

Nov. 7, 1944.

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2,362,419

CODED FEED BACK CIRCUIT FOR RAILWAY TRAFFIC CONTROL

Filed Sept. 23, 1942

3 Sheets-Sheet 1

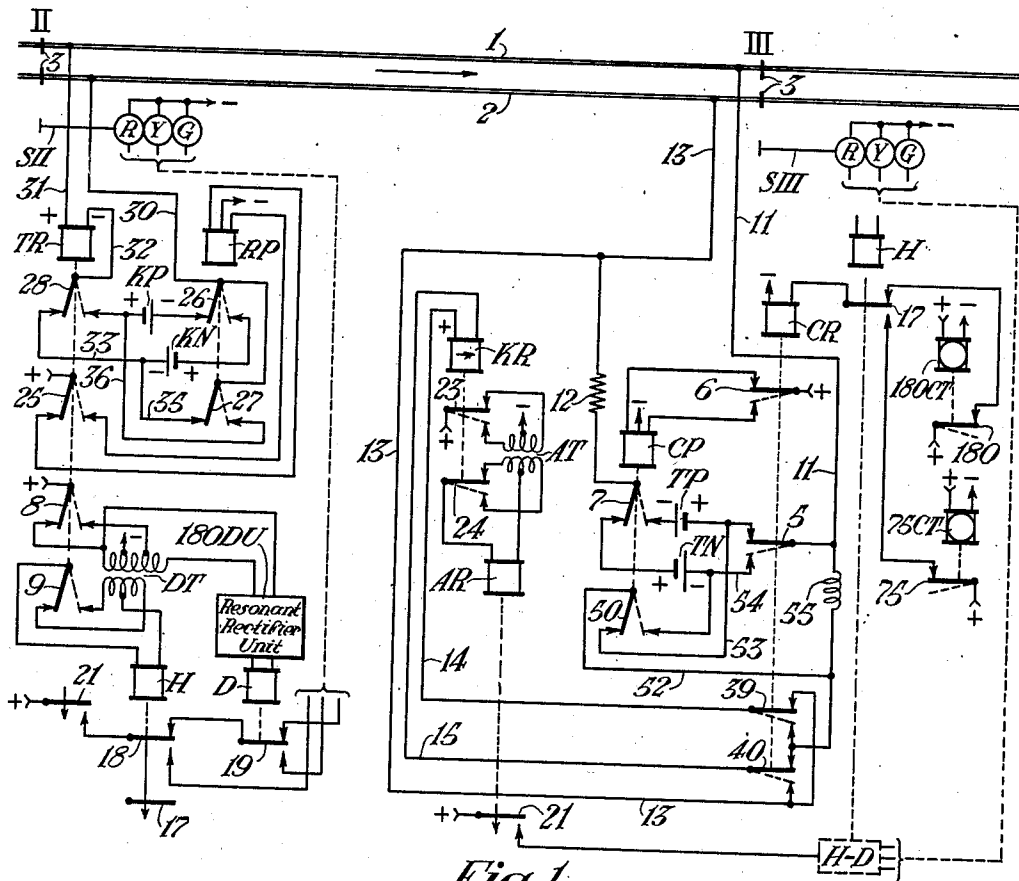


Fig.1.

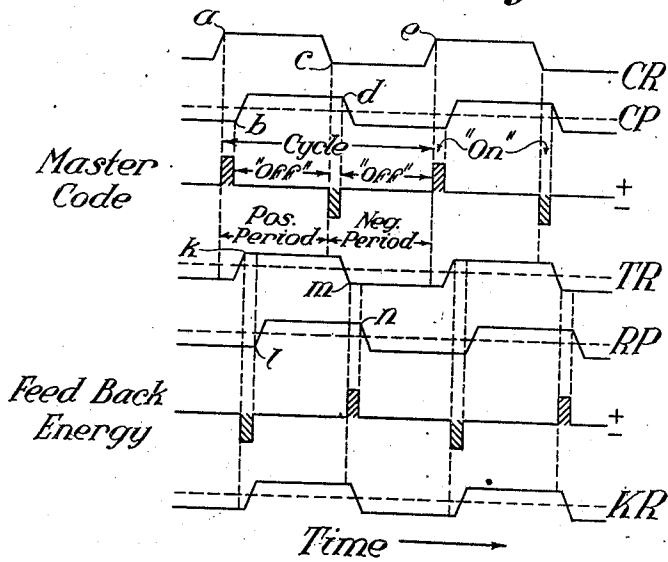


Fig. 2.

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3 Sheets-Sheet 2

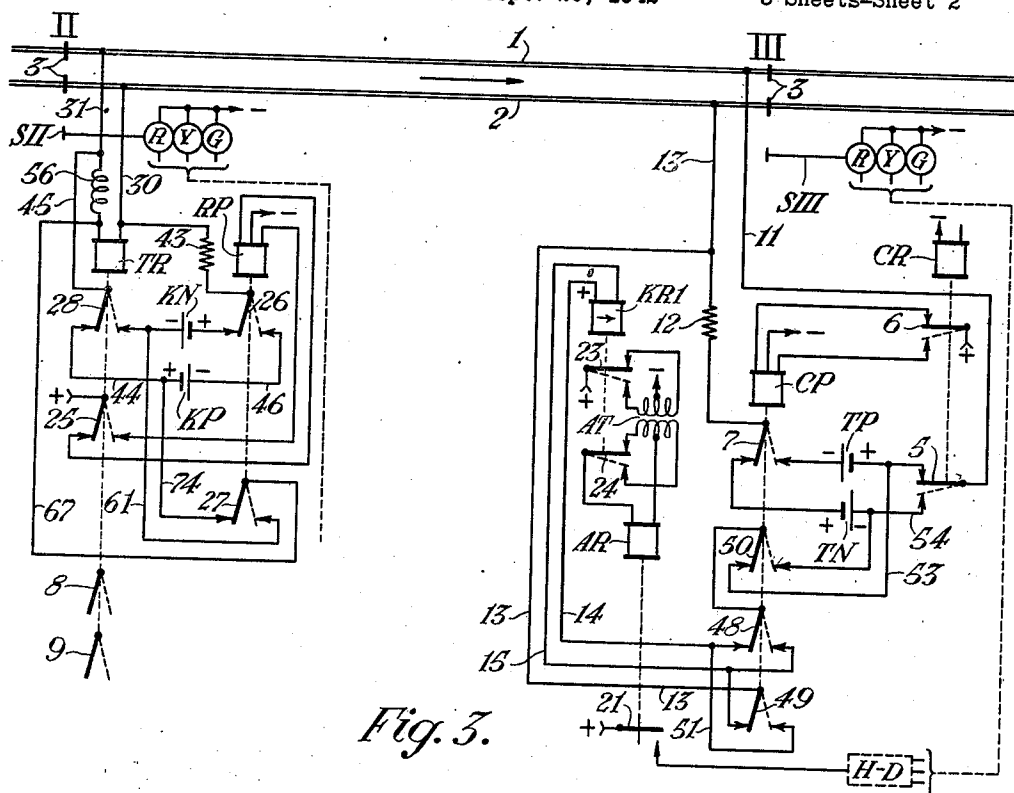


Fig. 3.

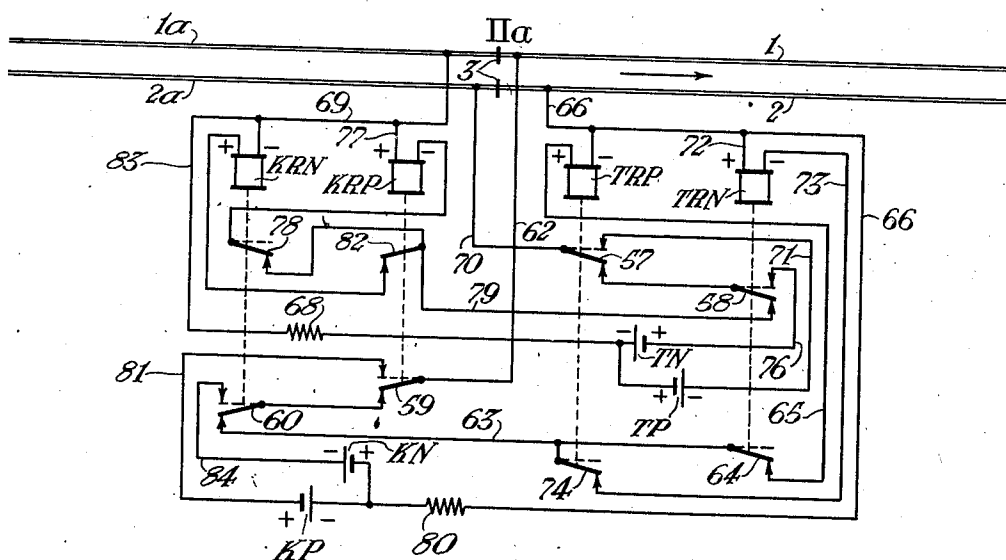


Fig. 4.

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3 Sheets-Sheet 3

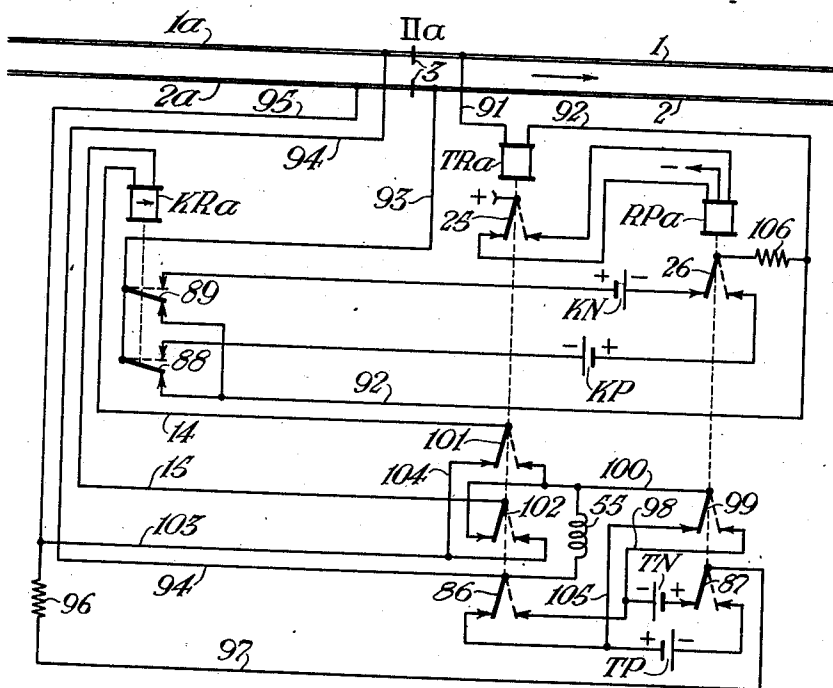


Fig. 5.

