July 24, 1962 C. E. STAPLES 3,046,454

CODE DETECTING APPARATUS

Filed Nov. 14, 1957

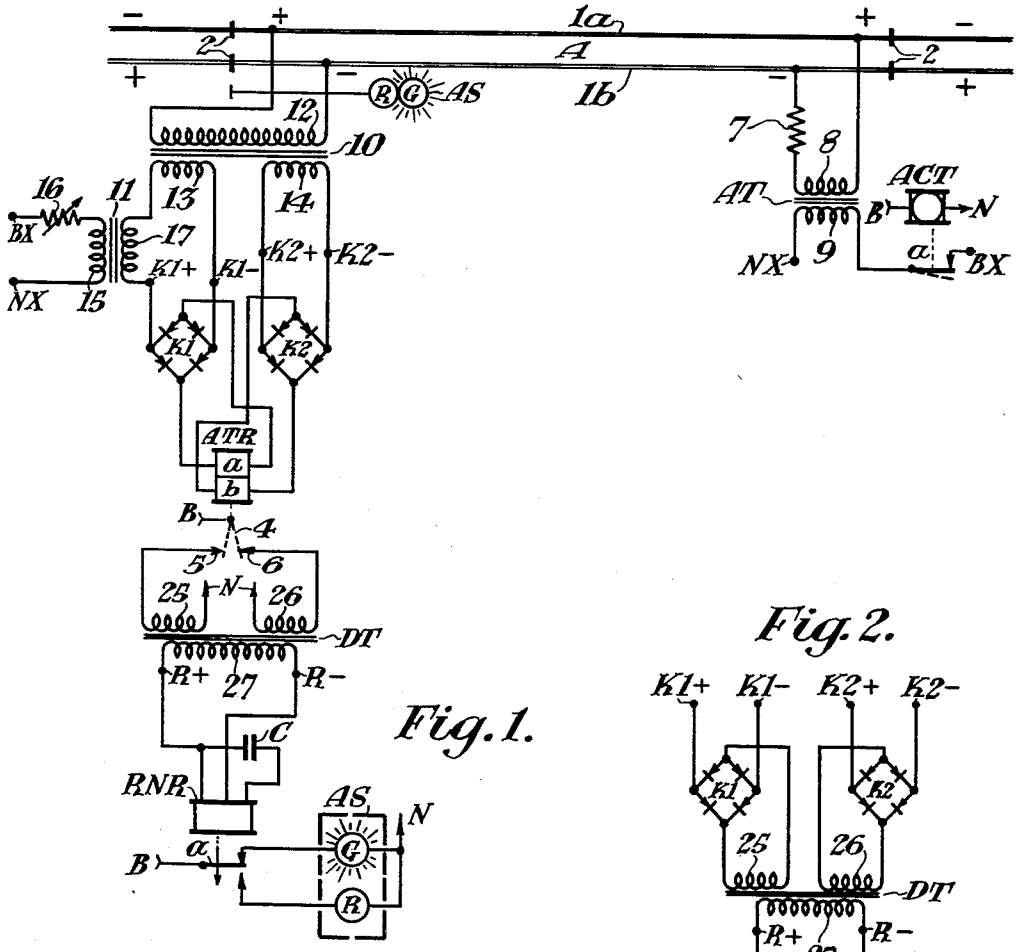


Fig. 1.

Fig. 2.

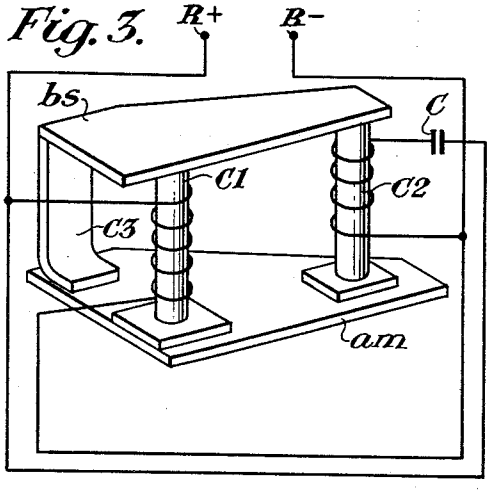


Fig. 3.

