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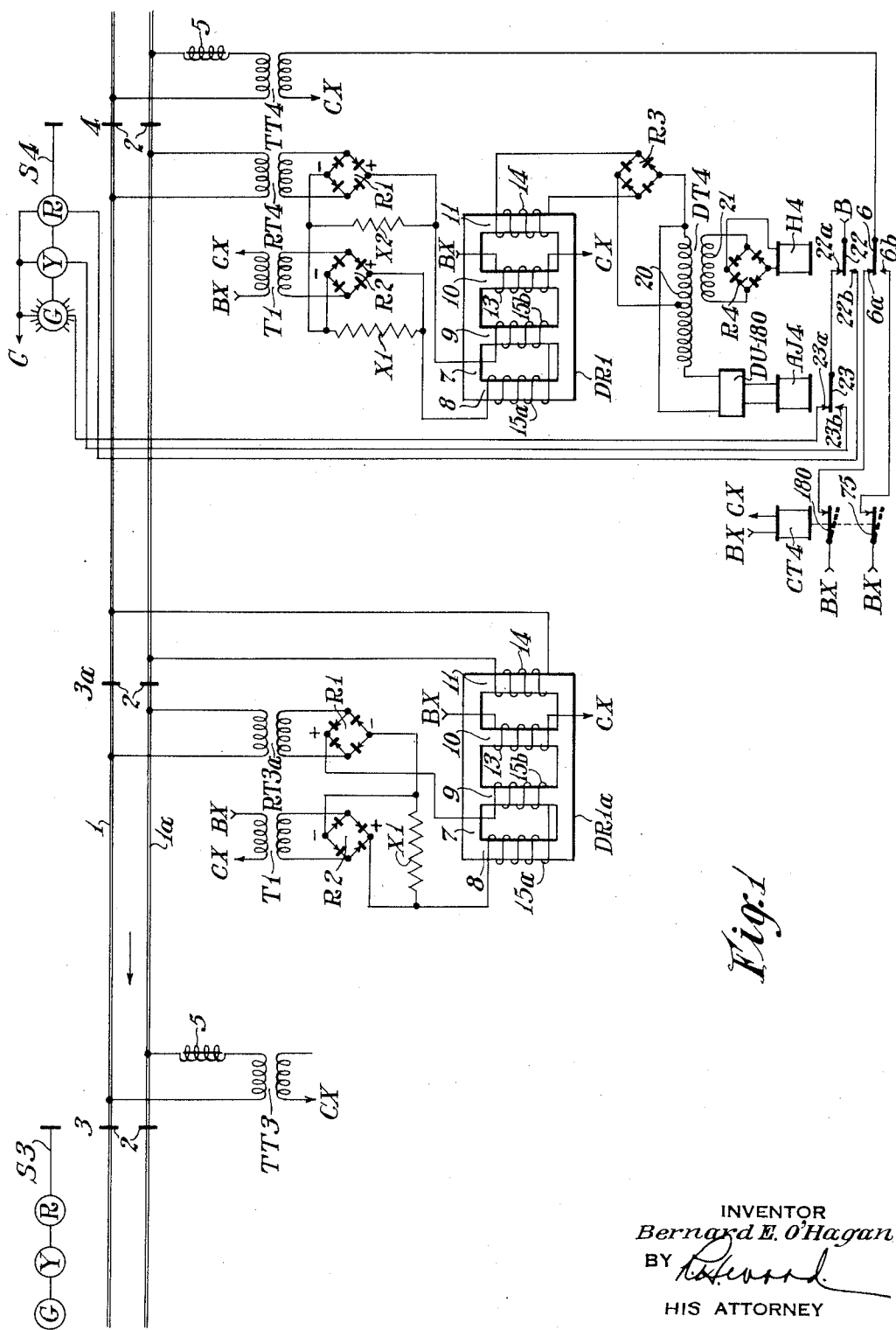
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2,215,821

RAILWAY SIGNALING APPARATUS

Filed June 24, 1939

3 Sheets-Sheet 1



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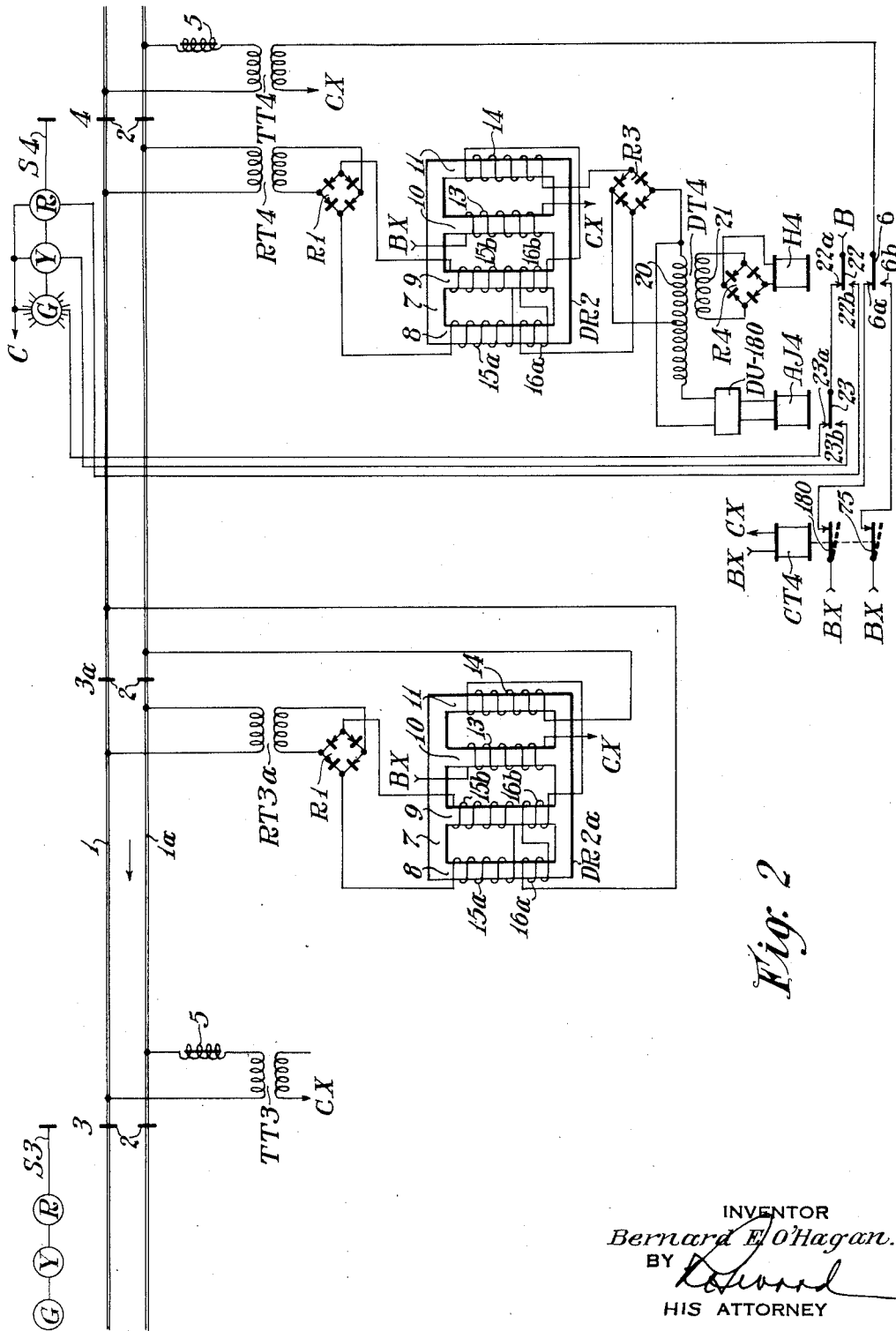
B. E. O'HAGAN

