Feb. 17, 1942. H. A. THOMPSON ET AL 2,273,477

RAILWAY TRAFFIC CONTROLLING APPARATUS

Filed March 2, 1940 2 Sheets-Sheet 1

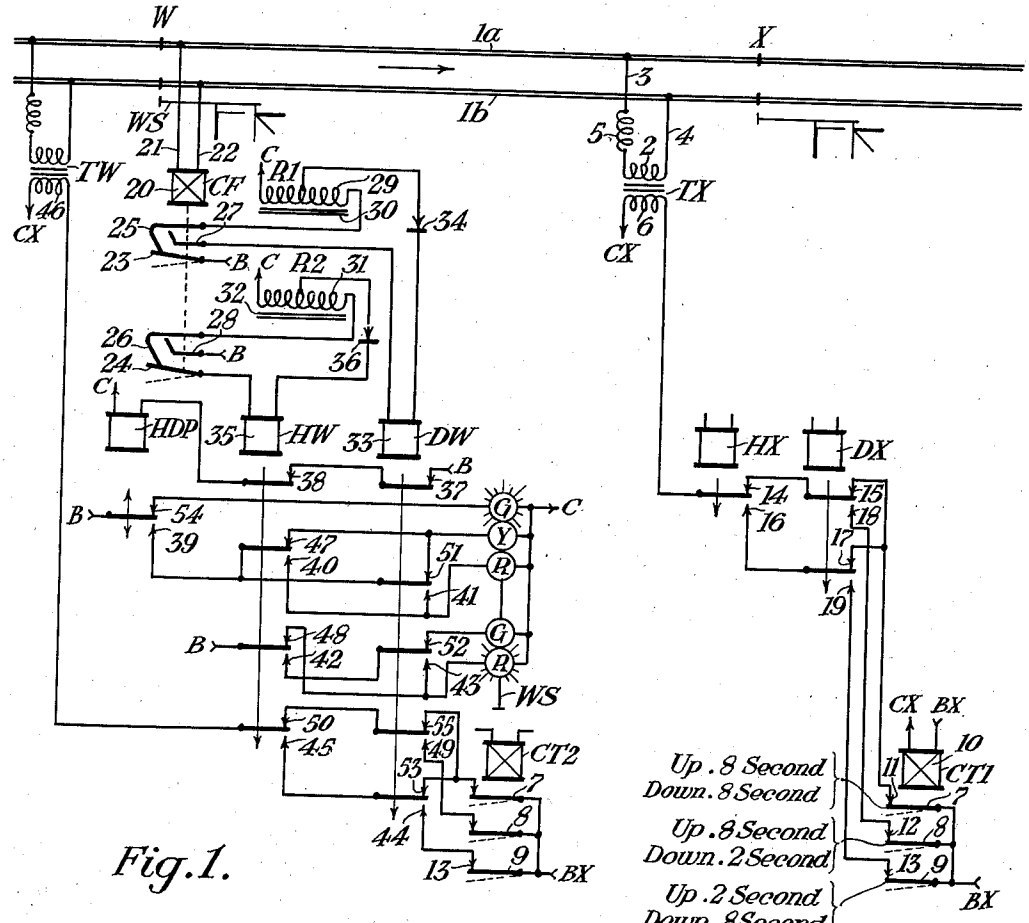

Fig. 1.

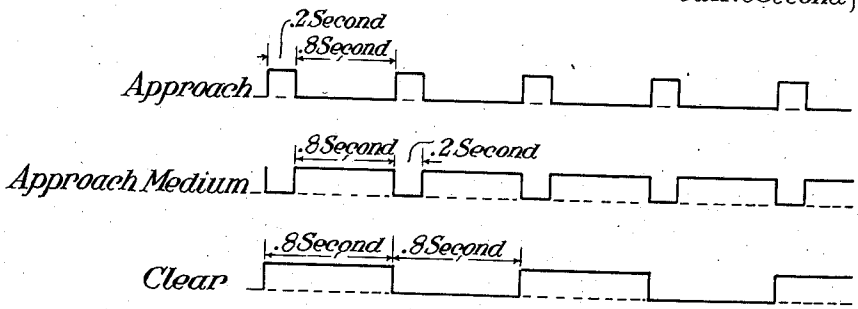

Fig. 2.

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RAILWAY TRAFFIC CONTROLLING APPARATUS

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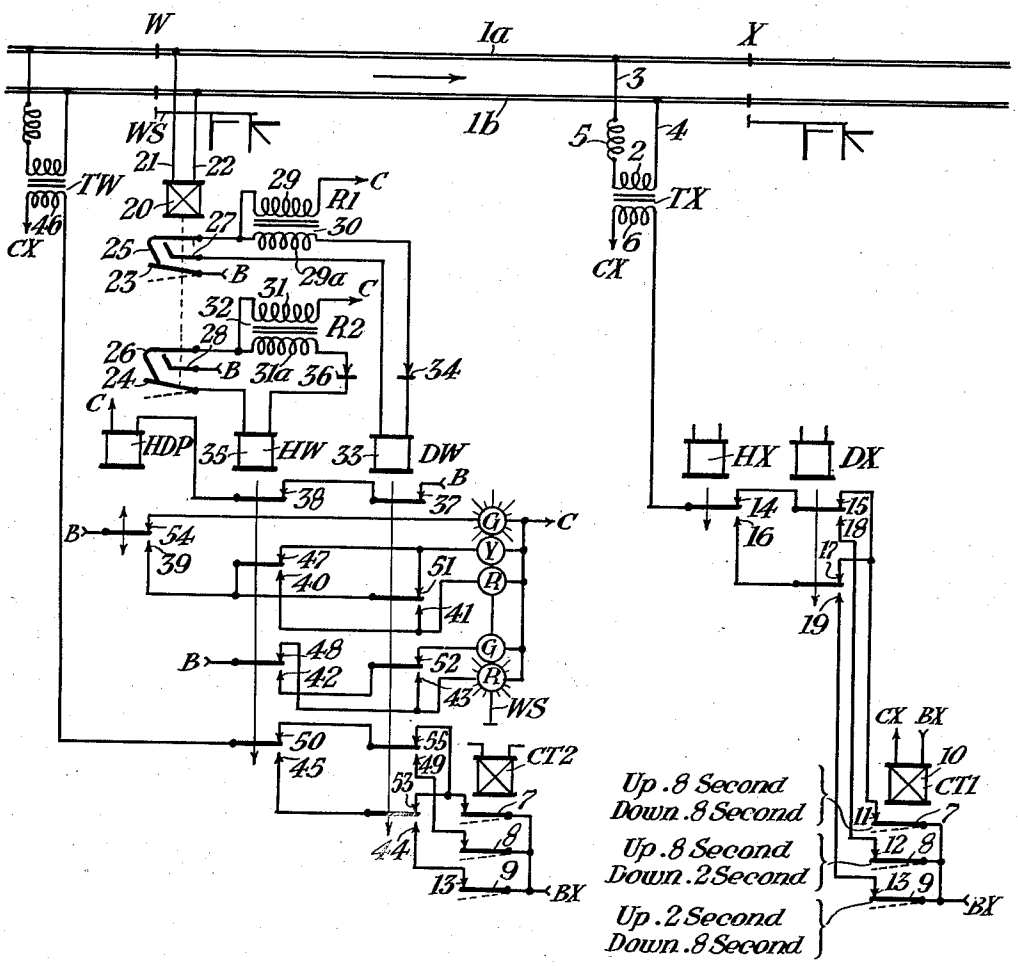

