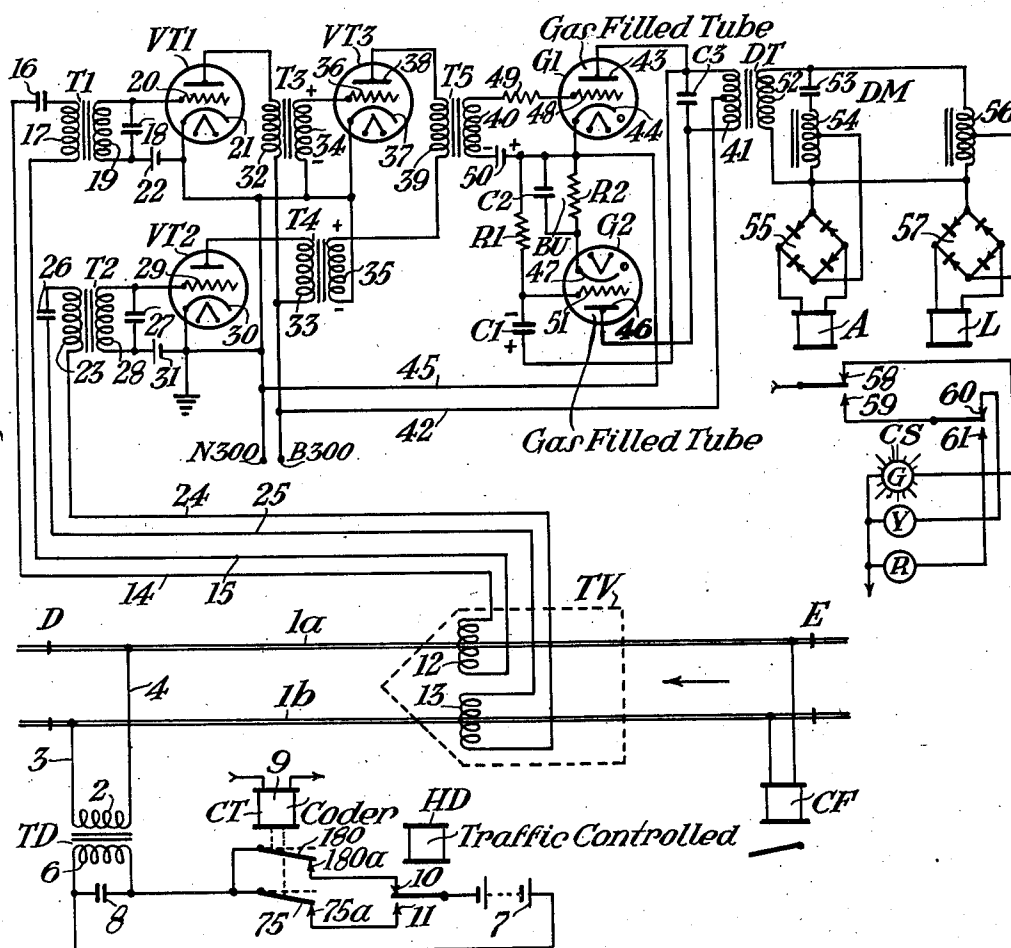


Fig.1.

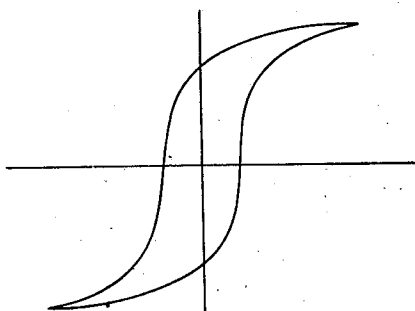


Fig. 2.

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RAILWAY TRAFFIC CONTROLLING
APPARATUS

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

Generally speaking, the coded current used to govern present day train carried train control apparatus is supplied across the track rails of a track section at the exit end of the section so that when a train occupies the section, current flows along one rail, through the wheels and axles of the train and back the other rail, such current flowing in opposite directions in the rails at any given instant. Inductors are mounted on the train ahead of the leading pair of wheels with one inductor over each rail to inductively pick up an electromotive force in response to such coded rail current. In many cases the two inductors are connected together in such manner that the electromotive forces induced therein due to current flowing in opposite directions in the rails add their effects and the resultant electromotive force is applied to the input side of a train carried amplifier for operating a code following relay connected to the output side of the amplifier. The code following relay in turn governs decoding means selectively responsive to the rate at which the relay is operated and in turn selectively responsive to the code rate of the rail current. In some cases the two train carried inductors are connected to separate amplifiers and the two electromotive forces picked up by the inductors are amplified separately. In such case, the output sides of the separate amplifiers are connected in such a manner that the outputs are combined for operating the code following relay.

It is the practice to use alternating current of the order of 100 cycles per second and to code such current by periodically interrupting the circuit at different rates, such as 180, 120 and 75 times per minute. At least such code rates are those generally used to reflect clear, approach-medium and approach traffic conditions, respectively.

The length of the track section is predetermined in part according to the desired spacing of trains and according to the braking distance required for the trains operating over the section. The braking distance required depends upon the maximum permissible speed and the nature of equipment, such as passenger or freight cars. The high speeds prescribed for present day traffic in both freight and passenger train service require relatively long braking distances and hence a relatively long track section

if a train is to be brought from maximum speed to a stop in a single track section. For this reason track sections of the order of 11,000 feet in length are provided where high train speeds prevail. Broken rail protection is also an essential feature in such railway signaling systems. A single track circuit for a track section of 11,000 feet may not provide satisfactory broken rail protection when alternating current of 100 cycles per second is used. Consequently such 11,000 foot track section may require that it be provided with one or more cut section locations to divide the section into subsections, each of which includes a track circuit. Such cut section locations add to the apparatus required and correspondingly increase the cost.