2,215,821

RAILWAY SIGNALING APPARATUS

Filed June 24, 1939

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RAILWAY SIGNALING APPARATUS

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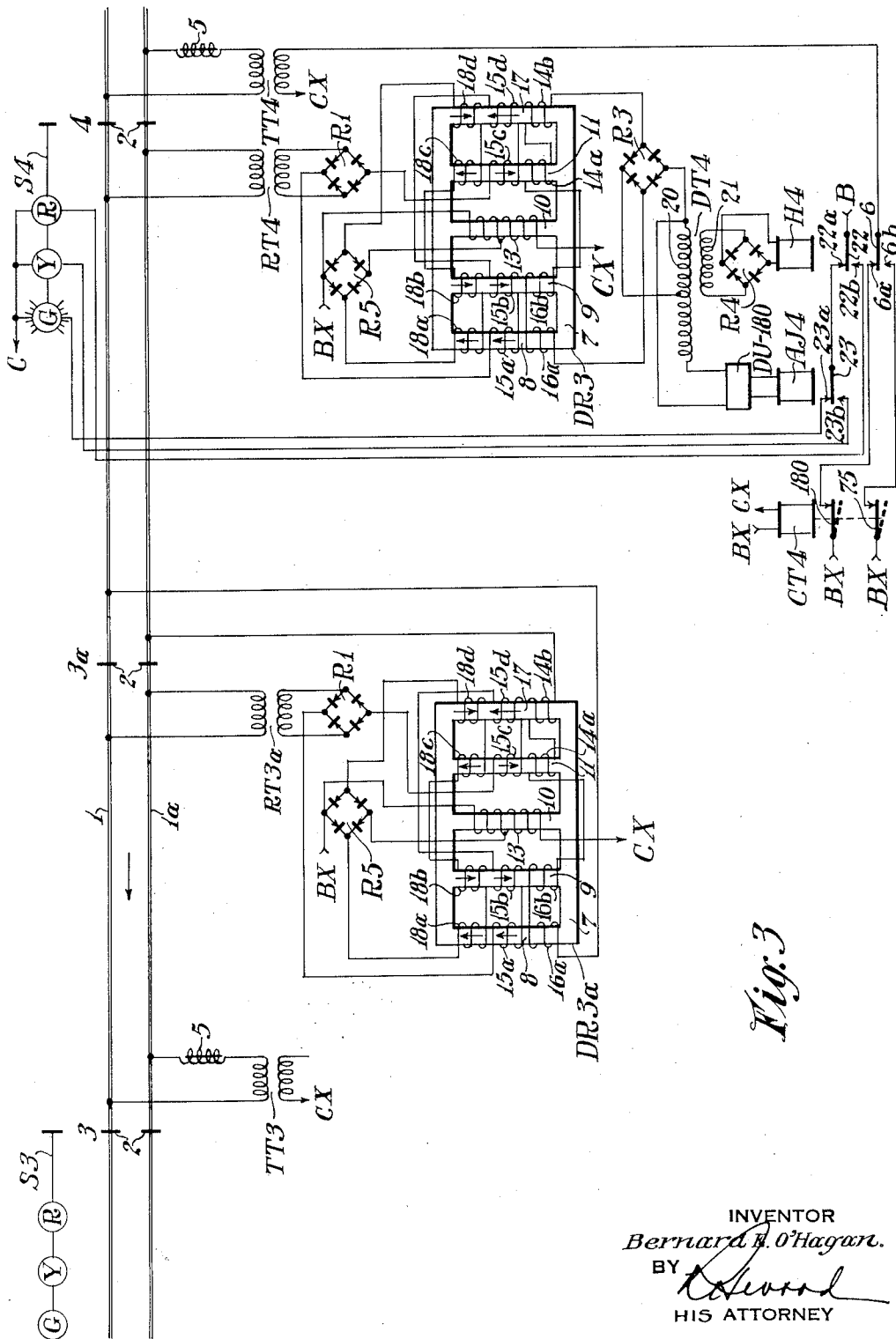


Fig. 3

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UNITED STATES PATENT OFFICE

2,215,821

RAILWAY SIGNALING APPARATUS

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Application June 24, 1939, Serial No. 280,997

24 Claims. (Cl. 246—34)

My invention relates to railway signaling apparatus, and has particular reference to apparatus of the type employed in railway signaling systems in which coded trackway energy is utilized to control either or both wayside signals and train carried cab signals.

It has hitherto been proposed to employ relays of the saturation type as code following relays in connection with signaling systems utilizing coded trackway energy. I have found that when saturation type code following relays are so employed, the energy reproduced in such relays in response to the coded trackway energy may be distorted, that is, the length of the code impulse induced in the saturation relays may be prolonged, and also there may be a residual output of the relays during the "off" or no energy period of the trackway code. Accordingly, an object of my invention is the provision of novel and improved means for employing code following relays of the saturation type in coded track circuit signaling systems, whereby more efficient and improved operation of such relays is effected by the coded trackway energy.

A further object is the provision of improved cut-section facilities for cascading trackway energy around a cut in a track section. These facilities are an improvement upon the apparatus shown in a copending application, Serial No. 280,371, filed on June 23, 1939, by Claude M. Hines, and certain features disclosed in the present case are broadly claimed in the said copending application.

Another object is the provision of novel and improved forms of relays of the saturation type, especially adaptable for use in systems of the above class.

A further object is to prevent distortion in the coded output of such relays when used as code following relays.

An additional object is to prevent such distortion by preventing the prolongation of the code impulses induced in such relays.

Another object is to prevent distortion of the code output of such relays by decreasing the residual output of such relays.

Other objects and advantages of my invention will appear as the description proceeds.

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

In the accompanying drawings, Fig. 1 is a diagrammatic view showing a preferred form of apparatus embodying my invention. Figs. 2 and 3

are diagrammatic views showing modified forms of the apparatus shown in Fig. 1, each also embodying my invention.

Similar reference characters refer to similar parts in each of the several views.

Referring first to Fig. 1, the reference characters 1 and 1a designate the track rails of a stretch of railway track over which traffic normally moves in the direction indicated by an arrow in the drawing, and which direction I shall assume to be the westbound direction. The rails 1 and 1a are divided by means of the usual insulated rail joints 2 into a plurality of successive adjoining track sections, of which only one section 3—4, is shown complete in the drawings. Section 3—4 also is further divided into a plurality of subsections, formed by interposing insulated joints 2 in the rails of section 3—4 at so-called "cut-section" locations. As shown, the rails 1 and 1a of Fig. 1 are provided with insulated joints 2 at cut-section location 3a, with the result that section 3—4 is divided into an advance subsection 3—3a and a rear subsection 3a—4.

Each track section is provided with a signal, designated by the reference character S with a distinguishing suffix, located adjacent the entrance end of the section for governing traffic operating thereover. Signals S may take any one of many suitable forms but in the form herein shown are three-indication signals of the color light type, and each signal comprises a red lamp R, a yellow lamp Y and a green lamp G, which lamps when illuminated indicate "stop," "caution" and "proceed," respectively.

Each section is further provided with means, located at the exit end of the section, for supplying to the rails of the associated section coded trackway energy, the code frequency or rate of which is controlled by traffic conditions in advance. These means are herein shown in the usual form and comprise a track transformer, designated by the reference character TT with a distinguishing suffix, the secondary of which is constantly connected with the rails of the associated section in series with the usual current limiting impedance 5. The primary of transformer TT is connected with the terminals BX and CX of a suitable source of alternating current (not shown in the drawings) preferably of a frequency of 100 cycles per second, over one contact 180 or over another contact 175 of a coding device, designated by the reference character CT plus a distinguishing suffix, according as a

front contact 6—6a or a back contact 6—6b of a relay, designated by the reference character H with a distinguishing suffix, which is associated with the section next in advance is closed, only the coding device DT4 and the relay H4 which are associated with section 3—4 being shown in the drawings. Coding device CT4 is constantly supplied with current from a suitable source of current, the terminals of which are indicated by the reference characters BX and CX, and this device constantly opens and closes its contact 180 at the rate of 180 times per minute, and also opens and closes its contact 75 at the rate of 75 times per minute. It is readily apparent, therefore, that when the relay H of a section is picked up so that its front contact 6—6a is closed, the rails of the section next in the rear will be supplied with alternating trackway energy which is periodically interrupted or coded at the rate of 180 times per minute, but that, when the relay H of a section is released so that its back contact 6—6b is closed, the rails of the section next in the rear then will be supplied with alternating trackway energy which is periodically interrupted or coded at the rate of 75 times per minute. The 180 code is used to provide a "proceed" indication and the 75 code is used to provide a "caution" indication for the signal of the associated section, in a manner which will be made clear as the description proceeds. Each relay H is controlled by traffic conditions in the associated section in a manner which also will be made clear as the description proceeds.

Each section is provided at its entrance end with a code following track relay of what I shall term a "front contact" relay of the saturation type, designated by the reference character DR with a distinguishing suffix. A similar relay is located also at the cut-section location of each section, only the relays DR1 and DR1a located respectively at the signal location 4 and at the cut-section location 3a of section 3—4 being shown in the drawings. The relays DR are substantially similar in construction so that the following description of relay DR1a will suffice as well to describe relay DR1.