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CODE DETECTING APPARATUS

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9 Claims. (Cl. 317—134)

My invention relates to code detecting apparatus for use in connection with railway signaling systems.

One object of my invention is to provide simplified means for detecting the code following operation of a code following relay.

Another object of my invention is to provide improved code detecting means which will not be improperly energized in the event the contacts of a code following relay overlap.

A third object of my invention is to provide code detecting means for use in conjunction with the phase sensitive alternating current track circuit apparatus shown and described in my copending application Serial No. 611,330, filed September 21, 1956, now Patent No. 2,884,516, and which will eliminate the need for a code following relay.

In accordance with my invention I provide a relay of the retained-neutral type which is energized, through the means of a decoding transformer, by coded energy generated by a contact of a code following relay or received from the rails of a railway track through the phase sensitive apparatus shown in my said copending application.

Other objects and characteristic features of my invention will become apparent as the description proceeds.

I shall describe several embodiments of my invention, and shall then point out the novel features thereof in claims.

In the accompanying drawings,

FIG. 1 is a diagrammatic view of code detecting apparatus embodying my invention.

FIG. 2 is a diagrammatic view showing a modification of the apparatus shown in FIG. 1.

FIG. 3 is a schematic view illustrating the construction of one form of relay suitable for use in apparatus embodying my invention.

In each of the different views similar reference characters are used to designate similar parts.

Referring to FIG. 1, I have here shown a section of railway track designated by the reference character A, and comprising track rails designated by the reference characters 1*a* and 1*b*. The track section A is separated from adjoining track sections by insulated rail joints 2 in the usual and well known manner.

Traffic normally moves through the track section in a direction from west to east, or left to right, as viewed in FIG. 1, and the movement of traffic into the track section is controlled by a signal, here designated by the reference character AS, and located adjacent the entrance end of the track section. The signal is shown to be of the color light type although any of the well known types of railway signals may be used. The signal is provided with a red or stop lamp R and a green or proceed lamp G.

The track section A is provided with a track relay designated by the reference character ATR located adjacent the entrance end of the section. This track relay, as illustrated in FIG. 1, is a code following relay of the magnetic stick type, and is shown as having two windings *a* and *b*, or the relay may be provided with a single winding having a center tap.

Track relay ATR is connected to the rails of track section A through phase sensitive apparatus. This apparatus is identical to that described in my previously mentioned copending application, Serial No. 611,330, and only a brief description sufficient to an understanding of my present invention will, therefore, be given here. As here

shown, the windings *a* and *b* of relay ATR are connected to the D.C. terminals of full wave rectifiers, K1 and K2, respectively. One of the A.C. terminals, designated K1—, of rectifier K1, is connected to one side of the secondary winding 13 of a transformer 10. The other A.C. terminal, designated K1+, of rectifier K1 is connected to one end of the secondary winding 17 of a second transformer 11. The other ends of the secondary windings 13 and 17 are connected together.

One of the terminals, designated K2+, of rectifier K2 is connected to one end of the second secondary winding, 14 of transformer 10; and the other terminal, designated K2—, of rectifier K2 is connected to the other end of secondary winding 14.

The primary winding 12 of transformer 10 is connected to the rails of track section A, and the primary winding 15 of transformer 11 is connected to a source of alternating current energy, the terminals of which are designated BX and NX, through a phase displacement means 16.

At the exit end of track section A, rail 1*a* is connected to one end of a secondary winding 8 of a transformer designated by the reference character AT. Rail 1*b* is connected to the other end of secondary winding 8 through a current limiting device, here shown as a resistance and designated by the reference character 7. This resistance limits the flow of current through the transformer when the rails of the track section are shunted. One end of the primary winding 9 of the transformer AT is connected, through a contact *a* of a coding device, here shown as a relay designated by the reference character ACT, to the terminal BX of the source of alternating current energy. The other end of winding 9 of transformer AT is connected to terminal NX of the source. This arrangement causes the track section A to be supplied with alternating current energy which is periodically interrupted at a suitable code rate to cause the code following track relay ATR at the entrance end of the section to operate.