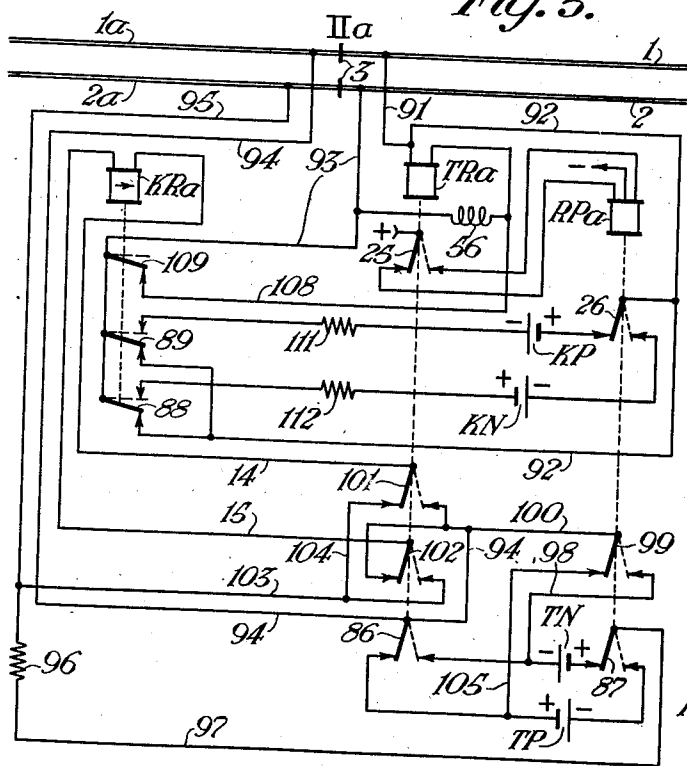


Fig. 6.

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2,362,419

CODED FEED-BACK CIRCUITS FOR
RAILWAY TRAFFIC CONTROL

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Application September 23, 1942, Serial No. 459,348

12 Claims. (Cl. 246—38)

My invention relates to coded control circuits for use in systems of railway signaling and it has special reference to the employment by such circuits of the "coded feed back" operating principle that first was disclosed by Frank H. Nicholson, United States Patent No. 2,021,944 (issued November 26, 1935), and that also is shown by numerous later patents and applications of common ownership herewith.

Generally stated, the object of my invention is to increase the utility and broaden the range of application of "coded feed back" control circuits of both the track and the line type.

A more specific object is to impart to the "feed back" portions of such circuits the "master code" operating advantages that are inherent in control circuits of the "polar impulse" type which my United States Patent No. 2,282,099, dated May 5, 1942, discloses and claims.

Another object is to render both the feed back and the master code relays of such circuits highly immune to false operation by "foreign current" that may be present in the circuit conductors.

Another object is to eliminate operating difficulties due to persistence of "storage energy" and/or generation of "kick back" energy in the conductors following each pulse of both master code and feed back energy that is supplied thereto.

A further object is to provide improved facilities for impressing the pulse feed back energy upon the circuit conductors and for receiving that energy from those conductors.

A still further object is to organize the improved facilities in such manner that the resulting "coded feed back" control circuits are readily usable in signaling systems of the "frequency code" and other types of commercially proven practicability.

In practicing my invention, I attain the above and other objects and advantages by: (1) employing recurring pulses of "master code" energy that have positive and negative polarities in alternating sequence and that are of relatively short individual duration; and (2) by utilizing intervening pulses of "feed back" energy that also have positive and negative polarities in alternating sequence and that also are of short individual duration.

I shall describe several forms of "coded feed back" control circuits which embody my invention, and shall then point out the novel features thereof in claims. These illustrative embodiments are disclosed in the accompanying drawings in which:

Fig. 1 is a diagrammatic representation of a track type of control circuit that incorporates the improvements of my invention and that is organized to form part of an automatic block signaling system having "coded feed back" approach lighting control;

Fig. 2 shows the "master" and "feed back" codes for the circuit of Fig. 1 and indicates the manner in which those codes are produced by joint operation of the circuit relays;

Fig. 3 illustrates modified entrance end apparatus and modified exit end apparatus for the track circuit of Fig. 1; and

Figs. 4, 5 and 6 show apparatus suitable for repeating both the "master" and the "feed back" energy pulses around the insulated joints of a cut section.

In the several views of the drawings, like reference characters designate corresponding parts. Referring first to Fig. 1, the improved control circuit organization of my invention is there disclosed in association with a coded track circuit system of automatic block signaling for a railway track 1—2 over which it will be assumed that traffic moves in the single direction indicated by the arrow, or from left to right in the diagram. The protected stretch of this track is divided into the customary successive sections by insulated rail joints 3 and the rails of each section form part of a track type of control circuit which normally is capable of transmitting energy between its two ends but which at times is rendered incapable of such transmission.

The "polar impulse" frequency code track circuit of Fig. 1

In this view of Fig. 1, reference characters II and III respectively designate the entrance and the exit ends of one of these track sections. This particular section is illustratively shown as being a full signal block in length and its entrance end is guarded by the usual wayside signal SII.

Control of this signal is effected through the medium of "polar impulse" code facilities which duplicate those shown in Fig. 3 of my issued United States Patent No. 2,282,099 earlier referred to.

At the exit location III those facilities utilize a source of positive polarity energy TP and a source of negative polarity energy TN; a coding relay CR having a contact 5 which repeatedly picks up and releases for the purpose of connecting in recurring code pulse manner the section rails first with the positive source TP and then with the negative source TN; a repeater relay

CP energized over a contact 6 of device CR and having a contact 7 which shortens the pulses of both positive and negative energy that are impressed upon the section rails; a pair of code transmitters 180CT and 75CT having contacts 180 and 75 which respectively operate at the rates of 180 and 75 times per minute; and a code detecting relay H having a contact 17 which when picked up assigns the driving circuit of coder relay CR to transmitter contact 180 and which when released transfers the driving circuit to transmitter contact 75.

At the entrance location II the "polar impulse" facilities utilize a track relay TR of the "polar stick" code following type which has its winding connected across the rails and which holds its contacts to the left during each positive polarity pulse of winding received energy and to the right during each negative polarity pulse of the received energy; a decoding transformer DT which receives primary current under the control of a pole changing contact 8 of the track relay; a code detecting relay H which is of the direct current delayed release type and which is energized from the decoding transformer secondary over a rectifying contact 9 of the track relay; a code distinguishing relay D which is energized from transformer DT through a frequency selective unit 180DU and which picks up only when relay TR follows the 180 or high speed code; and contacts 18—19 through which decoding relays H—D select the indication that is displayed by wayside signal SII.

In the form shown, this signal is of the well-known color light type. Its "clear" lamp G is lighted when the relays H—D are both picked up; its "approach" lamp Y is lighted when relay H is picked up at a time that relay D is released; and its "stop" lamp R is lighted whenever relay H is released.

In the "polar impulse" track circuit combination of Fig. 1, the earlier described exit end or location III apparatus operates in the following manner. With the track section in advance of location III vacant, contact 17 of relay H assigns coding relay CR's driving circuit to transmitter contact 180 and thus causes the relay's contacts 5—6 to operate at the high speed or 180 code rate.

Each pick-up or front closure of contact 5 produces a "positive" period in the "master code" energy pattern that is represented in Fig. 2. During the continuance of the energy pulse which defines that period, the positive source TP maintains rail 1 positive with respect to rail 2. This is done over a connection extending from the positive terminal of source TP through front contact 5 of device CR, conductor 11, the track rails 1 and 2, conductor 13, a current limiting impedance 12, and contact 7 of device CP in its right or "reverse" position (shown dotted) back to the negative terminal of source TP.

Upon each release of the coding contact 5 there is produced a "negative" period in the master code energy pattern of Fig. 2. During the continuance of the energy pulse which defines that period the negative source TN maintains rail 2 positive with respect to rail 1. This is done over a connection that extends from the positive terminal of source TN through contact 7 of relay TP in its left or "normal" position (shown in full lines), impedance 12, conductor 13, track rails 2 and 1, conductor 11, and back contact 5 of device CR back to the negative terminal of source TN.

As the specification of my issued United States Patent No. 2,282,099 more fully explains, the repeater relay CP is a code following device of the "polar stick" or magnetically toggled type. Flow of energy over device CR's front contact 6 through the left portion of relay CP's winding moves contact 7 to the left or normal position, while flow of energy over CR's back contact 6 through the right portion of the relay CP's winding shifts contact 7 to the right or reverse position. Once, moreover, contact 7 reaches either of these two positions, it there remains continuously until the winding of relay CR receives energy of the opposing polarity.

As my issued United States Patent No. 2,282,099 further explains: (1) each back contact closure by coder relay CR thus causes the repeater device CP to shift its contact 7 from the left or normal to the right or reverse position; and (2) each front contact closure by device CR thus causes relay CP to shift contact 7 from its right or reverse position back to the left or normal position. Each of these shifts is accompanied by a short delay during which each of the rail supply circuits earlier traced is completed. In consequence, the recurring pulses of positive polarity energy supplied from source TP are rendered much shorter than the recurring code periods which those pulses define and the intervening pulses of negative polarity energy from source TN likewise are rendered much shorter than the intervening code periods which those pulses define.

This will become more apparent upon reference to Fig. 2 wherein: (1) the elevated portions of the "CR" pattern designate picked up conditions of contacts 5—6, while the depressed portions of the same pattern designate released conditions of those contacts; and (2) the elevated portions of the "CP" pattern designate a normal or left closure of contact 7, while the depressed portions of that pattern designate a reverse or right closure of the same contact.

If, for example, contacts 5—6 of device CR reach their picked up position at point a, then the repeater relay contact 7 will begin moving from its right to its left position at the slightly later point b. Likewise, if contacts 5—6 reach their released position at point c, then repeater relay contact 7 will begin movement from its left to its right position at the slightly later point d.

Each of the positive pulses of master code energy supplied from source TP will, therefore, be of the relatively short duration designated at a—b in Fig. 2, and each of the negative pulses supplied from trackway source TN will have a corresponding shortness designated by c—d in Fig. 2. As compared with the total length a—c and c—e of the "positive" and "negative" code periods which the just named pulses respectively define, the duration of rail energy application will be seen to be relatively short.

In being transmitted over the section rails to entrance location II, each positive polarity pulse of master code energy causes the track relay TR to move its contacts to the left or "normal" position and each negative polarity energy pulse causes the relay to shift the contacts to the right or "reverse" position. Each of these shifts takes place rapidly and requires only a short application of energy to the relay winding.

This action is shown by the "TR" portion of Fig. 2. There the elevated portions of the pattern designate left or normal closures of the track relay contacts, while the depressed por-

tions of the pattern designate right or reverse contact closures. From Fig. 2 it will be seen that operation of the track relay TR is exactly the same as were each of the positive pulses of master code energy to be prolonged for the full duration of the "positive" code periods and each of the negative pulses to be prolonged for the full duration of the "negative" code periods.

In the entrance end organization shown, such a code following operation by the track relay TR causes the detector relay H to hold its contacts continuously picked up regardless of whether that operation be at the high speed or 180 code rate or at the low speed or 75 code rate. In either event, the winding of relay H receives (from source terminals "plus" and "minus" and through transformer DT) code frequency pulses of energizing current which hold contacts 17—18 picked up.

In the case of code distinguishing relay D, however, pick-up occurs only when the track relay TR follows code at the 180 or high speed rate. And finally, stoppage of relay TR's code following operation causes relays H and D both to release.

From the foregoing description of the "polar impulse" coded track circuit apparatus of Fig. 1, it is apparent that a three indication automatic block signaling system may be provided by equipping each of a plurality of consecutive track sections with this Fig. 1 apparatus and arranging that the entrance end relay H of each section determine (by means of contact 17 as shown at location III) the rate of pulse recurrence of the polarized "master code" energy that is supplied to the exit end of the rear adjoining section.