It has been proposed to use railway traffic controlling apparatus responsive to coded direct current because direct current will provide satisfactory broken rail protection for any length of track section within the limits here contemplated. In order to conserve the output required from the track battery that serves as the source of the coded direct current, and to provide track circuits of high shunting sensitivity, it has also been proposed to code the direct current in such a manner that a single impulse of current of relatively high peak voltage and short duration is supplied to the rails at the start of each on code period. When the aforementioned code rates of 180, 120 and 75 impulses per minute are used with such coding, then the current impulse is short as compared with the duration between successive impulses. For example, the duration of a current impulse may be of the order of .05 second and hence under the 180 code rate the duration between successive impulses is about .28 second. Under the other code rates of 120 and 75, the duration of the impulse would be the same and the duration between successive impulses would be correspondingly greater. Such code impulses of direct current cause the code following relay to be operated with unequal on and off periods unless some additional means is provided to prolong the effect of each code impulse. That is, some means for equalizing the on and off periods of the code following relay is desirable because the standard form of decoding means governed by the code following relay is most satisfactorily operated when the code following relay is operated at substantially equal on and off periods. In the present day arrangement, the code following relay governs the decoding means by governing the supply of direct current to a decoding transformer, direct cur-

rent being alternately supplied to preselected portions of a primary winding of the transformer over normal and reverse contacts of the relay so that when the relay is operated to alternately open and close its contacts current is alternately supplied to the two portions of the primary winding and there is created in a secondary winding of the transformer an alternating electromotive force of a frequency corresponding to the code rate at which the relay is operating and of course, in turn, according to the code rate of the rail current. Consequently, as set forth hereinbefore, it is desirable to provide some equalizing means for equalizing the on and off periods of the relay. Again rigid requirements are placed upon a code following relay having mechanical moving parts because such code following relay is in continuous operation.

When coded direct current is used operating difficulties may be experienced because of the possible false energization of the train carried amplifier produced by the so-called "magnetized spots" of the track rails. Such magnetized spots occur at random and act to induce an electromotive force in a train carried inductor as the train moves over such rail spot. Such stray electromotive force when amplified may adversely affect the operation of the code following relay.

In view of these various conditions imposed upon railway traffic controlling apparatus of the type here involved, a feature of my invention is the provision of a novel and improved organization of railway traffic controlling apparatus responsive to coded direct current.

Another feature of my invention is the provision of train carried train control apparatus incorporating novel and improved receiving and amplifying means wherewith such amplifying means is effectively excited only when two electromotive forces are simultaneously picked up one from each rail and when such electromotive forces are of a predetermined phase relation, and electromotive forces created by random magnetic fields do not effectively excite the amplifier.

Again, a feature of my invention is the provision of railway traffic controlling apparatus of the type here contemplated incorporating novel means for equalizing the resultant on and off periods of a code following relay governed by energy impulses of short duration as compared to the duration between successive impulses.

Another feature of my invention is the provision of train carried train control apparatus which is free from mechanical moving parts.

Furthermore, a feature of my invention is the provision of railway traffic controlling apparatus of the type here involved incorporating novel means for alternately firing two gas filled tubes for substantially equal periods in response to coded direct current and which means automatically varies the firing period according to the code rate of the current and which tubes are adaptable of functioning as a code following relay of no moving parts for controlling decoding means selectively responsive to different predetermined code rates.

Other features, objects and advantages of my invention will appear as the specification progresses.

The above features, advantages and objects of my invention are obtained by providing on a train adapted to travel a track section whose rails are supplied with direct current coded at different code rates, a receiving and amplifying means, an

equalizing relay means and the usual standard decoding and signaling means. The receiving and amplifying means comprises two inductors mounted on the train in advance of the leading pair of wheels with one inductor over each rail, and a multiple tube two channel amplifier. The two electromotive forces induced in the two inductors by each on period or code impulse of rail current are applied one to each of two tubes of the amplifier with the result an enlarged electromotive force of a code corresponding to the code of the rail current appears in the output of each such tube. The output electromotive force of one of these two tubes is applied to the grid of a third tube of the amplifier and the output electromotive force of the other one of the first mentioned two tubes of the amplifier is applied to the plate circuit of the third tube, the arrangement being such that current flows in the output of the third tube only if the two electromotive forces created in the outputs of the first two mentioned tubes appear simultaneously and are in phase with each other. Thus a current impulse in the output of the third tube of the amplifier can happen only when the coded rail current flows in the two rails in opposite directions at the same instant, and stray magnetic fields which excite one inductor only or which excite both inductors but at different times or which excite both inductors at the same time but do not create electromotive forces of a proper phase relation do not cause an effective current impulse to appear in the output of the third tube of the amplifier.