It is to be understood that the track sections to the left and right of track section A are furnished with apparatus similar to that shown for track section A, but the coded currents furnished to the rails of those sections are of opposite relative polarity to that of the rails of section A as shown in FIG. 1 of the drawings.

It is to be further understood that a common source of alternating current energy is used for both ends of track section A as well as for the track sections to the left and right of track section A so that phase relations can be established.

To prevent the track relay ATR from being operated due to current flowing across defective insulated joints separating track section A from the adjoining track section to the left of track section A, the phase sensitive apparatus described above and which, as stated, is identical to that shown and described in my said copending application, Serial No. 611,330 is interposed between the track relay ATR and the track rails. This arrangement provides means for comparing the relative polarity of the current received at the entrance end of the track section with current having a predetermined relative polarity as described below.

The pulses of alternating current energy being supplied to the rails at the exit end of the track section, as previously set forth, cause pulses of energy to be supplied to the primary winding 12 of transformer 10 located at the entrance end of the track section. During the "on" period of the pulses, energy is induced in the secondary windings 13 and 14 of transformer 10. The phase displacement means 16 is so adjusted that the energy induced in the secondary winding 13 and that induced in secondary winding 17 of transformer 11 are slubstantially 180 degrees out of phase, that is to say, the two voltages induced in the secondary windings 13 and 17 oppose each other so

that the resultant voltage is substantially zero. Therefore, during the "on" period of track circuit energy, energy is supplied to winding *b* only of track relay ATR and the contact 4 of the relay is operated to its right-hand position. During the "off" period of the track circuit energy no energy is induced in either secondary windings 13 or 14 of transformer 10 and the energy induced in the secondary winding 17 of transformer 11 causes energy to be supplied to winding *a* of track relay ATR and contact 4 of that relay is operated to its left-hand position. It is thus apparent that relay ATR "follows" the pulses of energy being supplied to the rails of track section A.

When a train enters track section A and shunts the code pulses being supplied to the rails, no energy is supplied to the primary winding 12 of transformer 10 and the energy being induced in secondary 17 of transformer 11 causes contact 4 of relay ATR to be operated to its left-hand position and remain there.

In the event that the insulated joints 2 between track section A and the next track section to the left, become defective while a train occupies track section A, pulses of alternating current energy may be supplied to the primary winding 12 of transformer 10 from the track circuit energy being supplied to the rails of said next track section to the left. However, as previously stated this energy is of the opposite relative polarity to that being supplied to the rails of track section A, and the energy being induced in the secondary windings 13 and 14 of transformer 10 will also be of the opposite relative polarity to that normally induced therein. The pulses induced in secondary winding 13 of transformer 10 and secondary winding 17 of transformer 11 are now "in phase" and, during the "on" period of the pulses, combine to produce a resultant voltage greater than that induced in secondary winding 14 of transformer 10. The energy being supplied to winding *a* of relay ATR is, therefore, greater than that being supplied to winding *b*, and contact 4 of relay ATR will remain in its left hand position. Likewise, during the off period of the coded track pulse, the energy being supplied to winding *a* of relay ATR from transformer 11 will hold contact 4 of relay ATR in its lefthand position, there being no energy induced in the secondary winding 14 of transformer 10 at this time.

The movable contact member 4 of relay ATR cooperates with two fixed contact members 5 and 6 to complete a contact 4—5 or 4—6 according as the contact member 4 occupies its left hand or right hand position, respectively.

These contacts of relay ATR control a code detecting device, here shown as a relay designated by the reference character RNR by means of a transformer designated by the reference character DT. This transformer is preferably, but not necessarily, of a type wound on a core of a material having a substantially rectangular hysteresis characteristic, and has two primary windings designated by the reference characters 25 and 26, and a secondary winding, designated by the reference character 27.