Each train passing through such a signaled stretch of track sets up its own following protection in the three indication automatic block manner which my issued United States Patent No. 2,282,099 explains in detail.

Approach control apparatus of Fig. 1

Coded track circuits of the "polar impulse" type just described provide a most desirable form of block signal control and when organized into a complete "frequency code" system, they offer a number of important advantages. As the specification of my United States Patent No. 2,082,099 more fully sets forth, these include a lowering of the power requirements of the track circuits, a raising of the immunity to false operation by foreign currents, an elimination of operating difficulties due to storage energy persistence, a lowering of code distortion effects, and an improvement in shunting sensitivity. All of these advantages are, of course, in addition to the obvious elimination of all signal control line wires.

In many instances it is further desirable to approach energize the wayside signals SII, SIII, etc., and certain other traffic governing devices of the complete system. To meet this need, I have evolved the non-line-wire approach control combination which in one preferred form is further shown by the diagram of Fig. 1.

This combination utilizes the "coded feed back" operating principle of the earlier named Nicholson United States Patent No. 2,021,944, and the Fig. 1 form thereof requires that the "polar impulse" track circuit combination earlier described be supplemented by certain apparatus which will now be named.

At Fig. 1's exit location III, this supplemental apparatus includes: (1) an approach relay AR having a contact 21 which keeps wayside signal

SIII deenergized at all times except when a train approaches the signal location over the rails of section II—III; (2) a detector relay KR which controls the energization of relay AR through the medium of contacts 23—24 and an interposed transformer AT; and (3) circuits over which the winding of relay KR is connected in energy receiving relation with the section rails 1—2 during the "off" portions of the master code's positive and negative periods.

At Fig. 1's entrance location II, the supplemental apparatus includes: (1) a source of positive polarity "feed back" energy KP and a source of negative polarity "feed back" energy KN; (2) a repeater device RP for track relay TR which is energized over that relay's contact 25; and (3) circuits including contacts 26—27 of device RP and contact 28 of device TR over which sources KP and KN are selectively connected with the section rails 1—2 during the "off" portions of the master code positive and negative periods.

Entrance end relay RP has response characteristics similar to those earlier explained for the exit end repeater CP. Flow of current over device TR's left or "normal" contact 25 through the left portion of relay RP's winding causes contacts 26—27 to move to their left or normal position. Similarly, flow of current over relay TR's right or "reverse" contact 25 through the right portion of relay RP's winding causes contacts 26—27 to shift to their right or reverse position.

For a purpose later to be made evident, each such shift is accompanied by a short period of response delay. During this delay, one or the other of the "feed back" sources KP—KN is connected with the section rails and as a result those rails are supplied with intervening pulses of "feed back" energy that have positive and negative polarities in alternating sequence and that are of short individual duration.

The character of these "feed back" energy pulses will best be understood upon reference to Fig. 2. From that figure it will be seen that each positive pulse of "master code" energy is followed by a negative pulse of "feed back" energy and that each negative pulse of "master code" energy is followed by a positive pulse of "feed back" energy.

The manner in which these feed back pulses are supplied will now be explained. Under vacant conditions of track section II—III, the track relay TR moves its contacts 25—28 from their left to their right and from their right to their left positions repeatedly and in respective step with the pick-ups and releases of coder relay CR's contacts 5—6 at the section exit. At times this contact movement takes place at the high speed or 180 code rate and at other times at the low speed or 75 code rate.

In either case, each left positioning of relay TR's contacts 25—28 is followed after a brief time interval by a transfer of repeater device RP's contacts 26—27 from their right to their left positions. Similarly, each movement of the track relay TR's contacts 25—28 to their right positioning is followed after a brief interval by a transfer of repeater device RP's contacts 26—27 from their left position to their right position.

Again referring to Fig. 2, if the track relay contacts reach the left positions at instant *k*, then the repeater relay contacts will leave their right positions at the somewhat later instant *l*;

if the track relay contacts return to their right positions at instant m , then the repeater relay contacts will leave their left positions at the somewhat later instant n ; and so on.

Upon each left positioning of the track relay contacts, the section rails are supplied with a negative polarity pulse of feed back energy. This supply is over a circuit which extends from the positive terminal of feed back source KN through right contact 26 of device RP, conductor 30, track rails 2 and 1, conductor 31, the winding of relay TR, conductor 32, left contact 28 of device TR and conductor 33 back to the negative terminal of source KN.

This negative feed back supply continues for the time (see $k-l$ of Fig. 2) required for the repeater device RP to open its right contact. As shown in Fig. 2, this time is relatively short. The direction of feed back current flow through the winding of track relay TR is, moreover, such as to continue contacts 25—28 in their left positions.

Upon each right positioning of the track relay contacts by a pulse of negative polarity "master code" energy, the track rails are supplied with a positive polarity pulse of "feed back" energy. This supply is over a circuit extending from the positive terminal of source KP through right contact 28 of device TR, conductor 32, the winding of device TR, conductor 31, track rails 1 and 2, conductor 30 and left contact 26 of device RP back to the negative terminal of source KP.

Completion of that circuit continues only for the relatively short time designated at $m-n$ in Fig. 2, and interruption results when repeater relay RP shifts contacts 26—27 away from their left positions. This causes the positive feed back pulse to be of the relatively short duration illustrated. During that pulse, moreover, the flow of feed back current through the winding of track relay TR is in the direction which urges that relay's contacts 25—28 more firmly into their newly established right positions.

In the manner just stated, therefore, each response of the track relay TR to a positive pulse of "master code" energy causes the rails to be supplied with a negative pulse of "feed back" energy, and each response of the track relay to a negative pulse of "master code" energy causes the rails to be supplied with a positive pulse of "feed back" energy.

For assuring proper connection of the track relay with the section rails during each reception of a "master code" energy pulse, use is made of the repeater device RP's second contact 27. Through the medium of this contact and the track relay's contact 28, there is established between conductors 30 and 32 a current path over which the track relay winding is energized by each positive polarity pulse and by each negative polarity pulse of master code current that is received at the entrance location II.

Referring again to Fig. 2, it will be seen: (1) that following each rail-supplied pulse of negative polarity "feed back" energy, contacts 27—28 of relays RP—TR both occupy their left positions; and (2) following each positive pulse of rail supplied "feed back" energy, contacts 27—28 of devices RP—TR both occupy their right positions.

Under the condition first stated, there is completed for the winding of track relay TR a master code energizing path that extends from section rail 2, through conductor 30, left contact 27 of

device RP, conductors 35 and 33, the left contact 28 of device TR, conductor 32, the winding of relay TR and conductor 31 back to section rail 1. It is over this path that a succeeding negative polarity pulse of master code current energizes the track relay TR.

Under the conditions second stated above, there is set up for relay TR a master code energizing path which extends from section rail 1, through conductor 31, the winding of relay TR, conductor 32, right contact 28 of device TR, conductor 36, right contact 27 of repeater RP, and conductor 30 back to rail 2. It is over this path that a succeeding pulse of positive polarity master code current energizes the track relay TR.

Once established, moreover, each of the connections just traced remains intact until the track relay TR shifts its contacts in response to the received master code energy. When that happens, the connection is, of course, broken at contact 28 and the winding of relay TR then becomes momentarily disconnected from the section rails. The track relay energization which preceded that disconnection is, however, sufficient to complete the transfer of contact position and in consequence, relay TR follows code in the same manner as were its circuit conductors 30 and 32 to be continuously joined together.

At the exit end III of the Fig. 1 track section, the just described "feed back" energy pulses are impressed upon the winding of the detector relay KR in a manner which will now be explained.

This detector relay KR is a code following device of the "polar biased" type and it responds as noted below. In the absence of current flow through the relay winding, contacts 23—24 occupy the released position shown dotted; flow of current through the relay winding in the direction of from left to right (see the small arrow) picks contacts 23—24 up to the position shown in full lines; and flow of winding current in the opposite direction of from right to left urges contacts 23—24 downwardly into their released position.

Relay KR's winding is connected with the track rails over conductors 13—14, pole-changing contacts 39—40 of the master coder relay CR, contacts 50 and 5 of devices CP and CR, and conductors 11 and 13. Over this connection each pulse of "feed back" energy that is received from entrance sources KP—KN picks up relay KR's contacts while each pulse of "master code" energy that is supplied from exit sources TP—TN keeps those contacts released.

The stated pick-up of relay KR's contacts is effected by received "feed back" energy of both the positive and the negative polarity. This is due to the pole-changing action of coder relay CR's contacts 39—40. Because of that action all received feed back pulses of either polarity flow current through relay KR's winding in the arrow-indicated direction of from left to right.

Looking first at the "positive" feed back pulses, it has already been seen (from Fig. 2) that each such pulse makes rail 1 positive with respect to rail 2 and is accompanied by a closure of coder relay CR's back contacts plus a closure of repeater relay CP's right or reverse contacts. In appearing between the rails at the exit location III such positive feed back potential thus picks up relay KR over a path extending from rail 1 through conductor 11, device CR's back contact 5, conductor 54, device CP's right contact 50, conductor 52, device CR's back contact 39, conductor 14, the

winding of relay KR, conductor 15, device CR's back contact 40, and conductor 13 back to rail 2.

Looking next at the "negative" feed back pulses, it has already been seen (also from Fig. 2) that each such pulse makes rail 2 positive with respect to rail 1 and is accompanied by a closure of coder relay CR's front contacts plus a closure of repeater relay CP's left or normal contacts. In appearing between the rails at location III such negative feed back potential thus picks up the detector relay KR over a path extending from rail 2 through conductor 13, device CR's front contact 39, conductor 14, the winding of relay KR, conductor 15, device CR's front contact 40, conductor 52, device CP's left contact 50, conductor 53, device CR's front contact 5, and conductor 11 back to rail 1.

As long, therefore, as Fig. 1's track section II—III remains vacant: (1) recurring pulses of positive and negative polarity feed back energy are received from the rails at the location of relay KR; (2) that relay is by each of those pulses caused to pick up its contacts 23—24 and at the end of each of those pulses it is allowed to release those contacts; and (3) in that way the detector relay KR is operated in code following manner by feed back pulses which are transmitted thereto from entrance sources KP—KN.

Nor is this action in any way interfered with by the pulses of "master code" energy with which the rails are supplied by sources TP—TN at the detector relay location. From Fig. 2 it is seen that each of these pulses of master code energy has a polarity which is opposite to that of the feed back pulse which immediately follows it. That is, each positive pulse of feed back energy is immediately preceded by a negative pulse of master code energy while each negative pulse of feed back energy is immediately preceded by a positive pulse of master code energy.

During, therefore, the code periods in which the detector relay KR is picked up by positive feed back energy, the master energy potential earlier impressed thereon is of negative polarity and serves only to urge relay KR's contacts more firmly into their released positions. Likewise, during the code periods in which the detector relay KR is picked up by a negative feed back pulse, the master energy potential earlier impressed thereon is of positive polarity and serves only to urge relay KR's contacts more firmly into their released positions.

The detector relay KR is, accordingly, responsive to and only to feed back energy that is received over the rails from entrance sources KP—KN. Because of its "polar-biased" characteristics, that relay KR cannot be picked up by master code energy which further is impressed thereon by exit sources TP—TN. Under occupied section conditions, therefore, the master code energy which then continues to be impressed on relay KR can never move the contacts of that relay out of their released position.