The equalizing relay means comprises two gas filled or controlled ionization type of electron tubes, together with novel circuits and the necessary sources of current. The two gas filled tubes are provided with anode circuits that include a common source of direct current and preselected portions of a primary winding of a decoding transformer. This direct current source for the anode circuits is of a voltage sufficient to fire each tube when the grid of a tube is of substantially zero potential with respect to the tube cathode. The grid circuit of a first one of the gas filled tubes includes a voltage source, such as a battery, to effect a negative grid bias voltage so that this first gas filled tube is normally extinguished. The grid circuit for this first gas filled tube also includes a winding which is coupled to the output of the third tube of the receiving amplifier, and each current impulse caused to flow in the output of the receiving amplifier sets up an electromotive force in the grid circuit of the first gas filled tube that overcomes the normal grid bias voltage due to the battery and this first gas filled tube is fired. In other words, a first one of the gas filled tubes is normally biased to be extinguished and is fired in response to each on period of the rail current. The grid circuit for the second gas filled tube includes no normally active source of negative bias voltage and the tube is normally fired due to the voltage of the current source of the anode circuit. The grid circuit of the second tube is provided, however, with a biasing means including resistors and condensers, such condensers becoming charged due to the voltage drop across the associated resistors as caused by the normal flow of anode current. The arrangement of this biasing means is such that when the second gas filled tube becomes extinguished, the charge on the condensers produces a negative grid bias voltage that prevents this second tube from becoming refired by the anode current source until the charge on the condensers leaks off through

the associated resistors. In other words, the second gas filled tube is normally fired, but once extinguished it remains extinguished for an interval whose duration is predetermined by the charge built up on the associated biasing means. An extinguishing reactance, preferably in the form of a condenser, is connected to the anode circuits of the two gas filled tubes to alternately extinguish the tubes. To sum up, therefore, the first gas filled tube is normally extinguished and the second gas filled tube is normally fired, the first tube is fired in response to an electromotive force created by the coded rail current, the second tube is extinguished by the extinguishing condenser immediately following the firing of the first tube, the second tube is refired after a predetermined interval as determined by the charge on its biasing means, and the first tube is extinguished by the extinguishing condenser immediately following the refiring of the second tube, the two gas filled tubes being then ready to repeat this cycle of operation at the next electromotive force created by the coded rail current. It is to be understood of course that the second tube is refired during the duration between successive electromotive forces. Since the anode circuit of each of the gas filled tubes includes a preselected portion of a primary winding of the decoding transformer, such alternate firing of the gas filled tubes causes direct current to alternately flow in the two portions of the primary winding of the decoding transformer and an alternating electromotive force is induced in a secondary winding of such transformer, the frequency of such alternating electromotive force corresponding to the rate at which the two gas filled tubes are alternately fired, and in turn according to the code rate of the rail current.

The decoding means comprises tuned decoding circuits of the usual standard form and which circuits are connected directly to the secondary winding of the decoding transformer. The decoding circuits govern a cab signal or other train control devices according to the frequency of the electromotive forces applied to such circuits.

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

In the accompanying drawing, Fig. 1 is a diagrammatic view showing one form of apparatus embodying my invention when used with train carried train control apparatus. Fig. 2 is a diagram illustrating an operating characteristic of the apparatus of Fig. 1.

Referring to Fig. 1, 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 comprising a source of coded current connected across the rails at the exit end of the section and a code following relay connected across the rails at the entrance end of the section. In the present embodiment of my invention, use of code impulses of direct current is contemplated and the source of coded direct current for the track circuit of section D—E comprises a battery 7, a code transmitter or coder CT and a track transformer or reactor TD. Secondary winding 2 of transformer TD is connected across the rails at exit end D over wires 3 and 4. Primary winding 6 of transformer TD is con-

nected to battery 7 over either code contact member 75 or 180 of coder CT according to the position of a traffic controlled relay HD. A condenser 8 is preferably connected across primary winding 6.

Code transmitter CT may take the form of any one of several well-known structures for such devices and it is sufficient to point out that as long as its operating winding 9 is supplied with current from any convenient source of current, not shown, the code contact members 75 and 180 are operated at preselected code rates. For example, contact member 75 is operated to engage and disengage a contact 75a at the rate of 75 times per minute and contact member 180 is operated to engage and disengage a contact 180a at the rate of 180 times per minute. The relay HD is controlled by traffic conditions in advance of section D—E, but such control apparatus is not shown since it would be in accordance with standard practice and forms no part of my present invention. It is sufficient for the present application to point out that relay HD is picked up to close front contact 10 when the section next in advance of section D—E is unoccupied, and the relay is released closing back contact 11 when such section next in advance is occupied. In other words, relay HD is picked up under clear traffic conditions in advance and is released under approach traffic conditions in advance. When relay HD is picked up closing front contact 10, battery 7 is connected to primary winding 6 over a circuit including code contact member 180 of coder CT, and during each interval that contact 180—180a is closed direct current flows in winding 6 causing magnetic energy to be stored in the magnetic core of transformer TD. The circuit including battery 7, front contact 10 and primary winding 6 is so proportioned as to its time constant that the magnetic energy builds up relatively slow and little, if any, electromotive force is induced in secondary winding 2, at least such electromotive force is so small it can be neglected. When contact member 180 breaks engagement with contact 180a, the flow of current from battery 7 is interrupted and the magnetic energy stored in transformer TD decays rapidly and an electromotive force of relatively high peak voltage is induced in secondary winding 2 and a current impulse of relatively high peak voltage is supplied to the track rails of section D—E. This impulse of direct current is of a given polarity and is of short duration, the part being proportioned to provide an impulse of current of the order of say .05 second. Consequently, a code impulse of current is supplied to the rails each operation of code contact member 180 and direct current of the code rate of 180 impulses per minute is supplied to the rails as long as relay HD is picked up. That is, such code rate of direct current is supplied to the rails under clear traffic conditions. Under approach traffic conditions, relay HD is released closing back contact 11, and battery 7 is connected to primary winding 6 over contact member 75 and the operation is the same as described above except that current of the code rate of 75 impulses per minute is supplied to the track rails. It is to be observed that under each code rate the duration of the current impulse, here assumed as .05 second, is short as compared to the duration between successive impulses, the duration between the impulses of the 180 code rate being substantially .28 second, and being substantially .75 second under the 75 code rate.