Relay RNR is of the retained-neutral type which includes means for delaying the decay of flux when energy supplied to its windings is pole-changed. This relay is here shown as a double wound relay having a phase displacement means or device for relaying the decay of flux through its cores during periods of pole-changing. This phase displacement means or device is here shown as a capacitor *c* interposed in the circuit for one of the windings of relay RNR.

A contact *a* of relay RNR controls signal AS so that the green or proceed lamp is illuminated when the armature of the relay is picked up and the red or stop lamp is illuminated when the armature of relay RNR is released.

It is to be understood that any type of retained-neutral relay using a flux decay delaying means for retaining the armature of the relay picked up during periods of pole-changing may be used for relay RNR. One such relay is shown in FIG. 3 of the drawings. Referring to FIG. 3, this relay comprises two main cores designated *c*1 and *c*2 and an auxiliary core designated *c*3. The cores *c*1 and *c*2 are provided with windings connected in multiple. All three cores are joined by a common back strap designated *bs* and the three cores are so arranged that any of them can exert a magnetic attraction force upon the armature designated *am*. Complete details of the relay are not shown, but it is to be understood that when the armature is in its picked up position, as shown in FIG. 3, one or more movable contact members attached to the armature cooperate with one or more fixed contact members to close one or more front contacts. Likewise when the armature is in its released position the movable contact members become disengaged from the fixed front contact member to open the front contacts and engage fixed back contact members to close the back contacts. As shown in FIG. 1, relay RNR is provided with one such movable contact member *a* which cooperate with fixed front and back contact members to close a front contact or a back contact according as the armature of the relay is picked up or released.

The relay as shown in FIG. 3 is in the energized position, and the terminals R+ and R— are assumed to be connected to a source of current, R+ to the positive terminal and R— to the negative terminal of the source, through a pole-changing circuit controller. At this time capacitor *c* is fully charged and, therefore, no current flows through the winding of core *c*2. However, current is flowing through the winding of core *c*1 producing a magnetizing force to hold armature *am* in a picked up position. This magnetizing force produces a flux in core *c*1 which passes in an upward direction through core *c*1, through the back strap *bs*, downward through both cores *c*2 and *c*3 and through the armature *am* to the lower end of core *c*1.

I will now assume that the pole-changing circuit controller is operated so that the terminal R+ becomes connected to the negative terminal of the current source and terminal R— to the positive terminal of the source. During the time the pole-changing circuit controller is transferring its contacts, the circuit to the windings of the relay is open. The magnetizing force in core *c*1, produced by the winding on core *c*1, immediately drops to zero. A magnetizing force is produced in both cores *c*1 and *c*2, however, due to the energy stored in capacitor *c* flowing through the windings of cores *c*1 and *c*2. This magnetizing force causes a decaying flux in core *c*1 in an upward direction and in core *c*2 in a downward direction. Due to the balanced condition of these magnetizing forces, no flux passes through core *c*3 at this time. The armature *am* is retained in a picked up position by the magnetizing force produced in cores *c*1 and *c*2.

When the pole-changing circuit controller has completed the transfer of its contacts so that terminals R+ and R— are connected to the negative and positive terminals, respectively, of the current source, the magnetizing force in core *c*2 is momentarily continued by the current flowing from the current source through the winding of that core until capacitor *c* is fully charged. At the same time the current supplied to the winding of core *c*1 from the current source opposes that being received by that winding from the capacitor *c* and the magnetizing force in core *c*1 drops to zero. Flux at this time passes in a downward direction through core *c*2, through the armature *am* to the lower end of core *c*3 and upward through core *c*3. The armature is retained in a picked up position by the magnetizing force produced in core *c*2.