Code following operation on the part of detector relay KR thus can occur only when Fig. 1's section II—III is vacant. Such operation results in the approach relay AR receiving recurring pulses of energizing current which hold contact 21 continuously picked up. Such approach relay energy is derived from source terminals "plus" and "minus" and is transmitted to the relay winding over pole changing contact 23, the interposed transformer AT, and a rectifying contact 24.

In the event, however, that the detector relay KR's contacts 23—24 remain in one position continuously, energy transmission through transformer AT then ceases and the approach relay AR releases its contact 21. By such release, lighting current is supplied to wayside signal SIII. Optionally, of course, any other function or approach control might be performed by contact 21.

The mode of operation of my improved "coded feed back" approach control facilities will have become more or less apparent from the foregoing description of the entrance and exit end apparatus which the Fig. 1 track circuit utilizes. At all times, the continuously operating coding and repeater devices CR—CP connect the section rails 1 and 2 alternately with the positive and negative exit end sources TP and TN and thereby produce a "master code" having the "polar impulse" character which the upper portion of Fig. 2 shows.

In being received at the section entrance, the energy pulses of this master code operate track relay TR in conventional code following manner. Aided by repeater device RP, that relay alternately connects the section rails 1 and 2 with the negative and the positive polarity sources KN and KP and thereby produces a "feed back" code having the "polar impulse" character that is represented by the lower portion of Fig. 2.

In being received at the exit location III, the energy pulses of this feed back code operate detector relay KR in the code following manner earlier described. As a result of such operation, the approach relay AR holds contact 21 continuously picked up and thereby maintains wayside signal SIII normally deenergized. Such deenergization continues as long as the track section II—III remains vacant.

In the event now that a train comes into the section, the usual shunting action of its wheels and axles cuts off transmission of "master code" energy to the entrance end track relay TR and also discontinues transmission of "feed back" energy to the exit end detector relay KR. In consequence, relay KR ceases to pick up and release contacts 23—24 but it allows those contacts to remain continuously released.

As a result, transformer AT now discontinues all transmission of pick-up energy to relay KR and causes that relay to release contact 21. That release, of course, connects wayside signal SIII with its lighting source and thereby causes that signal to display the particular indication which is selected by decoding equipment H—D.

This release of the approach relay AR continues until the train moves out of section II—III. When that happens, master code energy is again transmitted to entrance end track relay TR, the section rails are once more supplied with feed back pulses, and by those pulses the exit end detector relay KR is again operated in code following manner. By that operation, the detector relay contacts 23—24 restore the supply of pick-up current to the approach relay AR. That relay, in turn, again picks up contact 21 and thereby restores the wayside signal SIII to its normally inactive condition.

Direct current track circuits of the "coded feed back" type frequently have to safeguard their "feed back" energized relays against false operation due to inductive "kick back" energy which may be generated in the track rails when those rails are shunted by a train. In the track circuit of Fig. 1 such so-generated "kick back"

energy appears in rails 1—2 at the end of each "on" period pulse of unidirectional current which master code sources TP—TN impress upon those rails over contacts 5 and 7 of coding devices CR and CP.

Direct current track circuits employing "detector" relays of the type shown at KR in Fig. 1 can experience serious operating difficulties due to such "kick back" energy and one early proposal to overcome such difficulties forms the subject of assignee's United States Patent No. 2,286,002 which issued to Frank H. Nicholson on June 9, 1942.

As the specification of that patent sets forth in considerable detail, "kick back" energy of the type here considered results from the inductance of the track circuit plus the conductance of the rail-to-rail ballast and its effect is to continue for a short interval after each disconnection of direct current sources TP—TN from the section rails the flow of current in those rails in the same direction as the so-disconnected source had established.

When, therefore, the rails of Fig. 1's section II—III are shunted by a train, each "on" period pulse of master code current which sources TP—TN impress upon those rails may be followed by a "kick back" energy pulse which though relatively short still is long enough to overlap the early portion of the succeeding "off" code period (see Fig. 2). Current due to these overlapping pulses thus may reach relay KR over conductors 11 and 13, contacts 5, 50, 39—40 of devices CR—CP, and conductors 14—15.

If of sufficient magnitude such "off" period "kick back" current may falsely cause relay KR to follow code even though the approach relay AR controlled thereby should stay released until the train has cleared the section.

In order to guard against such false operation of detector relay KR the exit end apparatus of Fig. 1 may be supplemented by a reactor 55. Preferably this reactor is organized in the same basic manner as my copending application for Letters Patent of the United States Serial No. 455,170 discloses and claims, and it then serves to keep relay KR's winding connected with the section rails during the master code "off" periods when coding devices CR and CP are shifting their contacts 5 and 50.

Such connection enables advantage to be taken of the inductive characteristics of relay KR's winding plus those of the reactor 55. The effect of such characteristics is to generate a local "kick back" voltage at the end of each passage of unidirectional current through the reactor and relay winding. That effect is, of course, produced by the collapse of magnetic flux which accompanies each disconnection of the named elements from their D.-C. energizing source.

By the added reactor 55 there is established for relay KR's winding a path over which each pulse of master code energy from exit sources TP and TN flows current through the winding of KR in the direction of from right to left. In the case of each "positive" pulse, such flow is from the positive terminal of source TP over device CR's front contact 5, through reactor 55, device CR's front contact 40, conductor 15, the winding of relay KR, conductor 14, device CR's front contact 39, conductor 13, impedance 12 and device CP's right contact 7 back to the negative terminal of source TP; in case of each "negative" pulse such flow is from the positive terminal of source TN, through device CP's left contact 7,

impedance 12, conductor 13, device CR's back contact 40, conductor 15, the winding of relay KR, conductor 14, device CR's back contact 39, reactor 55, and device CR's back contact 5 back to the negative terminal of source TN.

As earlier explained, such right-to-left current flow through relay KR's winding is ineffective for picking up relay KR and thus it does not interfere with the desired code following response of that relay to the "feed back" code pulses which are applied thereto under vacant section conditions. It does, however, render the relay immune to false pick-up by master code "kick back" energy which may be applied thereto following each disconnection of exit sources TP—TN from the section rails.

Upon each of these disconnections: (1) the section rails 1—2 tend to flow through the winding of relay KR a master code "kick back" current in the direction of from left to right; and (2) the energy of self-inductance in relay KR's winding plus that in reactor 55 tends to continue the flow therethrough of current in the opposite or right-to-left direction.

These currents directly oppose each other and by choosing the magnitude of the winding's plus reactor's "kick back" current to slightly exceed that generated in the rails, relay KR is effectively held released following each disconnection of master code sources TP—TN from the shunted rails.

In practice, reactor 55 may take the form of an adjustable element which is set at such a value as to produce the relation just expressed. Should relay KR's winding itself be capable of producing all of the counter inductive effect that is needed, then the reactor 55 may be replaced by a resistor (not shown) or other impedance. Most code following relays of commercial design are, however, found to require some counter inductive supplement when employed as is device KR at location III of Fig. 1 and for this reason use of the represented reactor for element 55 ordinarily will be preferred.

At Fig. 1's entrance location II no "kick back" neutralizing reactor is provided for the reason that none is there needed. In preventing track relay TR from falsely being picked up by kick back energy that following each disconnection thereof from feed back sources KP—KN may be present in the rails, this location II organization of Fig. 1 utilizes the expedients of assignee's United States Patent No. 2,286,002 to Nicholson.

Trackway current originating in each of sources KP—KN passes in series through the winding of relay TR in such direction as to hold that relay's contacts in the position to which they were biased by the pulse of master code energy last received from exit end source TP or TN. As any resulting kick back current in the section rails flows in the same direction through the relay winding it cannot produce false relay operation and hence no neutralizing reactor is needed for the relay TR of Fig. 1.

The modified combination of Fig. 3

The just described "coded feed back" track circuit organization of Fig. 1 incorporates only one of several possible structural arrangements which may be utilized to perform the explained functions. In Fig. 3, I have represented a generally equivalent track circuit combination wherein both the entrance end apparatus and

the exit end apparatus is modified as to certain of its details.

As in the organization of Fig. 1, the complete combination of Fig. 3 utilizes the basic "polar impulse" track circuit elements earlier described as being identified with my issued United States Patent No. 2,282,099. These elements comprise: (1) at the section exit III—coder and repeater relays CR and CP, positive and negative sources TP and TN of "master code" trackway energy, and rail supply circuits in which these sources are included; and (2) at the section entrance end II—a code following track relay TR of the "polar stick" type which is operated by "master code" energy transmitted thereto over the section rails and which selects (through decoding apparatus not shown in Fig. 3) the indication which signal SII displays.

As in the organization of Fig. 1, also, the complete track circuit combination of Fig. 3 further uses "feed back" elements which comprise: (1) at the section entrance II—a repeater device RP for track relay TR, positive and negative sources KP and KN of "feed back" trackway energy, and rail-supply circuits in which these sources are selectively included; and (2) at the section exit III—an approach relay AR which governs the energization of signal SIII, a detector relay KR, which controls the energization of relay AR, and circuits over which relay KR receives "feed back" energy from the section rails.

At Figs. 3's exit end III, the coder and repeater relays CR—CP are broadly equivalent to the similarly designated elements of Fig. 1. The same is true of master energy sources TP—TN and the circuits over which devices CR—CP selectively connect these sources in energy supplying relation with the section rails 1—2.

At Fig. 3's entrance end II, the feed back sources KP—KN also have a close correspondence to the similarly designated elements of Fig. 1 but differ in the manner in which they are connected with the section rails 1—2.

Whereas in Fig. 1 these sources supply feed back current to the rails over a series connection with the winding of track relay TR, in Fig. 3 the feed back supply circuits are connected in parallel with the track relay winding and thus impress their energy upon the track rails in a somewhat more direct manner. The supply connection for both sources may optionally include a current limiting impedance 43.

A further difference between the Fig. 3 and the Fig. 1 organizations is that each reception by the track relay of a positive pulse of master code energy is followed by a connection with the section rails of the positive "feed back" source KP instead of the negative source KN and that each reception by the track relay TR of a negative pulse of master code energy is followed by a connection of the track rails with the negative "feed back" source KN instead of the positive source KP as in Fig. 1.

Each of these positive feed back connections results from a positioning of the track relay contacts 25—28 to the left. There is then completed for the section rails a feed back supply circuit that extends from the positive terminal of source KP through conductor 44, left contact 28 of device TR, conductors 45 and 31, track rails 1 and 2, conductor 30, impedance 43, right contact 26 of device RP, and conductor 46 back to the negative terminal of source KP.

Once completed, this connection remains intact until repeater RP shifts its contact 26 to the

left or normal position. When that happens, the pulse of positive feed back energy is interrupted. During its continuance, however, this pulse energizes the track relay TR in a direction tending to hold contacts 25—28 in their just established normal or left position.

Each of the earlier named negative feed back energy supply connections is established upon movement of track relay TR's contacts 25—28 to their right or reverse position. Such movement completes for the section rails a negative feed back supply circuit which extends from the positive terminal of source KN through normal contact 26 of repeater RP, impedance 43, conductor 30, track rails 2 and 1, conductors 31 and 45, and the reverse contact 28 of relay TR back to the negative terminal of source KN.

Once established, this negative supply connection continues until relay RP shifts its contacts away from the left or reverse position and thereby disconnects source KN from the rails. During the continuance of each so-supplied pulse of negative feed back energy, the track relay TR is energized in the direction which holds its contacts 25—28 in their newly established right or reverse position.