Fig. 3.

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UNITED STATES PATENT OFFICE

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RAILWAY TRAFFIC CONTROLLING APPARATUS

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Application March 2, 1940, Serial No. 321,928

16 Claims. (Cl. 246—38)

Our invention relates to railway traffic controlling apparatus, and particularly to railway signaling apparatus using coded energy of the time code type.

In signal systems using coded energy of the time code type it has been proposed to provide slow release relays or slow pick-up relays or a combination of both as the decoding means, such relays responding in different combinations to the different durations of the on and off periods of the different codes. Inaccuracy of operation of such decoding relays due to variations of voltage of the current source and due to changes in the resistance of the relay windings because of variations of ambient temperature must be compensated in order that the durations of the on and off periods of the code patterns may be accurately and reliably detected.

Accordingly, an object of our invention is the provision of novel and improved means for detecting the durations of the on and off periods of different code patterns of the time code type.

Another object of our invention is the provision of novel and improved apparatus of the type here involved which compensates for variations in voltage of the current source and variations in the operating characteristics of the decoding relays due to changes in temperature.

Still another object of our invention is the provision of novel and improved apparatus of the type here contemplated for a three-block four-indication signal system for railways.

To attain the above objects as well as other advantages of our invention we provide two energy storage units or secondary sources of power for determining the durations of the on and off periods of different time codes by the amount of energy stored in the units, energy being stored in one of the units during the on period of each code cycle and in the other unit during the off period of each code cycle. The rate at which energy is stored in a unit is predetermined and hence the unit is in effect a time measuring device which determines the duration of a period by the amount of the stored energy. The amount of energy stored in a unit during the on or off code period as the case may be is determined by using the energy stored in a unit during a storage period of the code to create an electromotive force during a non-storage period and applying this electromotive force to a decoding relay which is adjusted for a predetermined operating electromotive force. For example, the energy stored in a selected one of the units during the on period of a code cycle is used during the off period of the code cycle to create an electromotive force which is applied to a decoding relay adjusted for a predetermined pick-up electromotive force. Hence this decoding relay is picked up only when the duration of the on period of the code is at least great enough to store a predetermined amount of energy in the storage unit. That is, for a code having a relatively short on period and only a small amount of energy is stored in the associated unit the decoding relay is not picked up, but the relay is picked up in response to a code having a relatively long on period and a greater amount of energy is stored. Furthermore the decoding relay is slow releasing in character and remains picked up from one off period to the next only if the intervening on period is not greater than the predetermined release period of the relay. Consequently this decoding relay is picked up and retained picked up only for codes having an on period of at least a predetermined duration but not greater than a given maximum duration.

In a similar manner, energy is stored in the other storage unit during the off period of the code cycle and the stored energy is used during the on period of the code cycle to create an electromotive force which is applied to another slow release decoding relay adjusted for a predetermined pick-up electromotive force and a predetermined slow release period. These two decoding relays are controlled, therefore, one in accordance with the duration of the on period of the code cycle and the other in accordance with the duration of the off period of the code cycle.

A code following relay connected with a transmitting circuit for operation thereof in step with the on and off periods of the coded energy supplied to such circuit, is used to connect a selected one of the energy storage units with a source of charging current each on period of the code, the circuit being proportioned for a given time constant so that the energy is stored at a predetermined rate. In like manner the code following relay connects the other energy storage unit to the current source during each off period and the associated circuit is proportioned for a given time constant so that the rate at which energy is stored is predetermined.

For such energy storage units we preferably provide reactors, each of which comprises a winding mounted on a ferric core. The winding of a selected one of the reactors is connected with a source of charging current such as a battery over a circuit including a contact of the code following relay closed during the on period

of the relay and current flows in the winding to store magnetic energy in the magnetic core, the circuit being proportioned as to its resistance and inductance for a given time constant. Hence the rate at which energy is stored is predetermined and the amount of energy stored is within limits of the reactor in accordance with the duration of the on code period so that this reactor serves as a time measuring device to determine the duration of the on period of the code. During the off period of the code the winding of this reactor is disconnected from the current source and that winding or another winding of the reactor is connected with a discharge circuit including a winding of an associated decoding relay which is energized in response to the electromotive force created in the winding of the reactor by the decay of the stored magnetic energy. This decoding relay is adjusted for a predetermined pick-up electromotive force and is picked up only if the particular code operating the code following relay is one whose on period is equal at least to a given duration and the amount of stored energy is sufficient to create the predetermined pick-up electromotive force of the decoding relay. This decoding relay which is energized during the off code period is slow releasing and hence is retained picked up during the next on period if the on period is not greater than the duration of the release period of the relay. Consequently such decoding relay is picked up and held picked up in response to a particular code only if the on period is at least equal to a given minimum duration and is less than a given maximum duration.