Relay DR1a, in the form herein shown, comprises a magnetizable core 7 provided with four parallel legs 8, 9, 10 and 11 connected together at each end to form an integral core structure. One of the inner legs 10 is provided with a primary or local input winding 13 constantly connected with a source of periodically varying current (preferably being connected with a source of alternating current which is indicated in the drawings by the terminals BX and CX) for setting up a flux in the core 7. The primary flux thus set up in core 7 normally divides between two magnetic circuits, one of which I shall term a main circuit, and the other of which I shall term a leakage circuit. The main magnetic circuit of core 7 comprises the common leg 10 and the adjacent outer leg 11, upon which latter leg is mounted a secondary or output winding 14. The other or leakage magnetic circuit comprises the common leg 10 and, in parallel the legs 8 and 9, upon which legs is disposed a saturation winding 15, which comprises two coils 15a and 15b disposed respectively on legs 8 and 9, the coils being connected in series in such manner that the resultant electromotive force normally induced in winding 15 as a result of the primary flux created by winding 13 is substantially zero. This arrangement of coils 15a and 15b also is such

that when winding 15 is supplied with unidirectional current in a manner to be made clear presently, the coils act cumulatively to circulate a flux through a local magnetic circuit formed by the parallel legs 8 and 9 and the adjoining top and bottom portions of the core forming a part of the leakage magnetic circuit of the relay, thereby varying the reluctance of such leakage circuit. The terminals of winding 15 are connected across the output terminals of a rectifier R1, the connection of winding 15 with the lower output terminal of rectifier R1 including in series therewith a resistor X1, which resistor in turn is connected across the output terminals of a biasing rectifier R2. The arrangement of rectifiers R1 and R2 in the above circuit is such that the electromotive force of rectifier R2 opposes the electromotive force of rectifier R1. The input terminals of rectifier R2 are connected with a suitable source of alternating current, which, as here shown, may be a transformer T1 having its primary winding connected with a source of alternating current, but if desired, rectifier R2 may be connected to a secondary winding mounted on leg 10 of the core 7 in inductive relationship with local input winding 13.

The saturation winding 15 of relay DR1a is supplied with energy from the track rails of subsection 3—3a through the medium of a relay transformer RT3, which transformer has its primary winding connected across the rails of subsection 3—3a, and has its secondary winding connected to the input terminals of rectifier R1, so that the coded alternating trackway energy received from the rails of subsection 3—3a is rectified into and is supplied to winding 15 as impulses of unidirectional current.

The output winding 14 of relay DR1a is connected across the track rails 1 and 1a of subsection 3a—4, for a purpose to be made clear presently.

With relay DR1a constructed and arranged in the foregoing manner, it can be seen that winding 13 is constantly supplied with periodically varying current so that the primary flux created thereby links both magnetic circuits of its core 7. It is apparent, therefore, that during the interval that the primary flux links both circuits, a voltage of a given value will be induced by such flux in output winding 14. When, however, control winding 15 is supplied with current (as for example during the "on" period of the code) so that the flux created thereby varies the reluctance of the leakage circuit (the winding 15 being preferably so proportioned as to magnetically saturate the leakage circuit), substantially all the primary flux then will circulate through leg 11 with the result that a greatly increased voltage will be induced in winding 14 at this time. During the "off" period of the code, the reluctance of the leakage circuit again will drop and the primary flux again divide between the two circuits so that the lower, or given, voltage will be induced in winding 14. It is readily apparent from the foregoing that a relatively high voltage is or is not induced in winding 14 according as winding 15 is or is not supplied with current, and that this relatively high voltage will be induced in the winding 14 in step with the impulses of current supplied from the rails of the section to winding 15, by virtue of the action of such current impulses in varying the reluctance of the leakage magnetic circuit and thereby varying the flux circulating in the main magnetic circuit of

the relay. It follows, therefore, that with winding 14 connected across the rails of the rear subsection 3a-4, such rails will be supplied with alternating trackway energy of relatively high voltage in step with the code current impulses supplied to the rails of the advance subsection 3-3a, whereby the coded trackway energy of subsection 3-3a is cascaded around the cut-section location 3a by virtue of relay DR1a reproducing the energy in kind and supplying the reproduced energy to subsection 3a-4.

The resistor X1 and the biasing rectifier R2 are incorporated into relay DR1a to prevent distortion of the coded energy induced in the secondary winding of the relay by applying to the control winding 15 of the relay an electromotive force which opposes the coded electromotive force present at times in that winding. As was pointed out heretofore, control winding 15 of relay DR1a is supplied by rectifier R1 with coded impulses of rectified current having a polarity indicated in the drawings, and as a result of the supply of such impulses, the reluctance of the leakage circuit of the relay core is varied to thereby vary the magnetic coupling of the primary and secondary windings of the relay whereby impulses of relatively high voltage are induced in the secondary winding 14 of the relay. But for the provision of resistor X1 and rectifier R2, the relatively high voltage impulses induced in secondary winding 14 might be longer in duration than the code impulses supplied to winding 15, because of the short-circuiting action of rectifier R1, which rectifier provides a shunt path in its low resistance direction across the highly inductive winding 15, through which path current from winding 15 tends to flow during the "off" period of the code, thereby delaying the decay of the flux set up by winding 15 in the leakage path of the core. The decay of flux in legs 8 and 9 being thus delayed, the primary flux is caused to circulate longer through the main magnetic circuit of the relay to thereby prolong the length of the impulse of current induced in winding 14. However, with resistor X1 connected in series with rectifier R1 and winding 15, and with rectifier R2 connected across the resistor in a manner such that the electromotive force of rectifier R2 opposes the electromotive force of rectifier R1, as soon as the voltage from rectifier R2 exceeds the potential drop across the resistor X1 due to the decaying current from winding 15, the current from the winding will be stopped just as though it had been stopped by the opening of a contact of a relay, and as a result a sharp "cut-off" in the saturating flux in the leakage circuit of the relay is thereby effected. It is readily apparent, therefore, that the voltages of rectifiers R1 and R2 may be proportioned and designed so that as long as rectifier R1 is supplied with current, the resultant of the voltages will cause the leakage magnetic circuit of relay DR1a to become saturated, but that, when rectifier R1 becomes deenergized, the voltage of rectifier R2 in opposing the decaying current of winding 15 prevents prolonged delay of the flux decay in the leakage magnetic circuit of the relay, whereby distortion of the impulses induced in the secondary winding of the relay is prevented. The form of coded trackway energy supplied by relay DR1a to rear subsection 3a-4 thus is improved and corresponds more closely to the form of trackway energy supplied by the track transformer TT3 to advance subsection 3-3a, whereby, as will be made clear presently,

the efficiency and operation of the decoding apparatus for the section is materially improved.

It should be noted that with relay DR1a constructed in the manner just described, relatively little current will be supplied by rectifier R2 to winding 15 during the "off" period of the code, since rectifier R1 is arranged so that its high resistance direction is presented to the flow of current from rectifier R2.

Relay DR1 located at signal location 4 of section 3-4 is substantially similar in construction to relay DR1a just described, except that in relay DR1 a resistor X2 is connected across the output terminals of rectifier R1. This resistor permits a small biasing flux to be built up in response to current supplied from rectifier R2 to winding 15 during the "off" period of the code, which flux is opposite in polarity to the flux set up in winding 15 in response to the resultant electromotive force of both rectifiers R1 and R2. Thus, with relay DR1 provided with resistor X2, a slight delay in flux growth in the leakage circuit of relay DR1 will be effected when current is supplied from rectifier R1, since the biasing flux in legs 8 and 9 first must be neutralized before the saturating flux becomes effective to vary the inductive coupling of the primary and secondary windings of the relay. The impulse of current induced in secondary winding 14 of relay DR1 accordingly will lag behind the code impulse supplied to rectifier R1. The parts of relay DR1 preferably are so proportioned that the lag of the induced impulse in winding 14 substantially equals the interval required for the decaying current in winding 15 to drop to the potential of rectifier R2 after the code impulse to rectifier R1 is cut off, thereby causing the impulse of current induced in secondary winding 14 of relay DR1 to have substantially the same length as the control code impulse supplied by the track transformer TT3 to the tracks rails of section 3-4.

Output winding 14 of relay TR1 is connected through the medium of a rectifier R3 with a primary winding 20 of a decoding transformer DT4, and it is apparent, therefore, that winding 14 of relay DR1 will supply transformer DT4 with impulses of unidirectional current which will have a code frequency and duration which corresponds to the frequency and duration of code present in the rails of section 3-4.