By this unique correlation of the feed back and master code energy polarities the entrance end feed back supply facilities of Fig. 3 function in the desired manner without interfering with the master code operation of the code following track relay TR. Such lack of interference, quite obviously, results only when each positive pulse of received master code energy is immediately followed by a positive pulse of supplied feed back energy, and each negative pulse of received master code energy is followed by a negative pulse of supplied feed back energy.

In the Fig. 1 organization, wherein the feed back energy flows serially through the track relay winding, a corresponding lack of interference is achieved by use of the inverted polarity master code and feed back energy relation which Fig. 2 represents. When using the series track relay connection of Fig. 1, that inverted relation is essential and the coinciding master code and feed back polarity relation of Fig. 3 cannot directly be substituted therefor.

In this "coinciding polarity" organization of Fig. 3 it is sometimes desirable to supplement the basic entrance end combination just described by a reactor 56 organized as per my copending application for Letters Patent of the United States Serial No. 455,170. Such a reactor keeps relay TR's winding connected with the track rails during the master code "off" periods when "feed back" energy pulses from sources KP—KN are being applied to the rails; its function is to safeguard track relay TR against false response due to inductive "kick back" energy that may be present in the track rails immediately following the feed back pulse ends.

As previously explained relative to Fig. 1's exit end reactor 55, such "kick back" energy results from the inductance of the track circuit plus the conductance of the rail-to-rail ballast; it is likely to be present in the rails of a shunted track section at the end of each direct current energy pulse that is impressed thereon; and when so generated its effect is to continue for a short time after each disconnection of the D.-C. source from the rails the flow of current in the same direction as was established by that source.

If in the entrance end organization of Fig. 3 such "kick back" energy persists after each dis-

connection of feed back sources KP and KN from the section rails it will, therefore, flow current through relay TR in such a direction as falsely to shift that relay's contacts from the position established by the immediately preceding pulse of "master code" energy that was received over the rails. Under operating conditions of Fig. 3's track section II—III such false contact shifting is objectionable and the purpose of added reactor 56 is to make it impossible.

By that reactor 56 there is established for relay TR's winding a connection through which each rail-applied pulse of feed back energy flows unidirectional current through that winding. The direction of this flow is: (1) from left to right in the case of each feed back pulse from positive source KP (which makes rail 1 positive with respect to rail 2); and (2) from right to left in the case of each feed back pulse from negative source KN (which makes rail 2 positive with respect to rail 1). In both instances the path of flow for this relay winding current includes contacts 26 and 28 of devices RP and TR, impedance 43, and reactor 56.

In each instance, moreover, this "feed back" current passes through relay TR's winding in the same direction as did the "master code" trackway current to which relay TR responded immediately before connecting Fig. 3's source (KP or KN) of feed back current to the rails. This is because each of Fig. 3's positive pulses of supplied feed back energy (rail 1 positive with respect to rail 2) is preceded by a positive pulse of received master code energy and each of Fig. 3's negative pulses of supplied feed back energy (rail 2 positive with respect to rail 1) is preceded by a negative pulse of received master code energy. In Fig. 3, therefore, the desired code following response of track relay TR to received master code energy is in no way interfered with by reactor 56.

In rendering track relay TR immune to false operation by rail "kick back" energy, that reactor 56 makes use of the before described unidirectional current which flows through the inductive turns of the reactor and of relay TR's winding during each and every pulse of feed back energy with which the rails are supplied by sources KP—KN. Such current builds up magnetic flux around those turns and in being interrupted at each feed back pulse end the resulting collapse of that flux generates a local "kick back" current in the winding and reactor. By that local current, relay TR is prevented from shifting its contacts in response to trackway "kick back" energy.

Thus, upon each disconnection of Fig. 3's positive source KP from the section rails 1—2: (1) those rails tend to flow through the winding of relay TR a feed back energy "kick back" current in the direction of from right to left; and (2) the energy of self-inductance in relay TR's winding plus that in reactor 56 tends to continue the flow therethrough of current in the opposite or left to right direction. These currents directly oppose each other and by choosing the winding's plus reactor's "kick back" current to slightly exceed that generated in the rails relay TR will hold its contacts to the left, under the conditions stated.

Similarly, upon each disconnection of the negative source KN from Fig. 3's rails: (1) those rails tend to flow through the winding of relay TR a feed back energy "kick back" current in the direction of from left to right; and (2) the energy of self-inductance in relay TR's winding plus that in reactor 56 tends to continue the flow

therethrough of current in the opposite or right to left direction. The latter current overcomes the former and thus holds relay TR's contacts to the right, under the conditions stated.

Should relay TR's winding itself be capable of producing all of the counterinductive effect that is needed for the above, then the added reactor 56 may be replaced by a resistor (not shown).

In order that the operating sensitivity of Fig. 3's code following track relay TR will not be impaired by this added reactor 56 provision is made for by-passing that reactor whenever a "master code" energy pulse is being received. Such by-passing is effected by contacts 27—28 of devices RP and TR. Those contacts establish around reactor 56 a current path over which relay TR's winding receives each positive polarity pulse and each negative polarity pulse of master code energy that reaches location II.

This reception takes place in the following manner. Immediately after each rail-supplied pulse of positive polarity "feed back" energy, contacts 27—28 of relays RP—TR both occupy their left or normal positions and immediately after each rail-supplied pulse of negative polarity "feed back" energy contacts 27—28 of devices RP—TR both occupy their right or reversed positions.

Under the condition last stated there is completed for the winding of relay TR a master code energizing path which extends from section rail 1 through conductors 31 and 56, relay TR's right contact 28, conductor 61, device RP's right contact 27, conductor 67, the winding of relay TR and conductor 30 back to section rail 2. It is over this path that a succeeding positive polarity pulse of master code energizes the track relay TR.

Under the condition first stated above there is completed for the winding of relay TR a master code energizing path which extends from section rail 2 through conductor 30, the winding of relay TR, conductor 67, device RP's left contact 27, conductors 74 and 44, relay TR's left contact 28, and conductors 45 and 31 back to section rail 1. It is over this path that a succeeding pulse of negative polarity master code energy flows current through the winding of track relay TR.

Once established, moreover, each of the connections just traced remains intact until the track relay TR shifts its contacts in response to received master code energy. When that happens the connection is, of course, broken at contact 28 and the winding of relay TR then becomes momentarily connected with the section rails through reactor 56. The track relay energization which preceded that contact shift is, however, sufficient to complete the transfer of contact position and in consequence relay TR follows code in the same manner as were reactor 56 not included in its circuit conductor 31.

Looking next at the exit or location III "feed back" facilities of Fig. 3, it will be seen that they too are basically similar to the corresponding facilities of Fig. 1 but differ therefrom with respect to the circuit over which the detector relay KR1 is connected with the section rails 1—2.

As in Fig. 1, this detector relay is a code following device of the "polar biased" type and by it the slow release direct current approach relay AR is controlled in precisely the same manner as in Fig. 1. Contact 21 of Fig. 3's relay AR is, therefore, held continuously picked up as long as the detector relay KR1 follows code, and releases only when contacts 23—24 of the detector relay remain in one of their two positions continuously.

In the exit organization of Fig. 3 the winding of detector relay KR1 is connected with the section rails over conductors 14—15, pole changing contacts 48—49 of the code repeater relay CP, a third contact 50 of that relay, contact 5 of coder relay CR and conductors 11 and 13. Over this connection each pulse of "feed back" energy that is received from entrance sources KP—KN picks up relay KR1's contacts 23—24 while each pulse of "master code" energy that is supplied from exit sources TP—TN keeps those contacts released.

As in the organization of Fig. 1, the stated pick-up of relay KR1's contacts is effected by received "feed back" energy of both the positive and the negative polarity. Contributing to that response is the pole changing action of code repeater relay CP's contacts 48—49 and because of that action all received feed back pulses of either polarity flow current through relay KR1's winding in the arrow-indicated direction of from left to right.

Looking first at Fig. 3's "positive" feed back pulses, each such pulse makes rail 1 positive with respect to rail 2 and is accompanied by a closure of coder relay CR's front contacts plus a closure of repeater device CP's left or normal contacts. In appearing between the rails at the exit location III such positive feed back potential thus picks up detector relay KR1 over a path extending from rail 1 through conductor 11, device CR's front contact 5, conductor 53, device CP's normal contacts 50 and 48, conductor 14, the winding of relay KR1, conductor 15, device CP's normal contact 49, and conductor 13 back to rail 2.

Looking next at Fig. 3's "negative" feed back pulses, each such pulse makes rail 2 positive with respect to rail 1 and is accompanied by a closure of coder relay CR's back contacts plus a closure of repeater device CP's right or reverse contacts. In appearing between the rails at the exit location III such negative feed back potential thus picks up detector relay KR1 over a path extending from rail 2 through conductor 13, device CP's reverse contact 49, conductors 51 and 14, the winding of relay KR1, conductor 15, device CP's reverse contacts 48 and 50, conductor 54, device CR's back contact 5, and conductor 11 back to rail 1.

As long, therefore, as Fig. 3's track section II—III remains vacant: (1) recurring pulses of positive and negative polarity feed back energy are received from the rails at the location of relay KR1; (2) that relay is by each of those pulses caused to pick up its contacts 23—24 and at the end of each of those pulses it is allowed to release those contacts; and (3) in that way the detector relay KR1 is operated in code following manner by feed back pulses which are transmitted thereto from entrance sources KP—KN.

Nor is this action in any way interfered with by the pulses of "master code" energy with which the rails are supplied by sources TP—TN at the detector relay location. As already seen, each of Fig. 3's pulses of master code energy has a polarity which is the same as that of the feed back pulse which immediately follows it. That is, each positive pulse of feed back energy is immediately preceded by a positive pulse of master code energy while each negative pulse of feed back energy is immediately preceded by a negative pulse of master code energy.

However, between each master code pulse and the feed back pulse which immediately follows it there occurs in the position of code repeater

relay CP's contacts a shift which terminates the master code pulse and which is completed before the succeeding feed back pulse is received at location III. Incident to each such shift the connection of detector relay KR1's winding with the section rails 1—2 is pole changed (at contacts 48—49 of device CP).

In consequence: (1) each master code pulse of positive polarity energy which is impressed upon the winding of detector relay KR1 just before such a shift flows current through that winding in a direction which is opposite to that established by positive polarity feed back energy just after the shift; and (2) each master code pulse of negative polarity energy which is impressed upon detector relay KR1's winding just before such a shift flows current through that winding in a direction which is opposite to that established by negative polarity feed back energy just after the shift. Master code pulses of both the positive and the negative polarity thus become ineffective for operating Fig. 3's detector relay KR1.

Under vacant section conditions, accordingly, detector relay KR1 is responsive to and only to feed back energy which is received over the rails from Fig. 3's entrance sources KP—KN and, because of its "polar-biased" characteristics, it cannot be picked up by master code energy which further is impressed thereon by exit sources TP—TN. Under occupied section conditions, therefore, the master code energy pulses which then continue to be impressed on relay KR cannot pick up the contacts of that relay and serve only to urge those contacts more firmly into their released positions.

Code following operation on the part of detector relay KR1 thus occurs only when Fig. 3's section II—III is vacant and as a result of the recurring pulses of positive and negative polarity feed back energy which then flow forwardly over the section rails. Such code following operation causes the approach relay AR to hold its contact 21 continuously picked up. By this holding, the approach governed wayside signal SIII is maintained inactive as long as the track section II—III remains vacant.