The winding of the other reactor is connected with the source of charging current over a contact of the code following relay closed during the off period of the code and energy is stored in the magnetic core of that reactor in accordance with the duration of the off period. During the on period the winding of this second reactor is disconnected from the current source and that winding or another winding of the reactor is connected to a discharge circuit including the winding of another decoding relay which is energized by the electromotive force created by the decay of the energy stored in the magnetic core of that reactor. This last mentioned decoding relay is picked up and retained picked up only when the particular code operating the code following relay is one whose off period is not less than a given minimum duration and is not greater than a given maximum duration. These two decoding relays are used to selectively govern the operating circuits of a signaling device.

To compensate for the variations in the resistance of the winding of each decoding relay due to changes in ambient temperature, an asymmetric unit such as a copper oxide rectifier unit is interposed in the respective discharge circuit. The characteristic of such asymmetric unit when a copper oxide rectifier unit is that its resistance in the low resistance or pass direction decreases as the temperature increases. The copper wire winding of the decoding relay increases in resistance as the temperature increases. The asymmetric unit and the relay winding are proportioned so that the resistance of the associated circuit is substantially uniform and the relay receives approximately the same amount of energy for all ambient temperatures.

Such asymmetric unit may also serve to block the flow of current from the source of charging current to the decoding relay during the interval of switching the reactor winding from the current source to the decoding relay and also to block the flow of current in the decoding relay that might be created by the electromotive force induced in the winding of the reactor as the magnetic energy builds up in its core.

To compensate for variations of voltage of the source of charging current the parts are so proportioned that the lowest permissible voltage of the current source effects substantial saturation of the magnetic core of the reactor in the code period required to store just sufficient energy to create the necessary pick-up electromotive force for the associated decoding relay. It follows that an increase in the voltage of the current source causes little if any increase in the stored magnetic energy so that substantially the same electromotive force is created and over-energization of the decoding relay due to a higher applied electromotive force because of a higher voltage of the charging current source is avoided.

We shall describe two forms of apparatus embodying our invention, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a diagrammatic view showing one form of apparatus embodying our invention when used for a three-block four-indication signal system for railways. Fig. 2 is a diagram illustrating three different time code patterns that may be used with the apparatus of Fig. 1. Fig. 3 is a diagrammatic view showing a modification of the apparatus of Fig. 1 and which modification also embodies our invention.

It will be understood of course that we do not wish to limit our invention to a three-block four-indication signal system for railways, but this one form of apparatus will illustrate the many places where apparatus embodying our invention is useful.

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 consecutive track sections of which sections only the one section W—X and the adjacent ends of the two adjoining sections are shown for the sake of simplicity since these are sufficient for a full understanding of our invention.

Each track section is provided with a track circuit which includes a source of coded current connected across the rails at one end of the section and a code following relay connected across the rails at the other end of the section, such coded energy having different cyclic patterns of the time code type in accordance with different traffic conditions.

The immediate source of coded energy for the track circuit of section W—X is a track transformer TX, whose secondary winding **2** is connected across the rails *1a* and *1b* at the exit end of section W—X over wires **3** and **4** with a current limiting reactor **5** interposed in wire **3**. The primary winding **6** of transformer TX is connected with the BX and CX terminals of a source of alternating current over contacts of a code transmitter CT*1* and traffic controlled relays HX and DX in a manner to be shortly described.

The code transmitter CT*1* is preferably of the well-known motor driven type which is provided with three contact members **7**, **8** and **9** each of which contact members is operated in a cyclic

manner as long as current is supplied to the motor element 10 of the code transmitter from any convenient source of current such as the current source whose terminals are indicated by BX and CX. In the form of the invention here disclosed, code transmitter CT1 is arranged so that contact member 7 during its cyclic operation is raised to engage a contact 11 for .8 second and is lowered to break engagement with contact 11 for .8 second, contact member 8 in its cyclic operation is raised to engage a contact 12 for .8 second and is lowered to break engagement with contact 12 for .2 second, and contact member 9 in its cyclic operation is raised to engage a contact 13 for .2 second and is lowered to disengage contact 13 for .8 second. When relays HX and DX are picked up closing front contacts 14 and 15, respectively, or when relay HX is released closing back contact 16 and relay DX is picked up closing front contact 17, the primary winding 6 of track transformer TX is connected with the source of alternating current over contact 7—11 of the code transmitter and coded current having a cyclic pattern consisting of an .8 second on period and an .8 second off period is supplied to the track circuit of section W—X. As illustrated in Fig. 2, such a code pattern is used to reflect clear traffic conditions in advance. When relay HX is picked up closing front contact 14 and relay DX is released closing back contact 18, the primary winding 6 of transformer TX is connected with the source of alternating current over contact 8—12 of the code transmitter and current having a cyclic pattern consisting of an .8 second on period and a .2 second off period is supplied to the track circuit of section W—X. As illustrated in Fig. 2, such code pattern is used to reflect approach medium traffic conditions in advance. Again, when relays HX and DX are released closing back contacts 16 and 19, respectively, the primary winding 6 is connected with the current source over contact 9—13 of the code transmitter and the current supplied to the track circuit of section W—X has a cyclic pattern consisting of a .2 second on period and an .8 second off period; and as indicated in Fig. 2, such a code pattern is used to reflect approach traffic conditions in advance. The manner of controlling relays HX and DX to selectively effect such time code patterns will appear hereafter.

It will be understood of course that our invention is not limited to these specific time code patterns either as to the relative or absolute durations of the on and off periods, but such codes would be satisfactory and are used for the purpose of illustrating the invention.

The code following relay of the track circuit of section W—X is an alternating current relay CF whose operating winding 20 is connected across the rails adjacent the entrance end of the section over wires 21 and 22. Relay CF is provided with two contact members 23 and 24 each of which forms the front contact member of a continuity transfer type of contact. It follows that during each on period of coded current supplied to the track circuit of section W—X and winding 20 of relay CF is energized, the contact members 23 and 24 are lifted to engage the respective transfer contact members 25 and 26 closing front contacts 23—25 and 24—26, but that during each off period of the code and winding 20 is deenergized, the contact members 23 and 24 fall to disengage the respective transfer contact members and the transfer contact members 25 and 26 engage back contact members 27 and 28 closing back contacts 25—27 and 26—28.