It will be understood, of course, that my invention is not limited to code rates of 75 and 180 impulses per minute or to impulses of the duration of .05 second, but such code rates and characteristics for the direct current impulses have been found satisfactory. As a matter of fact, the direct current for the track circuit of section D—E may be coded to provide substantially equal on and off periods for the current.

A code following track relay CF is connected across the rails at entrance end E, and when section D—E is unoccupied, that is, when a train shown conventionally at TV does not occupy the section, relay CF is operated at a code rate corresponding to the code rate of the current impulses supplied to the rails through transformer TD in the manner just explained. Track relay CF would be used to govern apparatus including a control relay for the section next in the rear of section D—E and which relay would be similar to control relay HD governed by traffic in advance of section D—E. The apparatus governed by track relay CF is not shown for the sake of simplicity because such apparatus forms no part of my invention and would be in accordance with standard practice.

The train shown conventionally at TV is provided with train carried train control apparatus embodying my invention, and which apparatus comprises a receiving and amplifying means to be shortly described, an equalizing relay means including two gas filled tubes G1 and G2 and a novel circuit arrangement, a decoding transformer DT, decoding circuits DM, control relays A and L and a cab signal CS, together with the necessary sources of current.

The receiving and amplifying means comprises inductors 12 and 13 and three amplifying electron tubes VT1, VT2 and VT3, together with the necessary circuits. Inductors 12 and 13 are preferably alike and are mounted on the train ahead of the leading pair of wheels and in inductive relation to the rails 1a and 1b, respectively. It follows that when train TV occupies section D—E and there is no other train between it and the exit end of the section, an electromotive force is picked up by each inductor 12 and 13 in response to each code impulse or on period of the direct current supplied to the rails of the section through track transformer TD, each such picked up electromotive force having a code rate characteristic corresponding to the coded rail current. This is so because such current flows along say, rail 1a, through the train shunt and back rail 1b.

Inductors 12 and 13 are connected to the input side of tubes VT1 and VT2, respectively, which as here shown are of the indirect heater type. To be explicit, inductor 12 is connected to primary winding 17 of a transformer T1 over wires 14 and 15, a condenser 16 being interposed in wire 14; and a condenser 18 is connected across secondary winding 19 of transformer T1, and secondary winding 19 and condenser 18 in multiple are connected across grid 20 and cathode 21 of tube VT1, a biasing battery 22 being interposed in the connection to provide a desirable grid bias voltage for the tube. Similarly, inductor 13 is connected to primary winding 23 of a transformer T2 over wires 24 and 25, a condenser 26 being interposed in wire 25; and a condenser 27 is connected across secondary winding 28 of transformer T2, and secondary winding 28 and condenser 27 in multiple are connected across grid 29 and cathode 30 of tube VT2, a battery 31

being interposed in the connection to provide a desired grid bias voltage for tube VT2.

The first tube VT1 has a plate circuit that includes a direct current source whose terminals are indicated at B300 and N300, and a primary winding 32 of a transformer T3; while the second tube VT2 has a plate circuit that includes the B300—N300 current source and a primary winding 33 of a transformer T4. The filaments of tubes VT1 and VT2 are heated in the usual manner by a current source, not shown, and it follows that the two electromotive forces induced in inductors 12 and 13 by a code impulse of rail current are applied simultaneously to the respective tubes VT1 and VT2, and correspondingly enlarged electromotive forces appear in the secondary windings 34 and 35 of transformers T3 and T4, these two latter electromotive forces being of like character and of a phase relation predetermined by the connection of inductors 12 and 13 and associated transformers. Furthermore, the electromotive forces created in secondary windings 34 and 35 are of the same code rate as the rail current. To aid in the understanding of the apparatus, it is to be noted that the connections are such that the effective electromotive forces induced in secondary windings 34 and 35 cause in each case the top terminal of the associated winding to be positive and the bottom terminal to be negative, as indicated by the plus and minus signs placed on the drawing.

The third tube VT3 of the amplifier is also shown as of the indirect heater type whose filament is normally heated in the usual manner. The secondary winding 34 of transformer T3 is connected across grid 36 and cathode 37 of tube VT3, and secondary winding 35 of transformer T4 is connected across plate 38 and cathode 37 of tube VT3. A primary winding 39 of an output transformer T5 is included in the plate circuit of tube VT3. Hence, the electromotive force picked up by inductor 12 and amplified by the tube VT1 causes a corresponding electromotive force to be applied to the grid of tube VT3, and the electromotive force picked up by inductor 13 and amplified by tube VT2 causes a corresponding electromotive force to be applied to the plate circuit of tube VT3. When these two electromotive forces applied to the plate and grid circuits of tube VT3 occur so that the grid is driven more positive in potential with respect to cathode 37 at the same instant plate 38 is positive, current flows in the plate circuit of tube VT3 and an electromotive force is induced in secondary winding 40 of output transformer T5. It is clear that if these two electromotive forces applied to tube VT3 are out of phase or only one occurs at a time, or are of the polarity opposite to that shown in Fig. 1, no electromotive force appears in the secondary winding 40 of output transformer T5. Consequently the coded direct current applied to the rails of section D—E is effective to create an electromotive force of a corresponding code rate in the secondary winding 40 of the output transformer T5, but stray magnetic fields that excite a single inductor at a time or excite the two inductors out of phase are ineffective to create an electromotive force in the output of the amplifier. The manner of using the code impulses of electromotive force created in secondary winding 40 will be described hereinafter.