When current begins to flow from the current source through terminal R— and the winding of core *c*1 a magnetizing force is again produced in core *c*1. Flux is now produced in a downward direction through core

c1. This flux passes through the armature *am* and, if at this time the magnetizing force in core *c1* produced by its winding is equal to the magnetizing force in core *c2* produced by its winding, a balanced condition again exists and the flux passes upward through core *c3*. As the capacitor *c* becomes charged a progressive unbalanced condition takes place and the flux passing downward through core *c1* eventually passes substantially equally upward through both cores *c2* and *c3*. This occurs when capacitor *c* is fully charged and current no longer flows in the winding of core *c2*. Armature *am* is now retained in a picked up position by the magnetizing force in core *c1*.

When the pole-changing circuit controller is operated to its original position, the armature *am* will again be retained in a picked up position in the manner just described, except all flux directions will be reverse to those just described. It is thus apparent that a relay of the type shown in FIG. 3 is a retained-neutral type relay, the armature of which is retained in a picked-up position during polarity reversals of current through its windings.

It should be pointed out at this time that a suitable source of direct current is provided for operation of apparatus other than the track circuit apparatus, this source being preferably a battery of proper voltage and capacity. For sake of simplicity this power source is not shown in the drawings, its positive and negative terminals being identified by the conventional reference characters B and N, respectively.

In explaining the operation of the apparatus as a whole, I will assume that all apparatus is in its normal condition as shown in FIG. 1 of the drawings, that is, code transmitter ACT is supplying coded energy to track section A at the exit end of that track section, and track relay ATR at the entrance end of the section is following the code being received from the rails of track section A.

Since relay ATR is following code, its movable contact member **4** is alternately establishing electrical contact with contacts **5** and **6**, and primary windings **25** and **26**, respectively, of transformer DT are alternately being energized in opposite directions. The energizing circuit for winding **25** may be traced from battery terminal B through contact **4** of relay ATR (assuming contact **4** to be in its left hand position), contact **5** of relay ATR, left hand terminal of primary winding **25** of transformer DT, and right hand terminal of primary winding **25** to battery terminal N. The energizing circuit for winding **26** may be traced from battery terminal B through contact **4** of relay ATR (assuming contact **4** to now be in its right hand position), contact **6** of relay ATR, right hand terminal of primary winding **26** of transformer DT, and left hand terminal of primary winding **26** to battery terminal. It is thus apparent that primary windings **25** and **26** of transformer DT are alternately being energized in opposite directions by the code following action of track relay ATR.

The alternate energization of the primary windings of transformer DT in opposite directions will induce in the secondary **27** of transformer DT an alternating current of a low frequency, the frequency corresponding to the code following action of relay ATR and its movable contact member **4**. This low frequency alternating current is substantially the same as would be produced by exceedingly rapid operations of a pole-changing device and, as shown in FIG. 1, the left and right hand sides of the secondary winding **27** of transformer DT are connected to terminals R+ and R—, respectively, of relay RNR. These terminals represent the identical terminals R+ and R— shown in FIG. 3. The capacitor *c* shown in FIG. 1, is also identical to the capacitor *c* shown in FIG. 3.

When current induced in the secondary winding **27** of transformer DT flows in the direction from right to left positive energy is supplied to terminal R+ and negative energy to terminal R—. A circuit is thus completed for energizing relay RNR which may be traced from terminal R+ through the left hand winding of relay RNR to the terminal R—. Simultaneously a circuit is completed to the capacitor *c* which may be traced from terminal R+ to the left hand terminal of capacitor *c*, right hand terminal of capacitor *c*, and the right hand winding of relay RNR to terminal R—. The armature of relay RNR is thus picked up. When the current induced in secondary **27** of transformer DT flows in the direction from left to right current flows through the circuits just described in the reverse direction and relay RNR is again energized. During the period of the current reversal the armature of relay RNR is retained in the picked up position in the manner set forth in the description relating to FIG. 3.

The armature of relay RNR being in a picked up position, a circuit is completed for causing signal AS to display a green aspect. This circuit may be traced in FIG. 1 from battery terminal B through front contact *a* of relay RNR, and the filament of the green lamp to battery terminal N. Signal AS thus displays a green or proceed aspect indicating that it is safe for a train to proceed past the signal.