Decoding transformer DT4 is provided with a secondary winding 21 connected through the medium of a rectifier R4 to a signal control relay H4 provided for section 3-4. The transformer DT4 is so proportioned and designed that relay H4 is energized and picked up whenever code of 75 or 180 impulses per minute is induced in the secondary winding 14 of relay DR1, but that whenever steady or non-coded energy of the lower or given voltage is induced in secondary winding 14, relay H4 is released. Relay H4 consequently functions as a code detecting relay since it is picked up whenever coded energy is supplied to relay DR1 from the rails of the section, but is released whenever control winding 15 of relay DR1 is deenergized.

The decoding transformer DT4 also supplies energy to another signal control relay AJ4 provided for section 3-4, which relay is connected with a portion of the primary winding 20 of transformer DT4 through a decoding unit DU-180. The details of construction of unit DU-180 are not shown in the drawings, but this unit usually comprises a rectifier and a reactor condenser tuning unit tuned to resonance at a frequency

corresponding to the 180 code whereby relay AJ4 is effectively energized and is picked up when and only when 180 code is supplied by the code following relay DR1 to the decoding transformer DT4. Relay AJ4 therefore functions as a code selecting relay since it is picked up when 180 code is supplied to its associated code following relay but is released when 75 code is supplied to its associated code following relay from section 3—4.

The code selecting relay AJ4 and the code detecting relay H4 cooperate to selectively control the various aspects displayed by signal S4, in the following manner. When relays H4 and AJ4 are both picked up, signal S4 is caused to display its "proceed" indication over a circuit which may be traced from terminal B through front contact 22—22a of relay H4, front contact 23—23a of relay AJ4, and the filament of lamp G of signal S4 to terminal C. When the code detecting relay H4 is picked up and the code selecting relay AJ4 is released, signal S4 then is caused to display its "caution" indication over a circuit passing from terminal B through front contact 22—22a of relay H4, back contact 23—23b of relay AJ4, and the filament of lamp Y of signal S4 to terminal C. When, however, both relays H4 and AJ4 are released, signal S4 then is caused to display its "stop" indication over a circuit passing from terminal B through back contact 22—22b of relay H4 and the filament of lamp R of signal S4 to terminal C.

The above selective control of signal S4 is effected by relays H4 and AJ4 in the following manner: Section 3—4 will be supplied with 180 or 75 code according as the section next in advance is unoccupied or occupied. When section 3—4 is supplied with 180 code and the section is unoccupied, all parts of the apparatus will occupy the position in which they are shown in Fig. 1. Under the above conditions, relays H4 and AJ4 are both picked up, the circuit for lamp G of signal S4 is completed whereby that signal is caused to display its "proceed" indication, and the circuit including front contact 6—6a of relay H4 and contact 180 of coding device CT4 is closed so that the section next in the rear of section 3—4 is supplied with 180 code also.

When section 3—4 is supplied with 75 code and the section is unoccupied, relay H4 is picked up but relay AJ4 is released, thus causing signal S4 to display its "caution" indication since the circuit previously traced for lamp Y of signal S4 is now completed. The rails of the section next in the rear of section 3—4, however, are still supplied with 180 code since front contact 6—6a of relay H4 is closed.

Whenever section 3—4 is occupied by a train, the coded trackway energy supplied to section 3—4 then is shunted away from the code following apparatus of that section. For example, whenever a train occupies the rear subsection 3a—4, the wheels and axles of the train then shunt the trackway energy away from relay transformer RT4 so that winding 15 of relay DR1 is deenergized. Also, whenever a train occupies the advance subsection 3—3a, the train then shunts the trackway energy from relay transformer RT3a so that non-coded energy of the given or lower voltage is induced in winding 14 of relay DR1a and is supplied to the rear subsection 3a—4. This steady or non-coded energy is of such low voltage that it is ineffective to materially vary the reluctance of the leakage circuit of relay DR1, and therefore the energy in-

duced in output winding 14 under the latter condition is substantially equivalent to the energy induced therein when no energy is supplied from the track rails of the section to winding 15. It can be seen, therefore, that the coded trackway energy is shunted from relay DR1 whenever a train occupies either or both subsections 3a—4 or 3—3a, and that the two subsections when taken together cooperate to provide a single track section which is responsive to traffic conditions in the same manner as if the rails of section 3—4 where continuous conductors from one end of the section to the other.

When the coded trackway energy of a section is shunted away from its associated code following relay, the signal for that section then is caused to display its restrictive or "stop" indication, since under the above conditions the energy induced in winding 14 of the code following relay is non-coded energy of relatively low voltage. This non-coded low voltage energy supplied by relay DR1 to decoding transformer DT4 is ineffective to cause energization of the signal control relays H4 and AJ4, so that both relays are released. Under the above conditions, signal S4 is controlled to its "stop" indication over back contact 22—22b of relay H4, and the section next in the rear of the section 3—4 is supplied with 75 code over back contact 6—6b of relay H4. It is apparent, therefore, that the signal for a section is controlled to its most restrictive indication whenever its associated section is occupied. It is also apparent that the section next in the rear of section 3—4 is supplied with trackway energy of 180 code at all times except when section 3—4 is occupied, and that under the latter condition the rear section is then supplied with trackway energy of 75 code. The code frequency or rate of the trackway energy supplied to each section is, therefore, governed by traffic conditions in advance of that section.

From the foregoing, it is readily apparent that selective operation of the signal for a section is effected by traffic conditions in advance of that section, as determined by the particular form of trackway energy supplied to the rails of a section, which energy then is translated by the decoding apparatus of a section to selectively control the associated signal control relays. It can be seen that if distorted energy having different characteristics than the original characteristics of the trackway energy is supplied to the control relays, the relays then will be less efficient in distinguishing between the several forms of trackway energy supplied to the track rails. It follows, therefore, that since relay DR1a cascades trackway energy from one subsection to the next with the minimum of distortion, and that since the energy reproduced in relay DR1 has substantially the same characteristics as the trackway energy supplied to the section, the selective operation and efficiency of the signal control relays in distinguishing between the several forms of trackway energy is materially improved, and that the efficiency of the decoding apparatus as a whole is increased.

Referring now to Fig. 2, the apparatus in the form herein shown includes a code following relay DR2a of the saturation type located at the cut-section 3a of section 3—4, and also includes a similar relay DR2 located at the signal location 4 of Fig. 2. The saturation relays shown in Fig. 2 are substantially similar in construction to the saturation relays shown in Fig. 1, except that the biasing rectifier R2 and the resistor X1 incor-

porated into the relays of Fig. 1 are now replaced by two coils 16a and 16b mounted respectively on legs 8 and 9 of the leakage magnetic circuits of the relays of Fig. 2. The coils 16a and 16b of the relays of Fig. 2 are connected in series in such manner that the electromotive forces induced therein by the primary flux of the relays are additive, and the two coils are connected in series with the output winding 14 of the relays in such manner that the electromotive force induced in winding 14 is opposed by the electromotive forces induced in the two windings 16a and 16b, the parts of the relays being so proportioned and designed that during the interval the primary flux divides between its two magnetic circuits, the resultant of the electromotive forces induced in coils 16a and 16b and in winding 14 is substantially zero. With relays DR2 and DR2a constructed in the foregoing manner, it is apparent that the coils 16a and 16b are effective to apply to the output winding 14 an electromotive force which opposes the electromotive force present at times in the output winding of the relay, whereby, as will be made clear presently, distortion is prevented in the output of the relay.

The control winding 15 of each relay DR2 and DR2a is supplied with current from its associated rectifier R1. Considering, for example, relay DR2a during the interval that its control winding 15 is deenergized, the primary flux of the relay at this time divided between the main and the leakage magnetic circuits of the relay, to thereby induce electromotive forces in winding 14 and in coils 16a and 16b. As pointed out previously, the electromotive force induced in winding 14 is opposed and neutralized by the electromotive forces induced in the coils 16a and 16b, so that the resultant of the electromotive forces induced at this time is substantially zero. At this time, therefore, no trackway energy is supplied from relay DR2a to the track rails of subsection 3a-4, and under the above conditions the relay functions as if the circuit connection of secondary winding 14 of the relay and the rails had been opened by the opening of a contact of the usual tractive armature type relay. In similar fashion, relay DR2 will supply no energy to the decoding transformer DT4 when control winding 15 of relay DR2 is deenergized.