The gas filled or controlled ionization tubes G1 and G2 of the relay equalizing means are shown

as of the indirect heater type whose filaments would be continuously heated in the usual manner. These tubes G1 and G2 are provided with anode circuits, each of which includes the B300—N300 current source and a preselected portion of a primary winding 41 of decoding transformer DT. That is, the anode circuit of the first tube G1 can be traced from terminal B300 over wire 42 to a center terminal of primary winding 41 of transformer DT, top half portion of winding 41 as viewed in Fig. 1, anode 43 of tube G1, intervening tube space to cathode 44, and wire 45 to terminal N300; and the anode circuit for tube G2 includes terminal B300, wire 42, lower half portion of primary winding 41, anode 46 of tube G2, intervening tube space to cathode 47, a biasing unit BU to be referred to later, and wire 45 to terminal N300. The voltage of the B300—N300 current source is high enough to fire tubes G1 and G2 when the grid of a tube is of substantially the same potential as the cathode of the tube.

The grid circuit for the first tube G1 includes grid 48, resistor 49, winding 40 of transformer T5, a battery 50 and cathode 44. Battery 50 is selected and disposed so as to provide a negative grid bias voltage sufficient that tube G1 is normally retained extinguished. The connections of secondary winding 40 of transformer T5 are such that the electromotive force produced therein in response to the coded rail current, as explained hereinbefore, overcomes the voltage of battery 50 and tube G1 is fired, due to the voltage of the B300—N300 current source. That is, tube G1 is normally retained extinguished or non-conductive and is fired and becomes conductive in response to each electromotive force created in winding 40 due to the rail current. Once fired, tube G1 remains in that condition subsequent to the termination of the electromotive force created in winding 40 until the tube is extinguished in a manner to shortly appear.

The grid circuit for the second gas filled tube G2 includes grid 51, grid leak resistor R1, biasing unit BU and cathode 47. The unit BU comprises a condenser C2 and a resistor R2 in multiple. Also a condenser C1 is connected between grid 51 and the anode 43 of the first tube G1. Since there is no normally active source of voltage in the grid circuit of tube G2, the tube is normally fired due to the voltage impressed across its anode and cathode by the B300—N300 current source. The anode current of tube G2 flowing through the lower half portion of primary winding 41 of transformer DT and through resistor R2 of unit BU causes condenser C2 of unit BU to be charged at a potential substantially equal to the voltage drop across resistor R2, and condenser C1 to be charged at a potential substantially equal to the voltage drop through the lower half portion of primary winding 41. It is clear that once tube G2 is extinguished the grid 51 is rendered negative in potential with respect to the cathode 47 by the charge on either or both condensers C2 and C1. When tube G2 is extinguished the charge on condenser C2 is discharged through resistor R2. The charge on condenser C1 can be discharged through a path comprising resistor R1 and the tube G1 when that tube is fired and made of low resistance. After a time interval, predetermined by the proportioning of the parts, condensers C1 and C2 become discharged and the negative grid bias voltage of grid 51 is re-

duced to a point where the tube G2 is refired due to the voltage of the B300—N300 current source.

An extinguishing reactance here shown as a condenser C3 is connected across the outside terminals of primary winding 41 of transformer DT, that is, condenser C3 is connected across the anodes of tubes G1 and G2. With tube G2 normally conductive and tube G1 normally non-conductive, condenser C3 is charged to a potential substantially equal to the voltage drop across the lower half portion of primary winding 41, the top terminal of condenser C3 being positive with respect to its lower terminal. If tube G1 is now fired the charge of condenser C3 is applied across cathode 47 and anode 46 of tube G2 to extinguish tube G2. It is to be noted that condenser C1 is charged at a polarity that its discharge aids in extinguishing tube G2. When tube G1 is conductive, condenser C3 is charged due to the voltage drop through the top half portion of primary winding 41, the lower terminal of condenser C3 being positive with respect to its top terminal. If tube G2 is now fired, the charge on condenser C3 is applied across cathode 44 and anode 43 of tube G1 to extinguish tube G1.

It is to be seen, therefore, that when a code impulse of electromotive force appears in secondary winding 40 of the output of the receiving amplifier, tube G1 is fired, tube G2 is immediately extinguished due to condenser C3 and remains extinguished until condensers C2 and C1 are discharged through the associated resistors. Tube G2 is then refired and tube G1 is extinguished due to condenser C3. This alternate firing of tubes G1 and G2 is repeated for each code impulse of electromotive force appearing in secondary winding 40, it being understood of course that the condensers C2 and C1 discharge to permit tube G2 to be refired during the interval between successive impulses of the electromotive forces.

The anode currents for tubes G1 and G2 flow in the two half portions of primary winding 41 of transformer DT alternately and hence cause an alternating electromotive force to be induced in secondary winding 52 of that transformer, the frequency of such alternating electromotive force corresponding to the rate at which the two tubes are alternately fired.