The contacts of the code following relay CF are used to control two energy storage units R1 and R2. These energy storage units are preferably reactors, reactor R1 comprising a winding 29 mounted on a magnetizable core 30 and reactor R2 comprising a winding 31 mounted on a magnetizable core 32. During the on period of a code and front contact 23—25 of relay CF is closed, at least a portion of winding 29 of reactor R1 is connected with a source of charging current such as a battery whose terminals are indicated at B and C and current flows in winding 29 causing magnetic energy to build up in the magnetic core 30. This circuit, including winding 29 and the current source, is proportioned as to its resistance and inductance so as to have a predetermined time constant and magnetic energy builds up at a predetermined rate with the result the amount of energy stored is determined within limits by the duration of the on period.

In like fashion, during the off period of a code and back contact 26—28 of relay CF is closed, at least a portion of winding 31 of reactor R2 is connected with the B and C terminals of the source of current and current flows in winding 31 causing magnetic energy to build up in the magnetic core 32 of reactor R2. The circuit including winding 31 and the current source is proportioned as to resistance and inductance so as to have a predetermined time constant and the magnetic energy is built up in core 32 at a predetermined rate and the amount of energy stored is determined within limits by the duration of the off period of the code.

The magnetic energy stored in reactors R1 and R2 is used to control decoding relays DW and HW, respectively. During the off period of a code, and front contact 23—25 is open and back contact 25—27 is closed, the winding 29 of reactor R1 is disconnected from the current source and a portion of the winding 29 is connected with a discharge circuit including the winding 33 of decoding relay DW and an asymmetric unit 34. When the winding 29 is disconnected from the current source, the magnetic energy stored in core 30 decays and induces an electromotive force in winding 29. The asymmetric unit 34 is disposed so that the electromotive force induced in winding 29 due to the decay of such storage energy causes current to flow in the winding 33 of the decoding relay and the relay is energized. Relay DW is adjusted for a predetermined pick-up electromotive force. The parts are so proportioned that the electromotive force created by the energy stored in reactor R1 during an on code period of .2 second is not sufficient to pick up relay DW but that the pick-up electromotive force of relay DW is created by the energy stored in reactor R1 during an on period of .8 second.

The core 30 of reactor R1 is so proportioned that the current flowing in winding 29 as caused by the minimum permissible voltage of the B—C current source substantially saturates the core in .8 second. Hence variations of voltage above this permissible minimum voltage of the current source creates no materially higher electromotive force when the winding 29 is disconnected from the current source and is connected with the decoding relay DW. Consequently a sub-

stantially uniform electromotive force is effected and over-energization of relay DW due to variations of voltage of the charging current source is avoided.

Relay DW is provided with a slow release period sufficient to bridge an .8 second period. Relay DW is therefore picked up and retained picked up for a code having an .8 second on period but is not picked up for a code having a .2 second on period and is released if the on period is extended to an interval somewhat greater than .8 second.

The asymmetric unit 34 is poled to pass in its low resistance direction the current created by the electromotive force induced in winding 29 by the decay of the magnetic energy and hence unit 34 serves to block the flow of current to the relay DW from the charging current source during the intervals both front contact 23 and back contact 27 are in engagement with the transfer contact 25. Also the unit 34 prevents the flow of current that might be caused by an electromotive force induced in winding 29 during the building up of magnetic energy in the core 30. Furthermore unit 34 is preferably of the copper oxide rectifier unit type which has a negative resistance characteristic and compensates for the increase in resistance of the copper windings 30 and 33 due to an increase in temperature, the unit 34 and the windings 30 and 33 being proportioned so that the circuit has a substantially uniform resistance and a substantially uniform energization of relay DW is effected for all ambient temperatures.

During each on period of the code and front contact 24—26 of relay CF is closed and back contact 26—28 is open, the winding 31 of reactor R2 is disconnected from the current source and is connected with a discharge circuit including the winding 35 of decoding relay HW and an asymmetric unit 36. With winding 31 disconnected from the current source the magnetic energy stored in core 32 decays to induce an electromotive force in winding 31. The asymmetric unit 36 is so disposed that this electromotive force causes current to flow in winding 35 of relay HW to energize such relay. This electromotive force has a value proportional to the amount of energy stored in the magnetic core 32. Relay HW is provided with a predetermined pick-up electromotive force and in the instant case the parts are so proportioned that the pick-up electromotive force of relay HW is that created in winding 31 of reactor R2 by energy stored therein during an .8 second off period. Relay HW is also provided with a slow release period just sufficient to bridge an .8 second period and hence decoding relay HW is picked up and retained picked up for a code having .8 second off period. The reactor R2 and the associated circuits are proportioned in a manner similar to that described for reactor R1 and its associated circuits and hence it is clear that over-energization of relay HW due to variations of voltage of the current source is avoided due to the proportioning of core 32 and compensation for the increase of resistance of windings 31 and 35 due to an increase in temperature is effected by asymmetric unit 36.

A slow acting repeater relay HDP is associated with relays HW and DW, relay HDP being energized over a simple circuit including front contacts 37 and 38 of relays DW and HW, respectively.

The decoding relays DW and HW and the repeater relay HDP control the operating circuits of a wayside signal WS which governs traffic through the track section W—X. Relays DW and HW also control the supply of coded current to the track circuit for the section next in the rear of section W—X in the same manner that relays DX and HX control the supply of coded current to the track circuit of section W—X. It is also to be noted that a code transmitter CT2, which preferably is of the same type as code transmitter CT1, is associated with decoding relays DW and HW to code the current supplied to the track circuit for the section next in the rear. Furthermore, it is to be pointed out that relays DX and HX are decoding relays which are controlled by the code following relay (not shown) of the section next in advance of section W—X in the same manner the decoding relays DW and HW are controlled by the code following relay CF.

The wayside signal WS may be of any of the standard types of signals and is here shown as a color-light signal capable of displaying four different signal indications. The operating circuits for signal WS will be pointed out as the operation of the apparatus is described.