When, however, winding 15 of relay DR2a is supplied with current and as a result its leakage magnetic circuit is saturated, then the electromotive force induced in winding 14 is greatly increased in magnitude, while the magnitude of the electromotive forces induced in coils 16a and 16b drops and approaches a zero value. The resultant of the electromotive forces at this time accordingly is relatively high and is substantially equal to the electromotive force induced in winding 14, so that under these conditions the rails of section 3a-4 are supplied with current of relatively high voltage. In like manner, when winding 15 of relay DR2 is energized, the decoding transformer DT4 is supplied with an electromotive force of relatively large magnitude. The code output of winding 14 of relay DR2a or DR2, as the case may be, therefore is similar to the code supplied by the track transformer TT3 to the rails of section 3-4, in that energy is supplied from relay DR2a or DR2 only during the "on" period of the code and energy is not supplied during the "off" period of the code, since there is substantially no residual output of the relay, that is, no energy is induced in the relay during the "off" period of the code.

It is readily apparent from the foregoing that, since control of the output of the code following relay DR2, which controls the signal for the section, is effected by virtue of the difference in magnitude of the electromotive forces supplied from the rails of the section to the control winding 15 of the relay during the "on" and during the "off" period of the code, if no electromotive force is present in the rails of the section during the "off" period of the code, the magnitude of the electromotive force induced in relay DR2a and supplied by that relay to the rails of the section can be much lower than if there is a residual output of the relay supplied to the rails of the section during the "off" period of the trackway code. Accordingly, it can be seen that operation of the code following relay of a section is effected by code impulses of relatively small magnitude.

Similarly, the operation of decoding transformer DT4 is based upon the difference in magnitude of the electromotive forces induced in winding 14 of relay DR2 during the "on" and "off" periods of the trackway code supplied to the relay. It is apparent, therefore, that since there is no residual output from relay DR2 so that transformer DT4 is not supplied with current during the "off" period of the code, no transfer of energy is effected at that time and further, an induced impulse of relatively small magnitude will effectively operate the decoding transformer.

It should be noted that although relays DR2 and DR2a are particularly effective as code following relays, the relays may be used as ordinary control relays with non-coded energy. In the event that the control winding 15 of the relay is supplied with non-coded energy, the relay will have the same improved amplification that it possesses when coded energy is supplied to the control winding. If used with non-coded energy, during the interval that the control winding of the relay is deenergized the resultant of the electromotive forces induced in winding 14 and in coils 16a and 16b is substantially zero, and the saturation relay in this condition therefore corresponds to a relay of the tractive armature type in its released condition, that is, with its front contact held open. When, however, control winding 15 is energized by the non-coded energy, the resultant of the induced electromotive forces then becomes relatively high so that the relay in this condition corresponds to a tractive armature type relay holding its front contact closed. The construction and arrangement of the apparatus shown in Fig. 2 therefore provides a relay of the saturation type having substantially the same characteristics as a relay of the tractive armature type.

Referring now to Fig. 3, the relay DR3 (and in similar fashion relay DR3a) here shown, is provided with a magnetizable core 7 having five parallel legs 8, 9, 10, 11 and 17 connected together at each end to form an integral relay core structure. The main magnetic circuit of relay DR3, as here shown, comprises a common leg 10 and, in parallel, the core legs 11 and 17, upon which legs is mounted the secondary winding 14 of the relay, and which secondary winding comprises two coils 14a and 14b disposed respectively on legs 11 and 17 of core 7 and connected in series in such manner that any electromotive forces induced therein are additive. The leakage magnetic circuit of the relay comprises the common leg 10 and, in parallel, the core legs 8 and 9, upon which legs is mounted, respectively, the opposing coils 16a and 16b connected in series

in such manner that any electromotive forces induced therein are additive. The two coils 14a and 14b of output winding 14 are connected in series with each other and with two coils 16a and 16b disposed on the leakage magnetic circuit of the relay in such manner that the electromotive force induced in coils 14a and 14b opposes the electromotive force induced in coils 16a and 16b, the parts preferably being so proportioned that the resultant of the electromotive forces normally induced in winding 14 and in coils 16a and 16b is substantially zero. The control winding 15 of relay DR3 comprises, in addition to the two coils 15a and 15b disposed on legs 8 and 9 of the leakage magnetic circuit, two other coils 15c and 15d disposed respectively on legs 11 and 17 of the core, the other two coils 15c and 15d being connected in series with each other and in series with the first two coils 15a and 15b so that the resultant electromotive force normally induced in winding 15 is substantially zero. The arrangement of the pairs of coils 15a and 15b disposed on the leakage magnetic circuit, and of the pairs 15c and 15d disposed on the main magnetic circuit, is such that when supplied with unidirectional current, each pair of coils acts cumulatively to circulate a flux around the local magnetic circuit formed by the two parallel core legs and the adjoining top and bottom portions of the core which form a portion of the magnetic circuit upon which that pair of coils is disposed. Relay DR3 (and in like manner relay DR3a also) further is provided with a biasing winding 18 which comprises a pair of coils 18a and 18b connected in series and disposed respectively on legs 8 and 9 of the leakage magnetic circuit, and another pair of coils 18c and 18d connected in series and disposed respectively on legs 11 and 17 of the main magnetic circuit, the two pairs of coils being connected in series across the output terminals of a rectifier R5, which rectifier as shown has its input terminals connected to terminal BX and a midtap of input winding 13 of relay DR3, but which rectifier may if so desired be energized from a separate source of current. The coils forming one pair of coils in the biasing winding 18 are so arranged on one of the magnetic circuits of the relay that when supplied with unidirectional current, the flux created thereby aids the flux created by the pair of coils of the control winding 15 mounted on that circuit, whereas the coils of the other pair of coils of the biasing winding 18 are so arranged on the other magnetic circuit of the relay so that the flux created thereby opposes the flux of the pair of coils of the control winding 15 mounted on the latter circuit. As shown, coils 18a and 18b are arranged on the leakage circuit so as to aid the flux created by coils 15a and 15b of control winding 15, and coils 18c and 18d are so arranged that when energized the flux created thereby opposes the flux created by coils 15c and 15d of control winding 15.

The operation of the saturation relay shown in Fig. 3 is as follows: Winding 13 of the relay is constantly energized by periodically varying current to set up a primary flux in the core 7 of the relay. Biasing winding 18 also is constantly energized to set up a biasing flux in both magnetic circuits of the core. If, now, control winding 15 of the relay is deenergized, the primary flux then divides between the two magnetic circuits of the core to thereby induce electromotive forces in output winding 14 and in coils 16a and 16b. As pointed out hereinbefore, the parts of

the relay are so proportioned and arranged that when the primary flux divides between the two magnetic circuits of the relay, the resultant of the electromotive forces induced in winding 14 and in coils 16a and 16b is substantially zero.

When, however, control winding 15 is energized to thereby set up a flux in both magnetic circuits of the core, the flux set up by winding 15 in the leakage circuit aids the biasing flux set up by its windings 18 in that circuit, and at the same time the flux set up by winding 15 in the main circuit opposes the biasing flux set up in that circuit by winding 18. The parts of the relay are preferably so proportioned and designed that with control winding 15 and biasing winding 18 both energized, the leakage magnetic circuit becomes magnetically saturated in response to the fluxes created by windings 15 and 18, but in the main magnetic circuit, the biasing flux opposes and substantially neutralizes the flux of winding 15. Under the above conditions, therefore, substantially all the primary flux is circulated through the main magnetic circuit of the relay and relatively little primary flux circulates through the leakage circuit, so that a relatively high voltage is induced in secondary winding 14 mounted on the main circuit and a relatively low voltage is induced in coils 16a and 16b mounted on that leakage circuit. The resultant of the electromotive forces induced in winding 14 and in coils 16a and 16b at this time, therefore, is relatively large in magnitude.

From the foregoing, it is apparent that when control winding 15 of relay DR3 is deenergized, the output of secondary winding 14 of the relay is substantially zero, but that when control winding 15 is energized, the output of winding 14 then is at its maximum value. The arrangement and construction of relay DR3 therefore provides a saturation relay having characteristics substantially the same as a tractive armature type relay, in that under one condition of the relay no energy is permitted to flow in a controlled circuit while under another condition of the relay energy is permitted to flow in the circuit.