Entry of a train into that section discontinues the feed back energy transmission, causes detector relay KR1 to cease following code and thereby releases contact 21 of approach relay AR. By that release, the approach governed signal SIII is connected with its lighting source and caused to display the particular indication that is selected by decoding apparatus H—D.

When the train moves out of the section, feed back energy is again transmitted to relay KR1, contacts 23—24 thereof once more follow code and relay AR again is picked up. By such pick-up, signal SIII is once more restored to its normally inactive state.

By the earlier described reactor 56, Fig. 3's entrance end track relay TR is rendered immune to false operation by "kick back" energy that may be present in the rails following each disconnection of feed back sources KP—KN therefrom.

At Fig. 3's exit location III no comparable "kick back" neutralizing reactor is needed and hence none has been shown. The reason for this lack of need lies in the polarity relation which Fig. 3's pulses of feed back and master code energy bear to each other. Unlike the organization of Fig. 1 wherein each entrance-end received pulse of master code energy is followed by a feed

back pulse of opposing polarity (see Fig. 2), the Fig. 3 combination is so set up that each received master energy pulse is followed by a feed back pulse of the same polarity.

At Fig. 3's exit location III, therefore, each master energy pulse that is supplied under vacant section conditions is immediately preceded by a received feed back pulse of the opposite polarity, and connections of Fig. 3's detector relay (KRI) winding with the rails are so set up that current due to each of those received feed back pulses flows through that winding in the arrow-indicated direction of from left to right.

Relay KRI's winding is also energized during each pulse of master code energy that exit end sources TP—TN supply to the rails. As has been seen, however, such energization flows winding current in the direction of from right to left and hence is ineffective for picking up relay KRI. "Kick back" energy which may follow each disconnection of sources TP—TN from the rails would, of course, reverse this direction of flow were the connection of relay KRI's winding with the rails to remain unchanged.

At the end of each master code pulse, however, that connection is reversed by contacts 5—50—48—49 of devices CR—CP and any current due to rail "kick back" energy that reaches relay KRI's winding thus also flows therethrough in the right to left direction and hence also is ineffective for producing relay pick-up.

In consequence, the track circuit of Fig. 3 is inherently immune to false operation of its exit end detector relay KRI by rail kick back energy and hence no reactor corresponding to Fig. 1's element 55 need be used therewith.

Cut section facilities of Fig. 4

In certain instances it may be desirable to subdivide the main signal block II—III of the Figs. 1-3 systems into two or more track sections. Typically, such subdivisions will be occasioned by requirements of excessive block length, highway crossing control or other equally well-known reasons.

In the event of such subdivision, means must be provided for repeating into the rails of each rear section the "master code" energy pulses that are supplied to the rails of each forward section and for repeating into the rails of each forward section the "feed back" energy pulses that are supplied to the rails of the rear section. In a system of the type shown by Figs. 1 and 3, moreover, the repeated pulses must have not only the same timing but must also be of alternately opposite polarity.

Facilities for performing such code repeating functions are illustrated in Fig. 4. There a block subdividing or cut section location IIa is shown as being occasioned by insulated joints 3 which are interposed between the entrance and exit locations of a signal block which has the character represented at II—III in each of Figs. 1 and 3.

Operated by the positive polarity "master code" energy that is received from the forward section rails 1—2 is a code following track relay TRP; operated by the negative polarity "master code" energy that is received from the forward section rails is a second code following track relay TRN; operated by the positive polarity "feed back" energy that is received from the rear section rails 1a—2a is a third code following track relay KRP; and operated by the negative polarity "feed back"

energy that is received from the rear section rails is a fourth code following track relay KRN.

Controlled by a coding contact 57 of relay TRP is a positive source TP of master code energy for the rear section rails; controlled by a coding contact 58 of relay TRN is a negative source TN of master code energy for the rear section rails; controlled by a coding contact 59 of relay KRP is a positive source KP of feed back energy for the forward section rails; and controlled by a coding contact 60 of relay KRN is a negative polarity source of feed back energy for the forward section rails.

Each pulse of positive polarity master code energy that is received from the forward section rails at location IIa picks up relay TRP over a circuit extending from rail 1 through conductor 62, back contact 59 of relay KRP, back contact 60 of device KRN, conductor 63, a back contact 64 of device TRN, conductor 65, the winding of relay TRP and conductor 66 back to rail 2. During each of these pick-ups, relay TRP's contact 57 causes source TP to supply the rear section rails with a pulse of positive polarity master code energy. The supply circuit extends from the positive terminal of source TP through a current limiting impedance 68, conductor 69, the rear section rails 1a—2a, conductor 70, front contact 57 of relay TRP and conductor 71 back to the negative terminal of source TP.

Each forward section pulse of negative polarity master code energy that is received at location IIa picks up track relay TRN over a circuit that extends from rail 2 through conductors 66 and 72, the winding of relay TRN, conductor 73, back contact 74 of device TRP, conductor 63, back contacts 60 and 59 of devices KRN and KRP and conductor 62 back to rail 1. During each of these pick-ups contact 58 causes source TN to supply the rear section rails with a pulse of negative polarity master code energy. The supply circuit extends from the positive terminal of source TN through conductor 76, front contact 58 of relay TRN, back contact 57 of device TRP, conductor 70, the rear section rails 2a—1a, conductor 69, and impedance 68 back to the negative terminal of source TN.

Each positive polarity pulse of feed back energy that is received from the rear section rails at location IIa picks up track relay KRP over a circuit extending from rail 1a through conductors 69 and 77, the winding of relay KRP, a back contact 78 of device KRN, conductor 79, back contacts 58 and 57 of devices TRN and TRP and conductor 70 back to rail 2a. During each of these pick-ups contact 59 causes source KP to supply the forward section rails with a pulse of positive polarity feed back energy. The supply circuit extends from the positive terminal of source KP through conductor 81, front contact 59 of relay KRP, conductor 62, forward section rails 1 and 2, conductor 66, and impedance 80 back to the negative terminal of source TP.

Each negative polarity pulse of feed back energy that is received from the rear section rails at location IIa picks up track relay KRN over a circuit extending from rail 2a through conductor 70, back contacts 57 and 58 of devices TRP and TRN, conductor 79, a back contact 82 of device KRP, conductor 83, the winding of relay KRN and conductor 69 back to rail 1a. During each of these pick-ups contact 60 causes source KN to supply the forward section rails with a negative polarity pulse of feed back energy. The supply cir-

cuit extends from the positive terminal of source KN through impedance 80, conductor 66, forward rails 2 and 1, conductor 62, back contact 59 of device KRP, front contact 60 of relay KRN and conductor 84 back to the negative terminal of source KN.

In addition to repeating the coded energy in the manner just described, the cut section facilities of Fig. 4 are capable of repeating steady energy of either positive or negative polarity and of either the master code or the feed back variety. Without interfering with the complete system operation, the Fig. 4 cut section facilities may, therefore, be interposed between the entrance and exit ends II and III of the "coded feed back" track circuit of either of Figs. 1 or 3.

Cut section facilities of Figs. 5-6

In installations where inductive "kick back" energy in substantial quantities is generated in the rails the just described apparatus of Fig. 4 may be replaced by one or the other of the cut section equipments of Figs. 5 and 6. These two equipments safeguard their relays against false response to "kick back" energy such as has been described re reactors 55 and 56 of Figs. 1 and 3.

The equipment of Fig. 5 is designed for use with coded track circuits of the Fig. 1 type wherein each received pulse of master code energy is followed by a supplied feed back pulse of opposing polarity; the equipment of Fig. 6 is designed for use with track circuits of the Fig. 3 type wherein each received pulse of master code energy is followed by a supplied feed back pulse of the same polarity.

Looking first at Fig. 5, it shows a cut location IIa interposed between the entrance and exit locations of Fig. 1's signal block II-III.

Installed at this cut location are: (1) a code following track relay TRa which has the same "polar stick" characteristics as does entrance end device TR of Fig. 1 and which is operated by "master code" energy pulses of both positive and negative polarity that are received from Fig. 5's forward section rails 1-2; (2) a repeater device RPa for relay TRa which is energized over that relay's contact 25 and which repeats each of relay TRa's operations in the same manner as explained for entrance end device RP of Fig. 1; and (3) a code following track relay KRa which has the same "polar biased" characteristics as does exit end device KR of Figs. 1 and 3 and which is operated by "feed back" energy pulses of both positive and negative polarity that are received from Fig. 5's rear section rails 1a-2a.

Further utilized by the cut section facilities of Fig. 5 are: (1) a positive source TP of master code energy which at proper times is connected with the rear section rails 1a-2a over contacts 86-87 of devices TRa-RPa; (2) a negative source TN of master code energy which at other times is connected with the rear section rails over the same contacts; (3) a positive source KP of feed back energy which at proper times is connected with the forward section rails 1-2 over contacts 26 and 88 of devices RPa and KRa; and (4) a negative source KN of feed back energy which at other times is connected with the forward section rails over contacts 26 and 89 of the just named devices.

Each pulse of positive polarity master code energy that is received from the forward section rails at Fig. 5's location IIa moves the contacts of track relay TRa to the left. Such movement results from an energization of that relay over

a path from rail 1 through conductor 91, the winding of relay TRa, conductor 92, back contact 88 of device KRa, and conductor 93 back to rail 2. During each of those left positionings of relay TRa's contacts and before repeater RPa shifts its contacts to the left, source TP supplies the rear section rails with a pulse of positive polarity master code energy. The supply path extends from the positive terminal of source TP through device TRa's left contact 86, conductor 94, the rear section rails 1a-2a, conductor 95, a current limiting impedance 96, conductor 97, and device RPa's right contact 87 back to the negative terminal of source TP.

Each forward section pulse of negative polarity master code energy that is received at Fig. 5's location IIa moves the contacts of track relay TRa to the right. Such movement results from an energization of that relay over a path from rail 2 through conductor 93, device KRa's back contact 88, conductor 92, the winding of relay TRa and conductor 91 back to rail 1. During each of those right positionings of relay TRa's contacts and before repeater RPa shifts its contacts to the right, source TN supplies the rear section rails with a pulse of negative polarity master code energy. The supply path extends from the positive terminal of source TN, through device RPa's left contact 87, conductor 97, impedance 96, the rear section rails 2a-1a, conductor 94, and device TRa's right contact 86 back to the negative terminal of source TN.

Each positive polarity pulse of feed back energy that is received from Fig. 5's rear section rails at location IIa picks up track relay KRa over a circuit extending from rail 1a through conductor 94, device TRa's right contact 86, conductor 98, device RPa's right contact 99, conductor 100, device TRa's right contact 101, conductor 14, the winding of relay KRa, conductor 15, device TRa's right contact 102, conductor 103, and conductor 95 back to rail 2a. During each of these pick-ups, contact 88 causes source KP to supply the forward section rails with a pulse of positive polarity feed back energy. The supply path extends from the positive terminal of source KP through device RPa's right contact 26, a current limiting impedance 106, conductor 92 device TRa's winding, conductor 91, the forward section rails 1-2, conductor 93, and device KRa's front contact 88 back to the negative terminal of source KP.