In describing the operation of the apparatus we shall first assume that a train occupies section W—X shunting the track circuit so that code following relay CF is inactive with its two back contacts 25—27 and 26—28 closed. When the electromotive force created by the decay of the energy in reactor R1 dies away relay DW becomes deenergized and is released at the end of its slow release period. Likewise relay HW is also deenergized and releases at the end of its slow release period. Repeater relay HDP is now without current and is released. With relays DW, HW and HDP all released, a circuit is formed from terminal B of the current source over back contact 39 of relay HDP either back contact 40 of relay HW or back contact 41 of relay DW, lamp R of the top group of lamps of signal WS and terminal C, and lamp R is illuminated. Also a circuit is formed from terminal B over back contact 42 of relay HW, back contact 43 of relay DW, lamp R of the bottom group of lamps of signal WS and terminal C, and this lamp is illuminated so that signal WS displays a red light over a red light for a stop signal indication.

With section W—X occupied and both relays DW and HW released a circuit is completed from the BX terminal of the source of alternating current over contact 9—13 of code transmitter CT2, back contacts 44 and 45 of relays DW and HW, respectively, primary winding 46 of track transformer TW for the track section next in the rear of section W—X and terminal CX of the current source, and the track circuit of this section next in the rear is supplied with coded energy of the approach code pattern because contact member 9 of code transmitter CT2 has the same operation cycle as the corresponding contact member 9 of code transmitter CT1.

Assuming next that the train which occupies section W—X moves to the right out of section W—X and occupies the section next in advance of section W—X, the decoding relays DX and HX are both released and the track circuit of section W—X is supplied with alternating current of the approach code pattern, it being recalled that relays DX and HX are controlled in a manner similar to relays DW and HW. During each on period of the code front contact 23—25 of re-

lay CF is closed and magnetic energy is stored in reactor R1, the amount of stored energy being in accordance with the .2 second duration of the on period. During each off period of the code the back contact 25—27 of relay CF transfers the winding 29 of reactor R1 to the relay DW. However, as stated hereinbefore, the electromotive force created by the dying away of the magnetic energy stored in reactor R1 during a .2 second period is not sufficient to pick up decoding relay DW and this relay remains released.

During each .8 second off period of the approach code back contact 26—28 of relay CF is closed and magnetic energy is stored in the reactor R2 and during the on period the reactor R2 is transferred to the relay HW. The electromotive force created by the decay of the magnetic energy stored in reactor R2 during an .8 second period is equal to that of the pick-up electromotive force for the relay HW, and relay HW is picked up, and is retained picked up due to its slow release period. With relay HW picked up and relay DW released, the repeater relay HDP is released. Under this set up of the relays, a circuit is formed from terminal B over back contact 39 and relay HDP, front contact 47 of relay HW, lamp Y of the top group of lamps of signal WS and terminal C, and lamp Y is illuminated. Also a circuit is formed from terminal B over front contact 48 of relay HW, lamp R of the bottom group of lamps and terminal C, and lamp R is illuminated so that signal WS displays a yellow light over a red light for an approach signal indication.

With relay HW picked up and relay DW released, a circuit is provided for the primary winding 46 of track transformer TW from terminal BX over contact member 8 of code transmitter CT2, back contact 49 of relay DW, front contact 50 of relay HW, primary winding 46 and terminal CX of the current source. Since contact member 8 of code transmitter CT2 has the same operation cycle as the corresponding contact member of code transmitter CT1, the track circuit for the section next in the rear of section W—X is supplied with coded current of the approach medium code pattern in response to section W—X being unoccupied and the section next in advance being occupied.

Assuming next that the train advances another track section to the right so that the section next in advance of section W—X is unoccupied and the second section in advance is occupied, relay HX is picked up and relay DX is released, since relays DX and HX are controlled by traffic conditions in a manner similar to relays DW and HW. With relay HX picked up and relay DX released the approach-medium code is impressed on the track circuit current of section W—X. The energy stored in reactor R1 during the .8 second on period of this code is sufficient to cause the electromotive force created by the decay of the stored energy during the off period of the code to be equal to the pick-up electromotive force of relay DW and relay DW is picked up. Furthermore the energization effected by relay DW does not fall below the release value of relay DW during the following on period and hence relay DW is held picked up from one off period to the next. The energy stored in reactor R2 during the .2 second off period of the approach-medium code is not sufficient to create an electromotive force great enough to pick up relay HW or retain it picked up and relay HW is released. Again repeater relay HDP is released. Under this set-up of the relays a circuit is formed from terminal B over back contact 39 of relay HDP, front contact 51 of relay DW, lamp Y of the top group of lamps and terminal C, and lamp Y is illuminated. Also a circuit is formed from terminal B over back contact 42 of relay HW, front contact 52 of relay DW, lamp G of the bottom group of lamps and terminal C, and lamp G is illuminated so that signal WS displays a yellow light over a green light for an approach-medium signal indication.

The circuit by which current is now supplied to the primary winding 46 of track transformer TW includes terminal BX, contact member 7 of code transmitter CT2, front contact 53 of relay DW, back contact 45 of relay HW, primary winding 46 and terminal CX, and the clear code pattern is impressed upon the track circuit current for the section next in the rear of section W—X in response to two unoccupied sections and the third section in advance of such occupied section.

Again assuming that the train advances another section to the right and occupies the third section in advance of section W—X, the two intermediate sections being unoccupied, the relay DX is picked up and relay HX is released and the clear code pattern is impressed upon current for the track circuit of section W—X.

The energy stored in reactor R1 during the .8 second on period of the clear code pattern is sufficient to create the pick-up electromotive force for relay DW and relay DW is picked up. Also the energy stored in reactor R2 during the .8 second off period is sufficient to create the pick-up electromotive force of relay HW and this relay is also picked up. With both relays DW and HW picked up and retained picked up, the repeater relay HDP is energized and picked up. A circuit is now formed from terminal B over front contact 54 of relay HDP, lamp G of the top group of lamps, and terminal C, and this lamp G is illuminated. Another circuit for lamp R of the bottom group of lamps is completed over front contact 48 of relay HW and signal WS displays a green light over a red light for a clear signal indication.

Current is now supplied to the primary winding 46 of track transformer TW over contact member 7 of code transmitter CT2, and front contacts 55 and 50 of relays DW and HW, respectively, so that the code pattern impressed upon the track circuit current for the section next in the rear is still of the clear code pattern.