It should be noted that the above construction provides a saturation relay which is controlled by supplying to its saturation winding a relatively small amount of energy. This reduced saturating energy effects the control of the relay just described by virtue of the fact that a portion of the biasing winding aids the saturation winding to effect the saturation of the leakage path of the relay, and the remainder of the biasing winding opposes the saturation winding to lower the reluctance of the main magnetic path of the relay, thereby causing the primary flux to circulate through that circuit to thereby induce a relatively high electromotive force in the secondary winding of the relay. It is apparent, therefore, that since the saturation of the leakage circuit is effected by flux created in the control winding together with flux created in the biasing winding, the amount of current supplied to the control winding need be only that amount sufficient to supply to the leakage path the differential in flux between that necessary to saturate the leakage path, and the flux already present in the path due to the biasing winding. The amount of current supplied to the control winding to control the output of the relay therefore is materially reduced by the provision of biasing windings on the relay core.

The relays DR3 and DR3a, as shown in Fig. 3, may be employed as code following relays to cas-

cade trackway energy around the cut-section in a track section, and to control the decoding apparatus for the coded track circuit, substantially in the same manner that was described in detail hereinbefore in connection with Figs. 1 and 2. It is believed that the manner in which the relays of Fig. 3 cooperate to improve the operation and efficiency of the decoding apparatus of the coded track circuit will be readily apparent from an inspection of the drawings, together with the foregoing description of the operation of the apparatus of Fig. 2, it being noted that the relays of Fig. 3 prevent distortion of the coded output of the relays substantially in the same manner that such distortion is prevented by the relays of Fig. 2. That is, the output of the relays of Fig. 3 during the "off" period of the code is substantially zero, so that the potential of the impulse induced in the relays of Fig. 3 during the "on" period of the code need not be as great, whereby the operation of the decoding transformer is effected by low peak potential induced in the relays of Fig. 3.

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

Having thus described my invention, what I claim is:

1. In a code following relay of the saturation type, in combination, a magnetizable core provided with a primary winding normally supplied with alternating current, said core also carrying two other windings one of which is a secondary winding inductively coupled with said primary winding and the other of which is a saturation winding normally supplied with coded energy, said saturation winding being effective when energized to vary the inductive coupling of said primary and secondary windings to cause the coded energy supplied to said saturation winding to be reproduced in said secondary winding, and means for preventing distortion in the coded energy reproduced in said secondary winding in response to coded energy in said saturation winding, said means being effective to apply to one of said two other windings an electromotive force which opposes the coded electromotive force present at times in that winding.

2. In a code following relay of the saturation type, the combination of, a magnetizable core provided with a primary winding normally supplied with alternating current, said core also being provided with two other windings one of which is a secondary winding inductively coupled with said primary winding and the other of which is a saturation winding normally supplied with coded energy, said saturation winding being effective when energized to vary the inductive coupling of said primary and said secondary windings to cause the coded energy supplied to said saturation winding to be reproduced in said secondary winding, and means for applying to one of said two other windings an electromotive force which opposes the coded electromotive force present at times in that winding, whereby distortion of the code output of said secondary winding is minimized.

3. In combination, a magnetizable core having two magnetic circuits one of which comprises two parallel paths, a primary winding linking both of said two magnetic circuits, two other windings one of which is a saturation winding comprising

two coils one linking each of the two parallel paths of said one magnetic circuit and connected in series in such manner that the resultant electromotive force normally induced in said saturation winding is substantially zero, the other of said two other windings being a secondary winding disposed on the other of said two magnetic circuits for inductive relationship with said primary winding, means for supplying periodically varying current to said primary winding for setting up a flux in each of said two magnetic circuits, means for at times supplying coded unidirectional current to said saturation winding for varying the reluctance of said one magnetic circuit whereby the flux in said other magnetic circuit is varied in step with the coded current supplied to said saturation winding, and means for applying to one of said two other windings an electromotive force which opposes the electromotive force present at times in that winding whereby distortion is prevented in the coded current induced in said secondary winding in response to the coded current supplied to said saturation winding.

4. In combination, a magnetizable core provided with a primary winding which is constantly supplied with periodically varying current, a secondary winding on said core inductively coupled with said primary winding, a saturation winding on said core effective when energized to vary the inductive coupling of said primary and secondary windings, a source of coded alternating current, means including a rectifier for supplying to said saturation winding impulses of rectified current from said source of coded alternating current, and means for applying to said saturation winding an electromotive force which opposes the electromotive force due to said rectifier to counteract the shunting action of said rectifier whereby distortion is prevented in the coded energy induced in said secondary winding in response to the impulses of rectified current supplied to said saturation winding.

5. In combination, a magnetizable core provided with a primary winding which is constantly supplied with periodically varying current, a secondary winding on said core inductively coupled with said primary winding, a saturation winding on said core effective when energized to vary the inductive coupling of said primary and secondary windings, a resistor, a source of coded alternating current, means including a rectifier connected in series with said resistor for supplying to said saturation winding impulses of rectified current from said source of coded alternating current, and means for impressing across said resistor a voltage which opposes that due to said rectifier to provide a sharp cut-off in the current induced in said secondary winding by the current flowing in said primary winding in response to the impulses of rectified current supplied to said saturation winding.

6. In combination, a magnetizable core having two magnetic circuits one of which comprises two parallel paths, a primary winding linking both of said two magnetic circuits, a secondary winding comprising three coils one disposed on each of said two parallel paths of said one magnetic circuit and the third disposed on the other magnetic circuit, said coils being connected in series in such manner that the resultant electromotive force normally induced in said output winding when said primary winding is supplied with alternating current is substantially zero, a saturation winding comprising two coils one disposed

on each of said two parallel paths of said one magnetic circuit and connected in series in such manner that when supplied with unidirectional current the coils act cumulatively to circulate a flux through said two parallel paths of said one magnetic circuit, means for supplying alternating current to said primary winding, and means for at times supplying unidirectional current to said saturation winding, whereby the reluctance of said one magnetic circuit is at times varied to vary the resultant electromotive force induced in said secondary winding.

7. A relay of the saturation type comprising, in combination, a magnetizable core having two magnetic circuits, a primary winding linking both said circuits and normally supplied with alternating current for setting up a primary flux in said core, a biasing winding having a portion disposed on each circuit, said biasing winding normally being supplied with unidirectional current for establishing a given condition of reluctance in each circuit, a secondary winding having a portion disposed on each circuit, said portions being connected in series in such manner that the resultant of the electromotive forces induced in said secondary winding under the given condition of reluctance of said circuits is substantially zero, a saturation winding having a portion disposed on each circuit one portion of which is effective when supplied with unidirectional current to increase the reluctance of one circuit and the other portion of which is effective when supplied with said unidirectional current to decrease the reluctance of the other circuit, and means for at times supplying unidirectional current to said saturation winding whereby the resultant of the electromotive forces induced in said secondary winding by said primary flux is relatively large in magnitude.

8. A relay of the saturation type comprising, in combination, a magnetizable core having two magnetic circuits, a primary winding linking both said circuits and normally supplied with alternating current for setting up a primary flux in said core, a biasing winding having a portion disposed on each circuit, said biasing winding normally being supplied with unidirectional current for establishing a given condition of reluctance in each circuit, a secondary winding having a portion disposed on each circuit, said portions being connected in series in such manner that the resultant of the electromotive forces induced in said secondary winding under the given condition of reluctance of said circuits is substantially zero, a saturation winding having a portion disposed on each circuit in such manner that when said saturation winding is supplied with unidirectional current the resultant of the electromotive forces induced in said secondary winding becomes relatively large in magnitude, and means for at times supplying said saturation winding with unidirectional current.

9. A relay of the saturation type comprising, in combination, a magnetizable core having two magnetic circuits each having two parallel paths, a primary winding linking both of said magnetic circuits, said primary winding normally being supplied with periodically varying current for setting up a primary flux in each of said magnetic circuits, a secondary winding comprising four coils one disposed on each of the parallel paths of said two magnetic circuits, said four coils being connected in series in such manner that the electromotive forces normally induced in the pair of coils disposed on each of said mag-

netic circuits are additive and the resultant of the electromotive forces normally induced in both pairs of coils when said primary flux circulates through both said magnetic circuits is substantially zero, a biasing winding comprising four coils one disposed on each of the parallel paths of said two magnetic circuits, said four coils of the biasing winding being connected in series in such manner that the resultant of the electromotive forces normally induced in the pair of coils disposed on each of said magnetic circuits is substantially zero, said biasing winding normally being supplied with unidirectional current for setting up a biasing flux in each of said two magnetic circuits whereby the primary flux normally is circulated through both said two magnetic circuits, a saturation winding comprising four coils one disposed on each of the parallel paths of said two magnetic circuits, said four coils of the saturation winding being connected in series in such manner that the resultant of the electromotive forces normally induced in the pair of coils disposed on each magnetic circuit is substantially zero, one pair of coils of the saturation winding being arranged on one magnetic circuit in such manner that when supplied with unidirectional current the flux created thereby aids the flux supplied to that circuit by said biasing winding whereby the reluctance of that circuit is increased, the other pair of coils of the saturation winding being arranged on the other magnetic circuit in such manner that when supplied with said unidirectional current the flux created thereby opposes the flux supplied to said other circuit by said biasing winding whereby the reluctance of said other circuit is decreased and substantially all the primary flux circulates through said other path and the resultant of the electromotive forces induced in said secondary winding becomes relatively high in magnitude, and means for at times supplying unidirectional current to said saturation winding.