Secondary winding 52 of transformer DT is connected to decoding circuits DM which preferably consist of the standard form of tuned decoding circuits. A first one of such decoding circuits includes a condenser 53 and an inductor 54, across at least a portion of which inductor control relay A is connected through a full wave rectifier 55. A second decoding circuit includes an inductor 56 across at least a portion of which is connected control relay L through a full wave rectifier 57. The first mentioned decoding circuit is tuned to resonance at the frequency of the alternating electromotive force created in secondary winding 52 in response to the 180 code rate of the rail current. The second mentioned decoding circuit is non-tuned. Consequently control relay A is effectively energized and picked up only in response to rail current of 180 code rate and relay L is effectively energized and picked up in response to rail current of either the 75 or 180 code rate. Both relays A and L are released when no electromotive force is produced in secondary winding 52.

Control relays A and L are used to govern the

operating circuits of suitable train carried train control devices such as cab signal CS operable to display any one of three different signal indications. As here shown, when relay A is picked up to close front contact 58 a circuit is formed for a green light G and signal CS displays a green light for a clear signal indication; when relay A is released and relay L is picked up, a circuit is formed over back contact 59 of relay A, front contact 60 of relay L, and yellow lamp Y of signal CS and signal CS displays a yellow light for an approach signal indication; and when both relays A and L are released closing back contacts 59 and 61, respectively, a circuit is formed for a red lamp R of signal CS and signal CS displays a red light for a slow speed signal indication.

In describing the operation of the apparatus I shall first assume that train TV occupies section D—E at a time when relay HD is picked up in response to clear traffic conditions in advance and code impulses of current of the 180 code rate are supplied to the rails of section D—E. At the start, a first code impulse of rail current induces electromotive forces in inductors 12 and 13 which are amplified by tubes VT1 and VT2, respectively, and there appears a corresponding impulse of electromotive force in secondary winding 40 of transformer T5 in the output of tube VT3. This latter electromotive force created in secondary winding 40 of transformer T5 causes tube G1 to be fired and with tube G1 fired, the normally fired tube G2 is immediately extinguished due to condenser C3. Tube G1 remains fired and tube G2 remains extinguished subsequent to the termination of the electromotive force created in winding 40 due to the biasing voltage created by unit BU and condenser C1 associated with tube G2. When the charges on condenser C2 of unit BU and condenser C1 are discharged sufficiently, tube G2 is refired and tube G1 is immediately extinguished due to condenser C3. At the next and at each successive rail current impulse, this cycle of operation of tubes G1 and G2 is repeated with the result there is induced in secondary winding 52 of the decoding transformer DT an alternating electromotive force of a frequency corresponding to the 180 code rate of rail current. The control relay A is now picked up and the cab signal CS is operated to display a green light as a clear signal indication. The biasing means associated with tube G2 is so proportioned and adjusted that tubes G1 and G2 are alternately fired at substantially equal periods, and the electromotive force induced in secondary winding 52 of decoding transformer DT and applied to the decoding circuits has substantially equal half cycle periods.

I shall next assume that the train TV occupies the section D—E at a time when control relay HD is released due to approach traffic conditions in advance and direct current of the 75 code rate is supplied to the rails of section D—E. The operation of the train carried apparatus is the same as described in connection with current of the 180 code rate, except the alternating electromotive force appearing in secondary winding 52 of the decoding transformer and applied to the decoding circuits is of a frequency corresponding to the 75 code rate, and relay A is released and relay L is picked up. This set-up of control relays A and L causes signal CS to display a yellow light as an approach signal indication.

In the event another train occupies section D—E ahead of train TV, then the coded current supplied to the rails is shunted away from train

TV and no electromotive force is picked up by the inductors and no alternating electromotive force is created in secondary winding 52 of the decoding transformer with the result relays A and L are both released and signal CS displays a red light for a slow speed signal indication.

In order to understand how equalized firing time (on and off periods) of the gas filled tubes is accomplished for the different code rates, consider the amount of current that flows through each half portion of the primary winding 41 of decoding transformer DT under the different conditions. If the firing times (on periods) of the two tubes are equal, the magnetic flux set up in transformer DT during the firing of each tube is substantially equal and opposite. Under such circumstances the hysteresis loop of transformer DT will be symmetrical as illustrated in Fig. 2, and the decoding transformer operates efficiently, the greater part of the current supplied to its primary winding being useful load current and only a small fraction of the current being used to supply magnetizing losses. If, however, the firing periods of the two tubes G1 and G2 are not equal in length, the operating point of the magnetic core of transformer DT shifts to a point on the BH curve where the operation during one period will not be efficient and an excess of magnetizing current is required. This is made use of by arranging the circuit constant of tube G2 so that its tendency is to become fired and conductive early. However, if the firing starts too early it will be conducting for a period greater than the conducting period of tube G1 and the excess of magnetizing current builds up a larger charge in condenser C2 of the biasing unit of tube G2. Such larger charge on condenser C2 tends to retain tube G2 extinguished a little longer at the next cycle of operation and the tendency is for the conducting (on) periods of the two tubes to equalize even if the code rates vary. That is, such variations of the magnetization in the code of the decoding transformer tends to vary the charge on the condenser of the biasing unit of tube G2 which in turn tends to cause a substantially equal firing time for the two tubes under the different code rates of the rail current impulses.

Apparatus embodying my invention has the advantage that coded direct current can be used and satisfactory broken rail and high shunting sensitivity provided for a long track circuit, stray magnetic fields and magnetized rail spots do not adversely excite the receiving amplifier to cause a false operating impulse, equalization of the half cycles of the current supplied to the decoding means is effected for the different code rates by gas filled tubes, the output of which tubes is sufficient to enable standard decoding circuits to be controlled direct from the output of the gas filled tubes and a code following relay having moving parts is avoided.