Each negative polarity pulse of feed back energy that is received from Fig. 5's rear section rails at location IIa also picks up track relay KRa. In this case, however, the pick-up circuit extends from rail 2a through conductor 95, conductors 103-104, device TRa's left contact 101, conductor 14, the winding of relay KRa, conductor 15, device TRa's left contact 102, conductor 100, device RPa's left contact 99, conductor 105, device TRa's left contact 86, and conductor 94 back to rail 1a. During each of these pick-ups contact 89 causes source KN to supply the forward section rails with a pulse of negative polarity feed back energy. The supply path extends from the positive terminal of source KN through device KRa's front contact 89, conductor 93, the forward section rails 2-1, conductor 91, device TRa's winding, conductor 92, impedance 106, and device RPa's left contact 26 back to the negative terminal of source KN.

The just examined cut section facilities of Fig. 5 thus are effective to repeat both "master code" and "feed back" energy pulses of both polarities

and they may, therefore, be interposed between the entrance and exit ends II and III of Fig. 1's coded track circuit without in any way interfering with that circuit's operation.

When rail "kick back" energy of the character earlier described is encountered in objectionable magnitude Fig. 5's basic code repeating combination may be supplemented by a reactor 55 which prevents detector track relay *KRa* from falsely responding to such energy under shunted conditions of the rear section rails. As in the case of Fig. 1's similarly designated element, this reactor 55 is organized as per my copending application for Letters Patent of the United States Serial No. 455,170 and it keeps relay *KRa*'s winding connected with rails 1a-2a at and following the end of each master code energy pulse.

Such connection causes each pulse of master code energy that is applied to rails 1a-2a by sources TP-TN to flow unidirectional current through the winding of relay *KRa*. Thus, source TP flows current through that winding over a path which includes device *TRa*'s left contact 86, reactor 55, device *TRa*'s left contact 102, conductor 15, the winding *KRa*, conductor 14, device *TRa*'s left contact 101, conductors 104-103, impedance 96, conductor 97, and device *RPa*'s right contact 87; likewise, source TN flows current through the same winding over a path which includes device *RPa*'s left contact 87, conductor 97, impedance 96, conductor 103, device *TRa*'s right contact 102, conductor 15, the winding of *KRa*, conductor 14, device *TRa*'s right contact 101, reactor 55, and device *TRa*'s right contact 86.

In both instances the direction of this current flow through relay *KRa*'s winding is from right to left and in consequence relay *KRa* is held released for the duration of each supplied master code energy pulse.

In addition this right to left flowing current renders relay *KRa* immune to false pick-up by master code "kick back" energy which may be applied thereto following each disconnection of sources TP-TN from the rear section rails 1a-2a.

Upon each of those disconnections: (1) rails 1a-2a tend to flow through the winding of relay *KRa* a master code "kick back" current in the direction of from left to right; and (2) the energy of self-inductance in relay *KRa*'s winding plus that in reactor 55 tends to continue the flow therethrough of current in the opposite or right to left direction.

These currents directly oppose each other and by choosing the magnitude of the winding's plus reactor's "kick back" current to slightly exceed that generated in the rails, relay *KRa* is effectively held released following each disconnection of master code sources TP-TN from rails 1a-2a.

In the case of Fig. 5's master code track relay *TRa*, no "kick back" neutralizing reactor is needed and hence none has been shown. Like device *TR* of Fig. 1, this track relay *TRa* utilizes the kick back safeguarding expedients of assignee's United States Patent 2,286,002 to Nicholson. Trackway current originating in each of Fig. 5's feed back sources KP-KN passes in series through the winding of relay *TRa* in such direction as to hold that relay's contacts in the position to which they were moved by the pulse of master code energy last received from rails 1-2. As kick back current from those rails flows in the same direction through the relay winding

it cannot produce false operation of relay *TRa* and hence no neutralizing reactor is needed therefor.

Referring now to Fig. 6, I have there shown cut section apparatus which is generally equivalent to that of Fig. 5 but which differs therefrom by being designed for use with track circuits of the Fig. 3 type wherein each received pulse of master code energy is followed by a supplied feed back pulse of the same polarity.

Like Fig. 5, the apparatus of Fig. 6 includes: (1) a first code following track relay *TRa* of the "polar stick" type which is operated by "master code" energy pulses of both positive and negative polarity that are received from the forward section rails 1-2; (2) a repeater device *RPa* for that master track relay *TRa*; and (3) a second code following track relay *KRa* of the "polar biased" type which is operated by "feed back" energy pulses of both positive and negative polarity that are received from the rear section rails 1a-2a.

Like Fig. 5 also, the apparatus of Fig. 6 further utilizes: (1) positive and negative polarity sources TP and TN for supplying master code energy to the rear section rails 1a-2a; and (2) positive and negative polarity sources KP and KN for supplying feed back energy to the forward section rails 1-2.

In operation of this Fig. 6 apparatus, each pulse of positive polarity master code energy that is received from the forward section rails at location IIa moves the contacts of track relay *TRa* to the left. Such movement results from an energization of that relay over a path from rail 1 through conductor 91, the winding of relay *TRa*, conductor 108, a back contact 109 of device *KRa*, and conductor 93 back to rail 2. During each of these left positionings of relay *TRa*'s contacts and before repeater *RPa* shifts its contacts to the left, source TP supplies the rear section rails with a pulse of positive polarity master code energy. This supply is from the positive terminal of source TP, through device *TRa*'s left contact 86, conductor 94, the rear section rails 1a-2a, conductor 95, impedance 96, conductor 97 and device *RPa*'s right contact 87 back to the negative terminal of source TP.

Each forward section pulse of negative polarity master code energy that is received at Fig. 6's location IIa moves the contacts of track relay *TRa* to the right. Such movement results from an energization of that relay over a path from rail 2, through conductor 93, device *KRa*'s back contact 109, conductor 108, the winding of relay *TRa*, and conductor 91 back to rail 1. During each of those right positionings of relay *TRa*'s contacts and before repeater *RPa* shifts its contacts to the right, source TN supplies the rear section rails with a pulse of negative polarity master code energy. This supply is from the positive terminal of source TN, through device *RPa*'s left contact 87, conductor 97, impedance 96, conductor 95, the rear section rails 2a-1a, conductor 94, and device *TRa*'s right contact 86 back to the negative terminal of source TN.

Each positive polarity pulse of feed back energy that is received from Fig. 6's rear section rails at location IIIa picks up track relay *KRa* over a circuit from rail 1a through conductor 94, device *TRa*'s left contact 102, conductor 115, the winding of relay *KRa*, conductor 14, device *TRa*'s left contact 101, conductors 104-103 and conductor 95 back to rail 2a. During each of these pick-ups contact 89 causes source KP to supply the

forward section rails with a pulse of positive polarity feed back energy. The supply path extends from the positive terminal of source KP, through device RPa's left contact 26, conductors 92—91, the forward section rails 1—2, conductor 93, device KRa's front contact 89, and a current limiting impedance 111 back to the negative terminal of source KP.

Each negative polarity pulse of feed back energy that is received from Fig. 6's rear section rails also picks up track relay KRa at location 11a. In this case, however, the pick-up circuit extends from rail 2a through conductors 95 and 103, device TRa's right contact 102, conductor 15, the winding of relay KRa, conductor 14, device TRa's right contact 101, and conductor 94 back to rail 1a. During each of these pick-ups contact 88 causes source KN to supply the forward section rails with a pulse of negative polarity feed back energy. The supply path extends from the positive terminal of source KN through impedance 112, device KRa's front contact 88, conductor 93, the forward section rails 2—1, conductors 91—92, and device RPa's right contact 26 back to the negative terminal of source KN.

The just examined cut section facilities of Fig. 6 thus are effective to repeat both "master code" and "feed back" energy pulses of both polarities and then may, therefore, be interposed between the entrance and exit ends II and III of Fig. 3's coded track circuit without in any way interfering with that circuit's operation.

When rail "kick back" of the character earlier described is encountered in objectionable magnitude, Fig. 6's basic code-repeating combination may be supplemented by a reactor 56 which prevents master track relay TRa from falsely responding to such energy under shunted conditions of the forward section rails. As in the case of Fig. 3's similarly designated element, this reactor 56 is organized as per my copending application for Letters Patent of the United States Serial No. 455,170 and it keeps relay TRa's winding connected with rails 1—2 at and following the end of each feed back energy pulse.

Such connection causes each pulse of feed back energy that is applied to rails 1—2 by sources KP—KN to flow unidirectional current through the winding of relay TRa. Thus, source KP flows current through that winding in the direction of from left to right and over a path which includes device RPa's left contact 26, conductor 92, the winding of relay TRa, reactor 56, conductor 93, device KRa's front contact 89 and impedance 111. Such current keeps relay TRa's contacts to the left.

Source KN also flows current through relay TRa's winding but in the direction of from right to left. This flow is over device KRa's front contact 88, conductor 93, reactor 56, the winding of relay TRa, conductor 92 and device RPa's right contact 26. By it relay TRa's contacts are kept to the right.

In each instance this feed back produced current flow renders relay TRa immune to false operation by rail "kick back" energy which may be applied thereto following each disconnection of feed back sources KP—KN from the forward section rails 1—2.

Upon each such disconnection of the positive feed back source KP: (1) rails 1—2 tend to flow through the winding of relay TRa a trackway "kick back" current in the direction of from right to left; and (2) the energy of self-inductance in relay TRa's winding plus that in reactor

56 tends to continue the flow therethrough of current in the opposite or left to right direction. The latter current may be chosen to overcome the former and following each disconnection of feed back source KP from the forward section rails it then holds relay TRa's contacts to the left.

Upon each such disconnection of the negative feed back source KN: (1) rails 1—2 tend to flow through the winding of relay TRa a trackway "kick back" current in the direction of from left to right; and (2) the energy of self-inductance in relay TRa's winding plus that in reactor 56 tends to continue the flow therethrough of current in the opposite or right to left direction. The latter current may be chosen to overcome the former and following each disconnection of feed back source KN from the forward section rails it then holds relay TRa's contacts to the right.

In the case of Fig. 6's feed back detector relay KRa, no "kick back" neutralizing reactor is needed and hence none has been shown. Like device KR1 of Fig. 3, this detector relay forms part of a combination which is inherently self-protecting against false relay operation by kick back energy that may be impressed thereon from rails 1a—2a.

In the track circuit of Fig. 3 with which the Fig. 6 cut section equipment is designed to be used, each entrance-end received pulse of master code energy is followed by a feed back pulse of the same polarity and relay KRa of Fig. 6 thus is the counterpart of Fig. 3's relay KR1. The reasons why the latter cannot falsely be operated by rail kick back energy have already been examined in detail. Those same reasons apply to relay KRa of Fig. 6 and hence no reactor corresponding to Fig. 1's element 55 need be provided therefor.

Summary

From the foregoing it will be seen that the improved "coded feed back" track circuits of my invention are of broad utility and that their application is by no means restricted to the approach lighting uses which are herein shown by way of illustration. While, moreover, the approach control facilities of Figs. 1 and 3 have been explained in "polar impulse" systems wherein the lights of wayside signals only are approach governed, it will be understood that these facilities have equal utility when used with approach control combinations which provide for other comparable functions instead of or in addition to the illustrative one here illustrated.

By these improved "coded feed back" track circuits a number of important advantages are offered and to these attention will now be directed.

First, the "master code" operating advantages of my issued United States Patent No. 2,282,099's "polar impulse" coded control circuits are imparted to the "feed back" portions of the complete circuit combination. As previously stated, these operating advantages include a lowering of power requirements plus further desirable features.