10. In combination, a five-legged magnetizable core having two magnetic circuits both including in common a central leg of said core, each said circuit also including two other legs of said core in parallel, a primary winding disposed on said common central leg of said core and constantly supplied with periodically varying current for setting up a primary flux in each of said two magnetic circuits, a secondary winding comprising two pairs of coils one pair of which is disposed one coil on each of the two parallel legs of one of said magnetic circuits and the other pair of which is disposed one coil on each of the two parallel legs of the other of said magnetic circuits, the coils of each pair being connected in series in such manner that the electromotive forces induced therein are additive and said pairs of coils being connected in series in such manner that the resultant electromotive force normally induced in said secondary winding is substantially zero, a biasing winding constantly supplied with unidirectional current and comprising two pairs of coils one pair of which is disposed one coil on each of the two parallel legs of said one magnetic circuit and the other pair of which is disposed one coil on each of the two parallel legs of said other magnetic circuit, said coils of the biasing winding being connected in series in such manner that when supplied with unidirectional current the coils of each pair act cumulatively to circulate a biasing flux through a local magnetic circuit comprising the two parallel legs of the associated magnetic circuit of the core upon

which that pair of coils is disposed, a saturation winding comprising two pairs of coils one pair of which is disposed one coil on each of the two parallel legs of said one magnetic circuit and the other pair of which is disposed one coil on each of the two parallel legs of said other magnetic circuit, said coils of said saturation winding being connected in series in such manner that when supplied with unidirectional current the coils of one pair of coils act cumulatively to circulate a saturating flux through the local magnetic circuit of the associated magnetic circuit of the core in agreement with the biasing flux of that local circuit, whereby that local magnetic circuit is substantially magnetically saturated, and the coils of the other pair of coils of the saturation winding act cumulatively to circulate a saturating flux through the local magnetic circuit of the associated magnetic circuit of the core in opposition to the biasing flux of that local circuit, whereby the biasing and saturating fluxes of the last mentioned local circuit substantially cancel each other, and means for at times supplying unidirectional current to said saturation winding to thereby vary the resultant electromotive force induced in said secondary winding of said relay.

11. In combination, a section of railway track, means for supplying coded alternating trackway energy to the rails of said section, a relay transformer having its primary receiving energy from the rails of said section, a track relay of the saturation type comprising a magnetizable core provided with a primary winding constantly connected with a source of alternating current, said relay having two other windings disposed on said core one winding of which is a secondary winding inductively coupled with said primary winding and the other winding of which is a saturation winding receiving energy from the secondary of said relay transformer, said saturation winding being effective when energized to vary the inductive coupling of said primary and secondary windings of said relay to cause the coded energy supplied to the saturation winding to be reproduced in said secondary winding, said relay also having means to apply to one of said two other windings an electromotive force which opposes the electromotive force present at times in that winding to thereby prevent distortion in the coded output of said track relay, and a signal for governing traffic in said section controlled by the coded output of said track relay.

12. In combination, a section of railway track, means for supplying coded trackway energy to the rails of said section, a track relay of the saturation type comprising a magnetizable core provided with a primary winding constantly supplied with alternating current, said relay having two other windings disposed on said core one winding of which is a secondary winding inductively coupled with said primary winding and the other winding of which is a saturation winding effective when energized to vary the inductive coupling of said primary and secondary windings, means for supplying unidirectional current from the rails of said section to said saturation winding to cause said relay to reproduce in said secondary winding the coded trackway energy supplied to the rails of said section, said relay also having means to apply to one of said two other windings of the relay an electromotive force which opposes the electromotive force present at times in that winding whereby distortion is prevented in the coded energy reproduced in the secondary winding of said relay, and

a signal governing traffic in said section controlled by the coded energy reproduced in the secondary winding of said relay.

13. Decoding apparatus for coded track circuits comprising a track relay of the saturation type having a magnetizable core provided with a primary winding which is constantly supplied with periodically varying current for setting up a flux in said core, two other windings on said core one of which is a secondary winding inductively coupled with said primary winding and the other of which is a saturation winding receiving energy from the track rails, said saturation winding being effective when energized to vary the inductive coupling of said primary and secondary windings whereby current is induced in said secondary winding in step with the coded energy supplied to the track rails, means for applying to one of said two other windings an electromotive force which opposes the electromotive force present at times in that winding to thereby prevent distortion of the coded current induced in said secondary winding in response to the coded energy supplied said saturation winding, a decoding transformer supplied with current from said secondary winding, and signal control means receiving energy from said transformer.

14. In combination, a section of railway track, means for supplying coded alternating trackway energy of a given code rate to the rails of said section, a relay transformer having its primary winding receiving energy from the rails of said section, a code following relay of the saturation type having a primary winding constantly supplied with current from a source of alternating current, said relay having a secondary winding inductively coupled with said primary winding, said relay also having a saturation winding effective when energized for varying the inductive coupling of said primary and secondary windings, a resistor, circuit means including a rectifier connected in series with said resistor for supplying impulses of rectified current to said saturation winding from said relay transformer whereby when coded current is supplied to the track rails there will be induced in the secondary winding of said relay pulses of alternating current having a rate corresponding to the code rate, means for impressing across said resistor a biasing voltage which opposes the voltage of said rectifier to provide a sharp cut-off in the current induced in said secondary winding, and traffic controlling apparatus controlled by the alternating current which is induced in said secondary winding in step with the impulses of rectified current supplied to said saturation winding.

15. In combination with a section of railway track having means for supplying to the track rails of said section trackway energy coded at a first rate under certain conditions and at a second rate under other conditions, a code following relay of the saturation type comprising a magnetizable core having a primary winding constantly supplied with alternating current and a secondary winding inductively coupled with said primary winding, said relay also having a saturation winding disposed on said core effective when supplied with unidirectional current to vary the inductive coupling of said primary and secondary windings, means for supplying unidirectional current to said saturation winding from the track rails of said section whereby pulses of energy are reproduced in the secondary winding of the relay having a rate which corresponds to

the rate at which the trackway energy is coded, means for applying to said saturation winding an electromotive force which opposes the electromotive force supplied to that winding from the track rails of the section to cause a sharp cut-off in the coded energy reproduced in the secondary winding of the relay, and a signal governing traffic in said section and selectively controlled by the energy reproduced in said relay in accordance with the rate at which such energy is coded.

16. In combination with a section of railway track having means for supplying to the rails of the section alternating trackway energy coded at a first rate under certain conditions and at a second rate under other conditions, a code following relay of the saturation type comprising a magnetizable core having a primary winding constantly connected with alternating current and a secondary winding inductively coupled with said primary winding, said relay also having mounted on said core a saturation winding effective when supplied with unidirectional current to vary the inductive coupling of said primary and secondary windings, means including a rectifier for supplying unidirectional current from the track rails to said saturation winding whereby energy is reproduced in the secondary winding of the relay coded in accordance with the rate at which the trackway energy then is coded, means for supplying to said saturation winding an electromotive force which opposes the electromotive force of said rectifier whereby the shunting action of said rectifier is minimized to cause a sharp cut-off in the coded energy reproduced in the secondary winding of the relay, and a signal governing traffic in said section and selectively controlled by the energy reproduced in said relay in accordance with the rate at which such energy is coded.