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 combination, a track section, means to supply coded direct current to the rails of the section, a train to travel such section, receiving means on the train coupled to the rails to pick

up time spaced electromotive forces in response to such coded rail current, two train carried gas filled tubes provided with anode circuits having a common source of direct current and each of which circuits includes a preselected portion of a primary winding of a decoding transformer, said direct current source of a voltage sufficient to normally fire each of said tubes, a grid circuit including a winding coupled to said receiving means and a source of biasing voltage for a first one of said tubes, said biasing voltage source disposed to provide a predetermined negative grid voltage to prevent said first tube from being fired and said winding disposed to overcome such negative grid voltage and permit the first tube to be fired in response to each said picked up electromotive force, a grid circuit including a biasing unit comprising a resistor and a condenser in multiple for a second one of said tubes, said biasing unit disposed adjacent the cathode of the second tube to be also included in the anode circuit of the second tube to charge said condenser while said second tube is fired to provide a negative grid bias voltage for the second tube for a predetermined period when the second tube is extinguished, means including another condenser connected to said anode circuits to alternately extinguish said tubes, and signaling means connected to said decoding transformer controlled by the current flowing in said portions of the primary winding due to the alternating firing of said tubes.

2. In combination, a track section, means to supply coded direct current to the rails of the section, a train to travel such section, receiving means on the train coupled to the rails to pick up time spaced electromotive forces in response to such coded rail current, a first and a second train carried gas filled tube, said tubes provided with anode circuits having a common source of direct current and each of which circuits includes a preselected portion of a primary winding of a decoding transformer, said direct current source effective to fire each such tube when its grid is of substantially the same potential as its cathode, a grid circuit for said first tube including a battery disposed to provide a negative grid bias voltage that normally prevents said first tube from being fired, a grid circuit for said second tube including a condenser and a resistor in multiple, said resistor disposed adjacent the cathode of the second tube to be also included in the second tube anode circuit to charge said condenser while said second tube is normally fired for providing a negative grid bias voltage that retains said second tube extinguished for a predetermined period subsequent to the second tube being extinguished, means to couple said receiving means to said first tube grid circuit to fire the first tube in response to each said electromotive force picked up, extinguishing means including a condenser connected to said anode circuits to alternately extinguish said tubes, and signaling means connected to said transformer effectively controlled by the currents thus caused to alternately flow in said anode circuits.

3. In combination, a track section, means to supply coded direct current to the rails of the section, a train to travel such section, receiving means on the train coupled to the rails to pick up time spaced electromotive forces in response to such coded rail current, a first and a second train carried gas filled tube, said tubes provided with anode circuits having a common source of direct current of a voltage sufficient to fire the tubes, a

decoding transformer having a different portion of its primary winding interposed in each said anode circuit, a grid circuit including a battery for said first tube to prevent said first tube from normally being fired, a grid circuit including a unit comprising a condenser and a resistor in multiple for said second tube, said unit disposed to be also included in the second tube anode circuit to charge said condenser when the second tube is fired to provide when the second tube is extinguished a negative grid bias voltage that prevents refiring of the second tube for an interval preselected to be less than the interval between successive picked up electromotive forces, means including a winding to couple said receiving means to said first tube grid circuit to fire the first tube by each picked up electromotive force, means including another condenser connected to said anode circuits to alternately extinguish said tubes, and signaling means connected to a secondary winding of said transformer and controlled by the currents thus caused to alternately flow in said portions of the primary winding.

4. In combination, a track section, means to supply to the rails of such section direct current coded to have alternate on and off periods, a train to travel the section, receiving means on the train coupled to the rails to pick up time spaced impulses of electromotive force characterized by each impulse being of short duration as compared to the duration between successive impulses in response to such coded rail current, two train carried gas filled tubes, an anode circuit including a direct current source for each said tubes and which direct current source is of a voltage effective to normally fire the tube, a decoding transformer having a different portion of its primary winding interposed in each of said anode circuits, a grid circuit including a bias voltage source for a first one of said tubes to normally prevent said first tube from being fired, means to couple said receiving means to said first tube grid circuit to fire the first tube in response to each said picked up electromotive force, a grid circuit including a biasing unit comprising a resistor and a condenser for the second one of said tubes, means including another condenser connected to said anode circuits to alternately extinguish the tubes, said biasing unit disposed to be also included in the second tube anode circuit to charge the condenser of the unit when the second tube is fired to create a negative grid bias voltage that effects a predetermined delay in the refiring of the second tube when it is extinguished and causes the tubes to be alternately fired for substantially equal periods of time in response to said time spaced electromotive forces, and signaling means connected to a secondary winding of said transformer effectively energized due to such alternating operation of said tubes.

5. In combination, a track section, means to supply to the rails of the section recurrent impulse of direct current each impulse of which is of short duration as compared to the duration between successive impulses, a train to travel the section, receiving means on the train coupled to the rails to pick up an electromotive force in response to each said current impulse, a first and a second train carried gas filled tube provided with anode circuits having a common source of direct current and each including a preselected portion of a primary winding of a transformer, said direct current source of a voltage effective to normally fire each of said tubes, a grid circuit for said first tube including a bat-

tery effective to normally prevent that tube from firing and a winding coupled to said receiving means to cause the first tube to be fired in response to each said electromotive force picked up by said receiving means, a grid circuit for said second tube including a biasing unit comprising a condenser and a resistor in multiple and disposed adjacent the tube cathode to be also included in the anode circuit for normally charging said condenser, another condenser connected to said anode circuits to alternately extinguish said tubes, said biasing unit effective to provide a predetermined delay in the refiring of the second tube and cause said tubes to be alternately fired for substantially equal periods of time in response to said recurrent impulses of rail current, and signaling means connected to a secondary winding of said transformer effectively energized due to the alternate flowing of current in said anode circuits.