I will now assume that, due to a train occupying track section A and shunting the track circuit, the coded alternating current being supplied to track section A at the exit end thereof is not being received at the entrance end. This will cause relay ATR to stop following code and its contact **4** will remain in the reverse position in which it engages contact **5**. When contact **4** is steadily closed against contact **5** primary winding **25** of transformer DT will be steadily energized by current from the battery through the circuit previously traced. No current will be induced in secondary winding **27** of transformer DT at this time, as is readily apparent, and as soon as the energy stored in capacitor *c* has been dissipated through the relay winding, the armature of relay RNR will release. The release of the armature of relay RNR will cause front contact *a* of that relay to open and back contact *a* to close. The previously described energizing circuit to the green lamp of signal AS is thus opened and a circuit is established for energization of the red lamp. This circuit may be traced from battery terminal B through back contact *a* of relay RNR, and the filament of the red lamp, to battery terminal N. The red lamp of signal AS is thus illuminated to display a stop indication and to indicate to a train approaching the signal from the west that a condition of danger exists. Upon the train vacating track section A coded energy will again be received at the location of signal AS, relay ATR will again follow the code, the armature of relay RNR will pick up, and the described red signal lamp circuit will be opened and the green signal lamp circuit will be closed. All apparatus will thus be returned to its normal condition.

In FIG. 2 of the drawings there is shown a modification of the apparatus shown in FIG. 1 in which the code following track relay ATR is eliminated. This is accomplished by connecting the direct current terminals of rectifiers K1 and K2 to the primary windings **25** and **26**, respectively, of transformer DT, rather than to the windings *a* and *b*, respectively, of track relay ATR. By this arrangement the pulses of alternating current energy supplied from transformers **10** and **11** shown in FIG. 1 are rectified and used to induce current in the secondary winding **27** of transformer DT rather than using a contact of the code following relay ATR to induce said current as in FIG. 1. The arrangement of the remaining apparatus of FIG. 2 is identical to that of FIG. 1, and it operates in the same manner as that previously described for FIG. 1. A detail description of the operation of relay RNR and the lighting circuit for signal AS is, therefore, not necessary in connection with FIG. 2.

I have previously stated that transformer DT is prefer-

ably of a type wound on a core of a material having a substantially rectangular hysteresis characteristic. This type of transformer is preferred in order to obtain additional safety by determining that correct coding action is taking place or that the circuits are intact. For example, if contact 4 of relay ATR in FIG. 1 is not alternately making contact with contacts 5 and 6, relay RNR should release. Also, in both FIGS. 1 and 2, if the circuit to one of the primary windings 25 or 26 of transformer DT is inadvertently open, relay RNR should release. This desired operation is obtained by the use of the described type of transformer. Due to the said rectangular hysteresis characteristic, when the core of such a transformer is magnetized and substantially saturated in a given direction by a current of a certain relative polarity flowing in a primary winding of the transformer, the core remains substantially saturated in said given direction, due to residual magnetism, until the primary current flow is changed in direction. This current flow change must be made in order to produce any sizeable output from the secondary of the transformer. Therefore, if improper coding action is taking place or if the circuit to one of the primary windings of transformer DT is open, the primary current flow cannot be changed in direction, no sizeable secondary output is produced and the armature of relay RNR will release. Thus, by the use of this type of transformer for transformer DT, it can be insured that correct coding action is taking place and that the circuits to the primaries of the transformer are intact. The use of another type of transformer is possible but a certain margin of safety would be sacrificed since the armature of relay RNR may remain picked up if any of the above mentioned faults occur.

By using a transformer comprising a core of a material having a substantially square hysteresis characteristic, it is possible to provide a selective code detecting arrangement. For this purpose it is necessary to so proportion the core and primary and secondary circuit means of the transformer, that the output of energy from the secondary circuit means of the transformer will be at a substantially continuous minimum value only when the primary circuit means of the transformer is provided with alternate pulses of energy of opposite polarity at a predetermined minimum rate of speed or code rate. The parts of the transformer are further so proportioned, that the core of the transformer closely approaches but does not attain its saturation point when energy of one polarity is supplied to the primary circuit means for the duration of one of said pulses of energy of a predetermined code rate. If the parts of the transformer are so proportioned, and its primary circuit means is supplied with pulses of energy at a lower speed code rate than the predetermined code rate, the core of the transformer will become saturated at some point within the duration of each pulse and no energy will be induced in the secondary winding of the transformer for the remainder of the duration of the energy pulse, that is, during the latter portion of the pulse when the core of the transformer is saturated.