17. In combination with a section of railway track having means for supplying to the rails of the section alternating trackway energy coded at a first rate under certain conditions and at a second rate under other conditions, a track relay of the saturation type comprising a magnetizable core having a primary winding constantly connected with alternating current and a secondary winding inductively coupled with said primary winding, said relay also having mounted on said core a saturation winding effective when supplied with unidirectional current to vary the inductive coupling of said primary and secondary windings, a resistor, a first rectifier receiving energy from the track rails of said section, said saturation winding being connected in series with said resistor across the output terminals of said first rectifier whereby unidirectional current is supplied to said saturation winding to cause the energy induced in the secondary winding of the relay to be coded in accordance with the rate at which the trackway energy is coded, a second rectifier connected across said resistor and arranged in such manner that its electromotive force opposes the electromotive force of said first rectifier whereby the shunting action of said first rectifier is minimized to cause a sharp cut-off in the coded energy reproduced in the secondary winding of the relay, and a signal governing traffic in said section and selectively controlled by the energy reproduced in said relay in accordance with the rate at which such energy is coded.

18. In combination with a stretch of railway track having means for supplying coded track-

way energy to the rails of the section, a code following relay, said relay having a five-legged magnetizable core provided with two magnetic circuits having a central leg of the core in common and each circuit having two other legs of the core in parallel, said relay having a primary winding disposed on said central leg and constantly supplied with alternating current for setting up a primary flux in both said magnetic circuits, said relay having a biasing winding constantly supplied with unidirectional current and comprising two pairs of coils one pair disposed one coil on each of the two parallel legs of one of said magnetic circuits and the other pair disposed one coil on each of the two parallel legs of said other magnetic circuit, said coils of said biasing winding being connected in series in such manner that the coils of each pair of coils act cumulatively to circulate a biasing flux through the two parallel legs of the associated magnetic circuit, said relay also having a secondary winding comprising two pairs of coils one pair of which is disposed one coil on each of the two parallel paths of said one magnetic circuit and the other pair being disposed one coil on each of the two parallel paths of said other magnetic circuit, said coils of said secondary winding being connected in series in such manner that the voltages induced in each coil of a pair are additive and the resultant of the voltages normally induced in both pairs of coils is substantially zero, said relay having a saturation winding receiving energy from the rails of said section and comprising two pairs of coils one pair of which is disposed one coil on each of the two parallel legs of said one magnetic circuit and the other pair is disposed one coil on each of the two parallel legs of said other magnetic circuit and said coils of said saturation winding being connected in series in such manner that one pair of coils acts cumulatively to circulate a saturating flux through its two associated parallel legs of the core in agreement with the biasing flux and the other pair of coils acts cumulatively to circulate a saturating flux through its two associated parallel legs of the core in opposition to said biasing flux, whereby the reluctances of said two magnetic circuits of said core are varied in such manner that impulses of relatively large resultant electromotive force are induced in said secondary winding of the relay having a rate corresponding to the rate of the coded energy supplied to the rails of the section, and a signal for governing traffic in said section controlled by the impulses of relatively large electromotive force induced in said secondary winding of the relay.

19. In combination with a section of railway track divided into adjoining advance and rear subsections, means for supplying coded trackway energy to the rails of said advance subsection, a code following relay of the saturation type having a magnetizable core provided with a primary winding constantly supplied with alternating current, said relay having two other windings disposed on said core one of which is a secondary winding inductively coupled with said primary winding and the other of which is a saturation winding effective when supplied with current for varying the inductive coupling of said primary and secondary windings of the relay, means for connecting said secondary winding across the track rails of said rear subsection, means for supplying current from the track rails of said advance subsection to said saturation winding whereby impulses of relatively large electromo-

tive force having a rate which corresponds to the rate of the trackway energy supplied to the rails of said advance subsection are caused to be induced in said secondary winding and are supplied to the track rails of said rear subsection, and means for applying to one of said two other windings of said relay an electromotive force which opposes the electromotive force present at times in that winding to thereby prevent distortion in the impulses of trackway energy supplied to the rails of said rear subsection.

20. In combination with a section of railway track divided into adjoining advance and rear subsections, means for supplying coded alternating trackway energy to the rails of said advance subsection, a code following relay of the saturation type having a magnetizable core provided with a primary winding constantly supplied with alternating current, said relay having a secondary winding disposed on said core in inductive relationship with said primary winding, said secondary winding being connected across the track rails of said rear subsection, said relay having a saturation winding disposed on said core and effective when supplied with unidirectional current to vary the inductive coupling of said primary and secondary windings of the relay, means including a rectifier for supplying unidirectional current from the rails of said advance subsection to said saturation winding to cause impulses of current of relatively high magnitude having a rate which corresponds to the rate of the trackway energy supplied to said advance subsection to be induced in said secondary winding of the relay and to be supplied to the rails of said rear subsection, and means for applying to said saturation winding an electromotive force which opposes the electromotive force due to said rectifier whereby the shunting action of said rectifier is minimized to prevent distortion in the impulses of trackway energy supplied to said rear subsection.

21. A relay of the saturation type comprising two magnetic paths both having a common portion linked by an input winding normally supplied with alternating current, an output winding comprising two portions one disposed on each of said two magnetic paths and connected in series and proportioned in such manner that the voltages induced therein in response to the primary flux set up in said paths by said input winding oppose and substantially cancel each other, another winding linking at least one of said two paths, and means for at times supplying to said other winding unidirectional current for varying the relative reluctances of said two paths whereby to shunt the primary flux created by said input winding away from said one path and cause a resultant voltage of relatively large magnitude to be induced in said output winding.

22. A relay of the saturation type characterized by the fact that the output thereof varies between a predetermined maximum value and a substantially zero minimum value, comprising the combination with a magnetizable core having two magnetic circuits provided with a common primary winding normally supplied with alternating current for setting up a primary flux in both of said two circuits, of two windings a first of which has two portions one disposed on each of said two circuits and the second winding of which is disposed on at least a particular one of said two circuits, means for supplying unidirectional current to said first wind-

ing for establishing a given condition of relative reluctance in said two circuits, other means for supplying unidirectional current to said second winding of a polarity such that said particular one circuit is supplied with flux which opposes the flux supplied thereto by said first winding whereby the relative reluctances of said two circuits is modified and the primary flux is shunted away from the other of said two circuits, an output winding disposed on at least one of said magnetic circuits, and means for controlling the supply of unidirectional current to at least one of said two windings whereby to control the magnitude of electromotive force induced in said output winding in accordance with the supply of current to said one winding.

23. A relay of the saturation type characterized by the fact that the output thereof varies between a predetermined maximum value and a substantially zero minimum value, comprising the combination with a magnetizable core having two magnetic circuits both including a common portion linked by a common primary winding normally supplied with alternating current for setting up a primary flux in both of said two circuits, of a first winding having two portions one disposed on each of said two circuits, means for supplying unidirectional current to said first winding for setting up a given condition of relative reluctances in said two circuits, other means including a second winding disposed on a particular one of said circuits and supplied with unidirectional current for supplying said one circuit with flux which opposes the flux set up by said first winding whereby the relative condition of reluctances is modified and the primary flux is shunted away from the other of said magnetic circuits, and an output winding disposed on at least one of said magnetic circuits for inductively receiving electromotive forces from said primary winding under the control of the supply of energy to said first winding.

24. In combination, a five-legged magnetizable core having two magnetic circuits both including in common a central leg of said core and each of said circuits also including two other legs of said core in parallel, a primary winding disposed on said common central leg of said core and constantly supplied with periodically varying current for setting up a primary flux in both of said two circuits, two windings a first of which comprises two pairs of coils one pair for each of said two circuits and each pair disposed one coil on each of the two parallel legs of its associated circuit and the second winding of which comprises at least one pair of coils disposed one coil on each of the two parallel legs of a particular one of said circuits, the two coils comprising each pair of coils of said two windings being arranged on the two parallel legs of its associated circuit in such manner that when supplied with unidirectional current both coils cooperate in circulating a flux through a closed magnetic circuit including in series the two parallel legs of its associated circuit, means for supplying unidirectional current to said first winding for establishing a given condition of relative reluctance in said two circuits, other means for supplying unidirectional current to said second winding of a polarity such that said particular one circuit is supplied with flux which opposes the flux supplied thereto by said first winding whereby the relative reluctances of said two circuits are modified and the primary flux is shunted away from the other of

said two circuits, an output winding comprising at least one pair of coils disposed one coil on each of the two parallel legs of one of said two circuits, said pair of coils of said output winding
5 being connected in series in such manner that electromotive forces induced therein due to said primary flux are additive, and means for con-

trolling the supply of unidirectional current to at least one of said two windings whereby to control the magnitude of the resultant electromotive force induced in said output winding in accordance with the supply of current to said one
winding. 5

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