While coded alternating current is used in the form of apparatus herein disclosed, it is apparent that coded direct current may be used for the track circuit if desired.

Also it is to be noted that the portion of winding 29 of reactor R1 connected with winding 33 of relay DW need not include the back contact 25—27 of the code following relay because the asymmetric unit 34 would block the flow of current to winding 33 of relay DW from the source of charging current when the front contact 23—25 of relay CF is closed. In like manner the front contact 24—26 of relay CF need not be interposed in a circuit for connecting winding 31 of reactor R2 with winding 35 of relay HW because of the asymmetric unit 36.

In Fig. 3 the apparatus of Fig. 1 is modified in that reactors R1 and R2 are provided each with two independent windings. Winding 29 of reactor R1 is connected to the current source over front contact 23—25 of relay CF to store magnetic energy in the magnetic core 30 of the re-

actor during each on code period and an independent winding 29a of reactor R1 is connected to decoding relay DW over back contact 25—27 of relay CF during each off code period to energize relay DW by the electromotive force induced in winding 29a due to the decay of the magnetic energy stored in core 30. Similarly, winding 31 of reactor R2 is connected to the current source over back contact 26—28 of relay CF during each off code period and an independent winding 31a of reactor R2 is connected to decoding relay HW over front contact 24—26 of relay CF to energize relay HW by the electromotive force induced in winding 31a due to the decay of the magnetic energy stored in reactor R2 by the current flowing in winding 31. The remaining portion of the apparatus of Fig. 3 is the same as in Fig. 1, and it is apparent therefore that the apparatus of Fig. 3 operates in the same manner as described for Fig. 1 and such description need not be repeated.

Although we have herein shown and described only two forms of railway traffic controlling apparatus embodying our 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 our invention.

Having thus described our invention, what we claim is:

1. In apparatus for use with a code following relay which at times is operated to a first and a second position in step with the on and off periods of a coded current having a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current, a reactor having a magnetic core; a first circuit including said source of direct current, a first position contact of said code following relay and a winding mounted on said reactor core; said first circuit proportioned for a predetermined time constant to build up magnetic flux in said reactor core at a predetermined rate and store a predetermined amount of magnetic energy during each on period of said coded current, a decoding relay adjusted for a preselected pick-up electromotive force; a second circuit including a winding mounted on said reactor core, a second position contact of said code following relay and a winding of said decoding relay; said second circuit proportioned to create said pick-up electromotive force by the decay of the magnetic energy stored in the reactor core during each off period of said coded current only when the stored magnetic energy is at least equal to said predetermined amount to selectively pick up the decoding relay in response to said coded current, and a signaling circuit including a contact of said decoding relay.

2. In apparatus for use with a code following relay which at times is operated to a first and a second position in step with the on and off periods of a coded current having a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current, a reactor having a magnetic core; a first circuit including said source of direct current, a first position contact of said code following relay and a winding mounted on said reactor core; said first circuit proportioned for a predetermined time constant to build up magnetic flux in said reactor core at a predetermined rate and store a predetermined amount of magnetic energy during each on period of said coded current, a decoding relay, an asymmetric unit; a second circuit including a winding mounted on said reactor core, said asymmetric unit in its low resistance direction and a winding of said decoding relay to apply to said decoding relay the electromotive force created by the decay of said stored magnetic energy during each off period of said coded current; said decoding relay adjusted for a pick-up electromotive force substantially equal to that created by the decay of said predetermined amount of stored magnetic energy to selectively pick up said decoding relay in response to said coded current, and a signaling circuit including a contact of said decoding relay.

3. In apparatus for use with a code following relay which at times is operated to a first and a second position in step with the on and off periods of a coded current having a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current, a reactor having a winding mounted on a magnetic core; a first circuit including said source of direct current, a first position contact of said code following relay and said reactor winding said first circuit proportioned for a predetermined time constant to build up magnetic flux in said reactor core at a predetermined rate and store a predetermined amount of magnetic energy during each on period of said coded current, a decoding relay, an asymmetric unit characterized by a decrease in resistance in its low resistance direction in response to increase in temperature; a second circuit including a winding mounted on said reactor core, said asymmetric unit in its low resistance direction and a winding of said decoding relay to apply to said decoding relay the electromotive force created by the decay of said stored magnetic energy during each off period of said coded current; said decoding relay adjusted for a pick-up electromotive force substantially equal to that created by the decay of said predetermined amount of stored magnetic energy to selectively pick up said decoding relay in response to said coded current, said asymmetric unit proportioned to substantially compensate the increase in resistance of said last mentioned reactor winding and decoding relay winding due to increase in ambient temperature to effect a substantially uniform resistance of said second circuit, and a signaling circuit including a contact of said decoding relay.

4. In apparatus for use with a code following relay which at times is operated to a first and a second position in step with the on and off periods of a coded current having a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current of a given voltage, a reactor having a winding mounted on a magnetic core; a first circuit including said source of direct current, a first position contact of said code following relay and said reactor winding to build up a predetermined amount of magnetic flux in said reactor core during the on period of said coded current; a decoding relay adjusted for a preselected pick-up electromotive force; a second circuit including a portion of said reactor winding, a second position contact of said code following relay and a winding of said decoding relay; said second circuit proportioned to create said pick-up electromotive force by the decay of the magnetic flux of the reactor core during the off period of said coded current only when said magnetic flux equals said predetermined amount to pick up said decoding relay in response to said

coded current, said reactor core proportioned for substantially magnetic saturation at said predetermined amount of magnetic flux to compensate variations of voltage of said direct current source above said given voltage, and a signaling circuit including a contact of said decoding relay.

5. In apparatus for use with a code following relay which at times is operated to a first and a second position in step with the on and off periods of a coded current having a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current of a given voltage, a reactor having a winding mounted on a magnetic core; a first circuit including said source of direct current, a first position contact of said code following relay and at least a portion of said reactor winding; a decoding relay adjusted for a preselected pick-up electromotive force; a second circuit including a portion of said reactor winding, a second position contact of said code following relay and a winding of said decoding relay; said reactor core proportioned for saturation at a predetermined amount of magnetic flux and said first circuit proportioned to build up said predetermined amount of magnetic flux during the on period of said coded current when said source of direct current is of said given voltage, said second circuit proportioned to create said pick-up electromotive force by the decay of the magnetic flux of said reactor core during the off period of said coded current only when such magnetic flux equals said predetermined amount whereby said decoding relay is picked up in response to said coded current and over energization of the decoding relay by an increase of voltage of said direct current source is avoided, and a signaling circuit including a contact of said decoding relay.