As an example, I will assume that the predetermined code rate at which the apparatus is to operate is 180 pulses per minute or 3 pulses per second of energy of any one polarity. At this code rate pulses of energy of approximately 0.167 second's duration are supplied to the primary circuit means of the transformer. As stated, this duration of pulse causes the core of the transformer to closely approach but not attain its saturation point. An output of energy is therefore induced in the secondary circuit means of the transformer during the entire duration of each of the energy pulses of 0.167 second's duration. The polarity of the next pulse of energy supplied to the primary circuit means of the transformer is in the reverse direction to that of the former pulse and also of approximately 0.167 second's duration, and an output of energy is again induced in the secondary circuit means of the transformer during the entire duration of the energy pulse. It is thus apparent that a substantially continuous output of energy is induced in the secondary circuit means of said transformer when pulses of energy are supplied to the primary circuit means of said transformer at the 180 code rate.

I will now assume that pulses of energy at a rate of 75 pulses per minute or approximately 1.25 pulses per second, of energy of any one polarity are supplied to the primary circuit means of the transformer. Each of these pulses are of approximately 0.4 second's duration. The core of the transformer becomes saturated in an extremely slight period of time over 0.167 second and, therefore, it is apparent that the core of the transformer is saturated during a single pulse at the 75 code rate (for a period of 0.4 second minus 0.167 second or approximately 0.233 second) and no energy is induced in the secondary of the transformer for that period of time.

It is believed to be readily apparent that, if code detecting relay RNR is used in combination with a transformer as described above, and is so proportioned in conjunction with the secondary winding of said transformer that its armature will be retained in the picked up position during the period of time necessary to pole-change the control circuit of the relay, but for a period of time somewhat less than 0.233 second, the relay will be code selective as between the 180 and 75 code rates. Similarly, if the relay is so proportioned in conjunction with the secondary winding of said transformer that its armature will be retained in the picked up position during the period of time necessary to pole-change the control circuit of the relay, but for a period of time somewhat less than 0.083 second, the relay will be code selective as between the 180, and the 120 and 75 code rates. It is to be understood that a certain margin must be provided in the timing periods set forth above in order to allow for a limited amount of variation in the operation of the circuits, and that the above described arrangement is set forth merely as an example.

From the foregoing description it is apparent that, with the arrangement of apparatus of my invention as shown in FIG. 1 of the drawings of this application, simplified means for detecting the code following operation of a code following relay are provided without sacrificing any of the safety features provided by other means. With the arrangement of apparatus of my invention as shown in FIG. 2 of the drawings, a code detecting means is provided without the use of a code following relay. Also, with the arrangement of apparatus as shown in either FIGS. 1 or 2, a new and simplified form of code selective apparatus can be provided by proportioning the parts of the apparatus in the proper manner.

While I have shown and described two forms of apparatus embodying my invention, it should be 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. A code detecting means including, in combination; a transformer comprising a core of a material having a substantially rectangular hysteresis characteristic, and primary circuit means and secondary circuit means; a retained-neutral code detecting relay comprising two cores provided with windings connected to said secondary circuit means of said transformer, an auxiliary core and an armature arranged in a magnetically attractable relationship with said cores; and means provided for one winding of said relay for delaying the decay of the flux through the cores of said relay so that said armature of said relay is picked up and retained picked up when and only when the primary circuit means of said transformer is alternately energized by pulses of energy of opposite relative polarity at a predetermined code rate.