6. In combination, a track section, means to supply time spaced impulses of direct current to the rails of the section, a train to travel such section, receiving means on the train coupled to the rails to pick up an electromotive force in response to each such impulse of rail current, a first and a second train carried gas filled tube provided with anode circuits having a common source of direct current and each of which circuits includes a preselected portion of a primary winding of a decoding transformer, said direct current source effective to fire each such tube when its grid is of substantially the same potential as its cathode, a grid circuit for said first tube including a battery disposed to provide a negative grid bias voltage that normally prevents the firing of the first tube, a grid circuit for said second tube including a resistor, a first condenser connected between the first tube anode and the grid of the second tube to charge that condenser while the second tube is normally fired, a winding coupled to said receiving means and interposed in said first tube grid circuit to cause said first tube to fire in response to each said picked up electromotive force, a second condenser connected to said anode circuits to alternately extinguish said tubes, said first condenser discharging through said resistor and said first tube when fired to provide a predetermined delay in the refiring of said second tube, and signaling means connected to a secondary winding of said transformer and controlled by the electromotive force induced in the secondary winding due to the alternating firing of said tubes.

7. In combination, a track section, means to supply time spaced impulses of direct current to the rails of the section, a train to travel such section, receiving means on the train coupled to the rails to pick up an electromotive force in response to each such impulse of rail current, a first and a second train carried gas filled tube provided with anode circuits having a common source of direct current and each of which circuits includes a preselected portion of a primary winding of a decoding transformer, said direct current source effective to fire each such tube when its grid is of substantially the same potential as its cathode, a grid circuit for said first tube including a battery disposed to provide a negative grid bias voltage that normally prevents the firing of that tube, grid circuit means including a biasing unit and a second condenser for said second tube, said unit comprising a first condenser and a first resistor in multiple and

disposed common to both anode and grid circuits of the said second tube to charge the first condenser when that tube is fired, said second condenser connected to the anode of said first tube and grid of said second tube to charge said second condenser when the second tube is fired, a third condenser connected across the anodes of said tubes to alternately extinguish said tubes, a winding coupled to said receiving means and interposed in the first tube grid circuit to cause the first tube to be fired in response to each said picked up electromotive force, said biasing unit and said second condenser cooperating to provide a negative grid bias voltage for said second tube to provide a preselected delay in the refiring of said second tube subsequent to the firing of said first tube and the extinguishing of said second tube, and signaling means connected to a secondary winding of said transformer effectively controlled by the electromotive force induced therein due to current caused to alternately flow in said portions of said primary winding.

8. Railway traffic controlling apparatus comprising, traffic controlled receiving and amplifying means including a control winding and operative to create across said winding time spaced impulses of electromotive force of any one of a plurality of different code rates, two gas filled tubes provided with anode circuits each of which circuits includes a preselected portion of a primary winding of a decoding transformer, a direct current source for said anode circuits having a voltage sufficient to fire each tube when a tube grid is of the same potential as the tube cathode, a grid circuit of the first one of said tubes including a voltage source to provide a negative grid bias voltage to prevent that tube from normally firing, a grid circuit including a biasing unit for a second one of said tubes, said biasing unit comprising a condenser and a resistor and disposed common to both the grid and anode circuits of such second tube to charge said condenser when the tube is fired and to provide a negative grid bias voltage that permits the refiring of said second tube for a preselected period subsequent to that tube being extinguished, another condenser connected across the anodes of said tubes to alternately extinguish the tubes, said control winding interposed in the grid circuit of said first tube to fire that tube in response to each of said impulses of electromotive force, said biasing unit and decoding transformer proportioned to effect substantially equal firing periods of the two tubes under each of said code rates, and decoding circuits connected to a secondary winding of said transformer and actuated to a distinctive condition in response to the frequency of the electromotive force induced in such secondary winding due to the different rates at which said tubes are alternately fired.

9. In combination, a track section, means to supply coded direct current to the rails of said section, a train to travel the section, two inductors mounted on the train one above each rail to pick up an electromotive force in response to each code impulse of said direct current, a train carried amplifier tube having its grid coupled to one of said inductors and its plate coupled to the other one of said inductors to create an electromotive force in a winding interposed in the plate circuit of said tube only when the inductor electromotive forces occur simultaneously and of a predetermined phase relation, two train carried gas filled tubes each provided with an

anode circuit having a current source of a voltage sufficient to fire the tube, a grid circuit including a source of bias voltage and a winding for a first one of said tubes, said bias voltage source of a voltage to normally prevent the firing of the tube and said grid circuit winding coupled to the first mentioned winding to cause said first tube to be fired by said electromotive force created in said first mentioned winding, a grid circuit including a bias unit for a second one of said gas filled tubes, said bias unit comprising a condenser and a resistor in multiple

5 and disposed to charge said condenser when the second tube is fired to provide a negative grid bias voltage for the second tube and provide a predetermined delay in the refiring of the second tube once it is extinguished, another condenser connected to the anode circuits of said gas filled tubes to alternately extinguish the tubes, and signaling means coupled to the anode circuits of the gas filled tubes controlled by the currents thus caused to alternately flow therein.

10 WILLARD P. PLACE.