6. In apparatus for use with a code following relay which at times is operated to a first and a second position in step with the on and off periods of a coded current having a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current of a given voltage, a reactor having a magnetic core; a first circuit including said source of direct current, a first position contact of said code following relay and a winding mounted on said reactor core; a decoding relay adjusted for a preselected pick-up electromotive force, an asymmetric unit characterized by a decrease in resistance in its low resistance direction in response to an increase in temperature; a second circuit including a winding mounted on said reactor core, said asymmetric unit in its low resistance direction and a winding of said decoding relay; said reactor core proportioned for saturation at a predetermined amount of magnetic flux, said first circuit proportioned to build up said predetermined amount of magnetic flux during the on period of said coded current when said direct current source is of said given voltage and an excess of magnetic flux due to an increase of voltage of said direct current source is avoided, said second circuit proportioned to create said pick-up electromotive force by the decay of said magnetic flux of said reactor core during the off period of said coded current to pick up the decoding relay in response to said coded current, said asymmetric unit proportioned to compensate for the increase in resistance of said decoding relay winding due to an increase in ambient temperature to assure a substantially uniform energization of the decoding relay for all ambient temperatures, and a signaling circuit including a contact of said decoding relay.

7. In apparatus for use with a code following relay which is operated to a first and a second position in step with the on and off periods of any one of a plurality of different coded currents when each such code has a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of charging current, a reactor having a winding mounted on a magnetic core; a charging circuit including said source of charging current, a contact of said code following relay closed at a selected one of its positions and the winding of said reactor for storing magnetic energy in said magnetic core to an amount predetermined by the duration of the period at which said contact is closed; a decoding relay having a predetermined pick-up electromotive force; a discharge circuit including a portion of the winding of said reactor, a contact of the code following relay closed at the position other than said one position and a winding of said decoding relay to energize the decoding relay by the electromotive force created by the decay of said stored magnetic energy to pick up the decoding relay only for such code whose period in which magnetic energy is stored is of a duration sufficient to store at least a given amount of magnetic energy; and a signaling circuit including a contact of said decoding relay.

8. In apparatus for use with a code following relay which is operated to a first and a second position in step with the on and off periods of any one of a plurality of different coded currents when each such code has a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of charging current, a reactor having a winding mounted on a magnetic core; a charging circuit including said source of charging current, a contact of said code following relay closed at a selected one of its positions and the winding of said reactor for storing magnetic energy in said magnetic core to an amount predetermined by the duration of the period at which said contact is closed; an asymmetric unit, a decoding relay effectively energized and picked up only when an electromotive force of at least a given minimum value is applied to its winding; a discharge circuit including a portion of the winding of said reactor, said asymmetric unit and said winding of the decoding relay to apply to the winding of the decoding relay the electromotive force created by the decay of said stored magnetic energy during the code period other than the period in which such energy is stored to pick up the decoding relay only for such code whose period in which magnetic energy is stored is of a duration sufficient to store at least a given amount of magnetic energy; and a signaling circuit including a contact of said decoding relay.

9. In apparatus for use with a code following relay which is operated to a first and a second position in step with the on and off periods of any one of a plurality of different coded currents when each such code has a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of charging current, a reactor having a winding mounted on a magnetic core; a charging circuit including said source of charging current, a contact of said code following relay closed at a selected one of its positions and at least a por-

tion of the winding of said reactor for storing magnetic energy in said magnetic core to an amount predetermined by the duration of the period at which said contact is closed; an asymmetric unit whose resistance in its low resistance direction decreases with an increase in temperature, a decoding relay having a predetermined pick-up electromotive force; a discharge circuit including a portion of the winding of said reactor, a contact of the code following relay closed at the position other than said one position, said asymmetric unit in its low resistance direction and a winding of said decoding relay to energize said decoding relay by the electromotive force created by the decay of said stored magnetic energy to pick up said decoding relay only for such code whose period in which magnetic energy is stored is of a duration sufficient to store at least a given amount of magnetic energy; said asymmetric unit effective to compensate for the increase in the resistance of said winding of the decoding relay due to an increase in temperature, and a signaling circuit including a contact of said decoding relay.

10. In apparatus for use with a code following relay which is operated to a first and a second position in step with the on and off periods of any one of a plurality of different coded currents when each such code has a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of charging current, a reactor having a magnetic core; a charging circuit including said source of charging current, a contact of said code following relay closed at a selected one of its positions and a winding mounted on said reactor core; said charging circuit proportioned as to its time constant to store magnetic energy in said reactor core at a predetermined rate to determine by the amount of energy stored the duration of the code period during which energy is stored, a decoding relay having a winding connected with a winding mounted on said reactor core over a contact of said code following relay closed at the position other than said one position to apply to said decoding relay during the non-energy storing period of the code the electromotive force created by the decay of said stored magnetic energy, said decoding relay adjusted for a pick-up electromotive force equal to that created when a predetermined amount of magnetic energy is stored in said reactor core to pick up the decoding relay only for such code whose period in which energy is stored is of at least a predetermined duration, and a signaling circuit including a contact of said decoding relay.

11. In apparatus for use with a code following relay which is operated to a first and a second position in step with the on and off periods of any one of a plurality of different coded currents when each such code has a cyclic pattern consisting of one on and one off periods of preselected durations, the combination comprising, a source of charging current, a reactor having a magnetic core; a charging circuit including said source of charging current, a contact of said code following relay closed at a selected one of its positions and a winding mounted on said reactor core; said charging circuit proportioned as to its time constant to store magnetic energy in said reactor at a predetermined rate to determine by the amount of energy stored the duration of the code period during which energy is stored, a decoding relay having a winding connected with a winding mounted on said reactor core over a contact of said code following relay closed at the position other than said one position to apply to said decoding relay during the non-energy storing period of the code the electromotive force created by the decay of said stored magnetic energy, said decoding relay adjusted for a pick-up electromotive force equal to that created when a predetermined amount of magnetic energy is stored in said reactor core to pick up the decoding relay only for such code whose period in which energy is stored is of at least a predetermined duration, and said decoding relay provided with a slow release period greater than said predetermined duration to retain the decoding relay picked up as long as such code persits, and a signaling circuit including a front contact of said decoding relay.