2. A code detecting means including, in combination; a transformer comprising a core of a material having a substantially rectangular hysteresis characteristic, first and

second primary circuit means and secondary circuit means; a retained-neutral code detecting relay comprising two cores provided with windings connected to said secondary circuit means of said transformer, an auxiliary core, and an armature arranged in a magnetically attractable relationship with said cores; and means provided for one winding of said relay for delaying the decay of flux through the cores of said relay so that the armature of said relay is picked up and retained picked up when and only when the first and second primary circuit means of said transformer are alternately energized by pulses of energy of opposite polarity at a predetermined code rate.

3. A code detecting means including, in combination, a transformer having a core of a material having a substantially rectangular hysteresis characteristic, and having first and second primary windings and a secondary winding; and a retained-neutral relay having a first winding provided with phase displacement means, and a second winding, said windings being so connected to said secondary winding of said transformer that the armature of said relay is picked up and retained picked up when and only when said primary windings of said transformer are alternately energized each by opposite relative polarity to the other by pulses of direct current energy.

4. A code detecting means including, in combination, a transformer comprising a core of a material having a substantially rectangular hysteresis characteristic, and first and second primary windings and a secondary winding; and a retained-neutral code detecting relay provided with a means for delaying the decay of flux through the cores of the relay and so connected to said secondary winding of said transformer that the armature of said relay is picked up and retained picked up when and only when said primary windings of said transformer are alternately energized each by opposite relative polarity to the other by pulses of direct current energy.

5. A code detecting means including, in combination, a transformer comprising a core of a material having a substantially rectangular hysteresis characteristic, and first and second primary windings and a secondary winding; and a retained-neutral code detecting relay provided with a means for delaying decay of flux through its cores and so connected to said secondary winding of said transformer that the armature of said relay is picked up and retained picked up when and only when said primary windings of said transformer are alternately energized by pulses of direct current energy of opposite relative polarity.

6. A code detecting means including, in combination, a transformer comprising a core of a material having a substantially rectangular hysteresis characteristic, and primary and secondary circuit means, a retained-neutral code detecting relay having two windings connected to said secondary circuit means of said transformer, and means provided for one winding of said relay for delaying the decay of flux through the cores of the relay so that the armature of said relay is picked up and retained picked up when and only when said primary circuit means of said transformer are alternately energized by pulses of current of opposite relative polarity at a certain predetermined code rate.

7. A code detecting means including, in combination, a transformer comprising a core of a material having a substantially rectangular hysteresis characteristic, and first and second primary windings and a secondary winding; a phase displacement device having first and second terminals; and a retained-neutral code detecting relay having first and second windings each having first and second terminals, said first terminals of said windings being connected to a first terminal of said secondary winding of said transformer, said second terminal of said second winding being connected to said first terminal of said phase displacement device and a second terminal of said secondary winding of said transformer, and said second terminal of said first winding being connected to said second terminal of said phase displacement device.

8. A code detecting means including, in combination, a code following relay; a transformer comprising a core of a material having a substantially rectangular hysteresis chracteristic, first and second primary circuit means and secondry circuit means; a retained-neutral code detecting relay having two windings connected to said secondary circuit means of said transformer, means provided for one winding of said relay for delaying the decay of flux through the cores of the relay; and circuit means including a contact of said code following relay so arranged that said first primary circuit means of said transformer are energized by a direct current of a certain polarity when the amature of said code following relay is controlled to its normal position, and said second primary circuit means of said transformer are energized, when the armature of said code following relay is controlled to its reverse position, by a direct current of the polarity opposite to that with which said first primary circuit means are energized when the armature of said code following relay occupies its normal position.

9. A code detecting means including, in combination, a transformer comprising a core of a material having a substantially rectangular hysteresis characteristic, and first and second primary circuit means and a secondary circuit means; a capacitor having first and second terminals; and a retained-neutral code detecting relay having first and second windings each having first and second terminals, said first terminals of said windings being connected to a first terminal of said secondary circuit means of said transformer, said second terminal of said second winding being connected to said first terminal of said capacitor and a second terminal of said secondary circuit means of said transformer, and said second terminal of said first winding being connected to said second terminal of said capacitor.

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