12. In apparatus for use with a code following relay which is operated to a first and a second position in step with the on and off periods of any one of a plurality of different coded currents when each such code has a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current, a first and a second reactor each having a winding mounted on a magnetic core, a first charging circuit to connect the winding of said first reactor with said direct current source over a first position contact of said code following relay, a second charging circuit to connect the winding of said second reactor with said direct current source over a second position contact of said code following relay, each of said charging circuits proportioned for a predetermined time constant to store at a predetermined rate magnetic energy in the core of the respective reactor to determine the duration of the corresponding code period by the amount of energy stored, a first and a second decoding relay each adjusted for a predetermined pick-up electromotive force, a first discharge circuit to connect a portion of the winding of the first reactor with a winding of said first decoding relay over a second position contact of said code following relay to apply to the first decoding relay the electromotive force created by the decay of the magnetic energy stored in said first reactor to pick up the first decoding relay for codes having an on period of a predetermined duration, a second discharge circuit to connect a portion of the winding of the second reactor with a winding of said second decoding relay over a first position contact of said code following relay to apply to the second decoding relay the electromotive force created by the decay of the magnetic energy stored in said second reactor to pick up the second decoding relay for codes having an off period of a predetermined duration, and a plurality of signaling circuits selectively controlled by said decoding relays.

13. In combination, a section of railway track, means for supplying the rails of said section with coded current of one of a group of three time codes selected in accordance with three different traffic conditions in advance of said section, each of said codes having a distinctive cyclic pattern which consists of one on and one off period of preselected durations, a code following relay receiving energy from the rails of said section operable to a first and a second position in step with the on and off periods of such codes, a first and a second reactor each having a winding mounted on a magnetic core, a source of direct current, a first charging circuit including a first position contact of the code following relay to connect said direct current source with the first reactor

winding, a second charging circuit including a second position contact of the code following relay to connect said direct current source with the second reactor winding, each of said first and second charging circuits proportioned for a predetermined time constant to build up magnetic energy in the respective reactor core at a predetermined rate to determine the duration of the respective code period by the amount of magnetic energy stored, a first and a second slow releasing decoding relay, each of said decoding relays adjusted for a predetermined pick-up electromotive force, a first discharge circuit including a second position contact of the code following relay to connect a portion of the first reactor winding with said first decoding relay to pick up that decoding relay only when the coded current has an on period of a predetermined duration, a second discharge circuit including a first position contact of the code following relay to connect a portion of the second reactor winding with said second decoding relay to pick up that decoding relay only when the coded current has an off period of a predetermined duration, and three signaling circuits one for each of said traffic conditions closed according as said first or said second or both of said decoding relays are picked up.

14. In apparatus for use with a code following relay which at times is operated to a first and a second position in step with the on and off periods of a coded current having a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current, a reactor having a magnetic core, a first circuit including a first position contact of said code following relay to connect said source of direct current to said reactor to store magnetic energy in the core of said reactor each on code period, said first circuit proportioned for a predetermined time constant to store a predetermined amount of magnetic energy during each on period of said coded current, a decoding relay adjusted for a preselected pick-up electromotive force, a second circuit including a second position contact of said code following relay to connect said reactor to said decoding relay to energize the decoding relay by the electromotive force created in said second circuit during each off code period by the decay of the magnetic energy stored in the core of said reactor, said second circuit proportioned to energize the decoding relay by said pick-up electromotive force only when the stored magnetic energy is at least equal to said predetermined amount, and a signaling circuit including a front contact of said decoding relay.

15. In combination, a section of railway track, means for supplying to the rails of said section coded current of one of a group of three time codes selected in accordance with three different traffic conditions in advance of said section, each of said codes having a distinctive cyclic pattern which consists of one on and one off period of preselected durations, a code following relay receiving energy from the rails of said section operable to a first and a second position in step with the on and off periods of such codes, a first and a second reactor each having a magnetic core, a source of direct current, a first charging circuit including a first position contact of the code following relay to connect said direct current source to said first reactor, a second charging circuit including a second position contact of the code following relay to connect said direct current source to said second reactor, each of said first and second charging circuits proportioned for a predetermined time constant to build up magnetic energy in the respective reactor core at a predetermined rate to determine the duration of the respective code period by the amount of magnetic energy stored, a first and a second slow releasing decoding relay, each of said decoding relays adjusted for a predetermined pick-up electromotive force, a first discharge circuit including a second position contact of the code following relay to connect said first reactor to said first decoding relay and said first discharge circuit proportioned to apply to the first decoding relay its predetermined pick-up electromotive force only when the coded current has an on period of a predetermined duration, a second discharge circuit including a first position contact of the code following relay to connect said second reactor to said second decoding relay and said second discharge circuit proportioned to apply to the second decoding relay its predetermined pick-up electromotive force only when the coded current has an off period of a predetermined duration, and three signaling circuits one for each of said traffic conditions and closed according as said first or said second or both of said decoding relays are picked up.

16. In apparatus for use with a code following relay which at times is operated to a first and a second position in step with the on and off periods of a coded current having a cyclic pattern consisting of one on and one off period of preselected durations, the combination comprising, a source of direct current, a reactor having a first and a second winding mounted on a magnetic core; a first circuit including said source of direct current, a first position contact of said code following relay and said first winding of said reactor; said first circuit proportioned for a predetermined time constant to build up magnetic flux in said reactor core at a predetermined rate and create a predetermined amount of magnetic flux during each on period of said coded current, a decoding relay adjusted for a preselected pick-up electromotive force; a second circuit including said second reactor winding, a second position contact of said code following relay and a winding of said decoding relay; said second circuit proportioned to create said pick-up electromotive force due to the decay of the magnetic energy stored in the reactor core during each off period of said coded current only when the stored magnetic energy is at least equal to said predetermined amount, and a signaling circuit including a contact of said decoding relay.

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