Second, both the feed back and the master code relays KR and TR of the circuit are rendered highly immune to false operation by "foreign currents" that may be present in the circuit conductors. Each of the named relays can be operated only by energy in the track rails which is of periodically reversed polarity (see

Fig. 2). Unless foreign current present in the rails is of that special character it, quite obviously, cannot produce false relay operation.

Third, "storage energy" difficulties are eliminated to a greater extent than has been possible in the past. Energy stored in the track ballast and rails following each application of code pulse energy (either master or feed back) thereto retains the polarity of the applied pulse and the potential thereof can progressively build up only when successive applied pulses are of the same polarity. By my alternate reversals of both master code and feed back pulse polarity (once more see Fig. 2) I keep the level of storage potential far below that which is effective for producing false operation by either the master code track relay TR or by the feed back detector relay KR.

Fourth, both the feed back detector and the master code track relays KR and TR are rendered immune to false operation by "kick back" energy that may be present in the rails. Depending upon the circuit details this immunity is achieved: (1) by the series relay expedients of United States Patent No. 2,286,002 to Nicholson, as for device TR of Fig. 1 and device TRa of Fig. 5; (2) by the neutralizing reactor expedients of my copending application for Letters Patent of the United States Serial No. 455,170, as for device KR of Fig. 1, device TR of Fig. 3, device KRa of Fig. 5, and device TRa of Fig. 6; and (3) by the inherently self-protecting organization of this invention, as for device KR of Fig. 3 and device KRa of Fig. 6.

In addition to thus improving the operating characteristics of "coded feed back" control circuits per se, I have provided improved facilities for impressing the pulsed "feed back" energy upon the circuit conductors and for receiving that energy from those conductors; and I have organized the improved facilities in such manner that the resulting "coded feed back" control circuits are readily usable in signaling systems of the "frequency code" and other types of commercially proven practicability.

Although the several improvements of my invention have been shown and described as forming part of "coded feed back" control circuits of the track type, it will be obvious that these improvements are not restricted thereto but that they also have utility when applied to control circuit combinations of any other form wherein the conductors lose their normal energy transmitting capability under certain conditions only.

Thus, instead of being track rails as shown, the control circuit conductors 1-2 may also take the form of line wires which connect master energy supply and feed back receiving equipment (see devices CR-CP-KR at location III in Figs. 1 and 3) at one end of the circuit with master energy receiving and feed back supply equipment (see devices TR-RP-KP-KN at location II in Figs. 1 and 3) at the other end of the circuit.

When used in a control circuit of the line conductor type just described, each of the improvements herein disclosed will function in exactly the same manner as when used with the track type of control circuit that is herein illustrated. My invention is, therefore, one of broad utility and is not to be restricted to the specific forms of application that I have shown by way of illustration.

Although I have herein shown and described only three forms of "coded feed back" control

circuits embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a control circuit that includes a pair of conductors which normally are capable of transmitting energy between given and opposite ends of the circuit but which at times are rendered incapable of such transmission, mean sincluding a coding device at the given end of said circuit for supplying said conductors with master code energy in the form of recurring "on" period pulses that are separated by "off" period intervals and that have positive and negative polarities in alternating sequence, a first code following relay at the opposite end of said circuit connected with said conductors during said master code "on" periods and having a contact which moves to a normal position upon each reception of a positive polarity master code pulse and to a reverse position upon each reception of a negative polarity master code pulse, means governed by said first relay contact and effective during code following operation thereof for further supplying said conductor with feed back energy in the form of pulses that recur in step with said master code "off" periods and that have positive and negative polarities in alternating sequence, a second code following relay at said given circuit end having an operating winding and being provided with a contact which picks up when given direction current is passed through said winding but which stays released when that winding receives opposite direction current or no current at all, means governed by said coding device for establishing from said conductors to said second relay winding a connection which is direct during each master code "off" period of odd number and reversed during each master code "off" period of even number and over which each conductor-transmitted pulse of said positive polarity feed back energy and of said negative polarity feed back energy flows given direction current through said second relay winding and thereby picks up said second relay contact, and apparatus controlled by said second relay contact and distinctively responsive according as that contact is or is not being repeatedly shifted between its said picked up and released positions.

2. In combination, a control circuit that includes a pair of conductors which normally are capable of transmitting energy between given and opposite ends of the circuit but which at times are rendered incapable of such transmission, positive and negative sources of master code energy at the given end of said circuit, a coding device which repeatedly connects said circuit conductors first to said positive source and then to said negative source and thereby produces a master code made up of recurring energy pulses which have positive and negative polarities in alternating sequence, a repeater relay for said coding device which interrupts each of said conductor-to-source connections early in the code period that the connection defines and which thereby causes each of said master code pulses to be followed by an "off" period interval, means located at the opposite end of said circuit and operated by the there received received pulses of said master code energy for further supplying said conductors with pulses of feed back energy that

recur in step with said master code "off" periods and that have positive and negative polarities in alternating sequence, a code following detector relay at said given circuit end having an operating winding and being provided with a contact which picks up when given direction current is passed through said winding but which stays released when that winding receives opposite direction current or no current at all, connections jointly controlled by said coding device and by said repeater relay for bridging said detector relay winding directly across said circuit conductors during master code "off" periods of odd number and reversely across said conductors during master code "off" periods of even number whereby each conductor-transmitted pulse of said positive polarity feed back energy and of said negative polarity feed back energy flows given direction current through said detector relay winding and thereby picks up said detector relay contact and whereby each conductor-supplied pulse of said positive polarity master code energy and of said negative polarity master code energy flows opposite direction current through said relay winding and thereby is ineffective for picking up said relay winding, and apparatus controlled by said detector relay contact and distinctively responsive according as that contact is or is not being repeatedly shifted between its said picked up and released positions.

3. In combination, a control circuit that includes a pair of conductors which normally are capable of transmitting energy between given and opposite ends of the circuit but which at times are rendered incapable of such transmission, positive and negative sources of master code energy at the given end of said circuit, a coding device having a first contact which repeatedly connects said circuit conductors first to said positive source and then to said negative source and thereby produces a master code made up of recurring energy pulses which have positive and negative polarities in alternating sequence, a repeater relay for said coding device having a contact which interrupts each of said conductor-to-source connections early in the code period that the connection defines and which thereby causes each of said master code pulses to be followed by an "off" period interval, means located at the opposite end of said circuit and operated by the there received pulses of said master code energy for further supplying said conductors with pulses of feed back energy that recur in step with said master code "off" periods and that have positive and negative polarities in alternating sequence, a code following detector relay at said given circuit end having an operating winding and being provided with a contact which picks up when given direction current is passed through said winding but which stays released when that winding receives opposite direction current or no current at all, second and third contacts of said coding device which operate in synchronous relation with respect to that relay's said first contact and which in cooperation with said repeater relay contact bridge said detector relay winding directly across said circuit conductors during master code "off" periods of odd number and reversely across said conductors during master code "off" periods of even number whereby each conductor-transmitted pulse of said positive polarity feed back energy and of said negative polarity feed back energy flows given direction current through said winding and thereby picks up said detector relay contact and whereby each

conductor-supplied pulse of said positive polarity master code energy and of said negative polarity master code energy flows opposite direction current through said detector relay winding and thereby is ineffective for picking up said detector relay contact, and apparatus controlled by said detector relay contact and distinctively responsive according as that contact is or is not being repeatedly shifted between its said picked up and released positions.

4. In combination, a control circuit that includes a pair of conductors which normally are capable of transmitting energy between given and opposite ends of the circuit but which at times are rendered incapable of such transmission, positive and negative sources of master code energy at the given end of said circuit, a coding device having a contact which repeatedly connects said circuit conductors first to said positive source and then to said negative source and thereby produces a master code made up of recurring pulses which have positive and negative polarities in alternating sequence, a repeater relay for said coding device having a first contact which interrupts each of said conductor-to-source connections early in the code period that the connection defines and which thereby causes each of said master code pulses to be followed by an "off" period interval, means located at the opposite end of said circuit and operated by the there received pulses of said master code energy for further supplying said conductors with pulses of feed back energy that recur in step with said master code "off" periods and that have positive and negative polarities in alternating sequence, a code following detector relay at said given circuit end having an operating winding and being provided with a contact which picks up when given direction current is passed through said winding but which stays released when that winding receives opposite direction current or no current at all, second and third contacts of said repeater relay which operate in synchronous relation with respect to that relay's said first contact and which in cooperation with said coding device contact bridge said detector relay winding directly across said circuit conductors during master code "off" periods of odd number and reversely across said conductors during master code "off" periods of even number whereby each conductor-transmitted pulse of said positive polarity feed back energy and of said negative polarity feed back energy flows given direction current through said winding and thereby picks up said detector relay contact and whereby each conductor-supplied pulse of said positive polarity master code energy and of said negative polarity master code energy flows opposite direction current through said detector relay winding and thereby is ineffective for picking up said detector relay contact, and apparatus controlled by said detector relay contact and distinctively responsive according as that contact is or is not being repeatedly shifted between its said picked up and released positions.

5. In combination, a control circuit that includes a pair of conductors which normally are capable of transmitting energy between given and opposite ends of the circuit but which at times are rendered incapable of such transmission, means at the given end of said circuit for supplying said conductors with master code energy in the form of recurring "on" period pulses that are separated by "off" period intervals and that have positive and negative polarities in al-

ternating sequence, a code following relay at the opposite end of said circuit having a winding which is connected with said conductors and being provided with a contact which responds to each winding-received pulse of said positive polarity master code energy by moving to a first position and which responds to each winding-received pulse of said negative polarity master code energy by moving to a second position, positive and negative sources of feed back energy at said opposite circuit end, means including said relay contact and effective upon each of said first positionings thereof for connecting said negative source with said circuit conductors by way of said winding and in such manner as to pass through the winding current that continues said contact in said first position and that impresses a pulse of negative feed back energy upon those conductors, means also including said relay contact but effective upon each of said second positionings thereof for connecting said positive source with said circuit conductors by way of said relay winding and in such manner as to pass through the winding current that continues said contact in said second position and that impresses a pulse of positive feed back energy upon those conductors, a repeater device for said relay which interrupts each of said feed back supply connections before the end of the master code "off" period during which that connection occurs, and apparatus at said circuit's given end controlled by the said polarized feed back pulses which are there received and selectively responsive according as said reception does or does not take place.

6. In combination, a control circuit that includes a pair of conductors which normally are capable of transmitting energy between given and opposite ends of the circuit but which at times are rendered incapable of such transmission, means at the given end of said circuit for supplying said conductors with master code energy in the form of recurring "on" period pulses that are separated by "off" period intervals and that have positive and negative polarities in alternating sequence, a code following relay at the opposite end of said circuit having a winding which is connected with said conductors and being provided with a contact which responds to each winding-received pulse of said positive polarity master code energy by moving to a first position and which responds to each winding-received pulse of said negative polarity master code energy by moving to a second position, positive and negative sources of feed back energy at said opposite circuit end, means including said relay contact and effective upon each of said first positionings thereof for connecting said negative source with said circuit conductors by way of said winding and in such manner as to pass through the winding current that continues said contact in said first position and that impresses a pulse of negative feed back energy upon those conductors, means also including said relay contact but effective upon each of said second positionings thereof for connecting said positive source with said circuit conductors by way of said relay winding and in such manner as to pass through the winding current that continues said contact in said second position and that impresses a pulse of positive feed back energy upon those conductors, a repeater device for said relay which interrupts each of said feed back supply connections before the end of the master code "off" period during which that connection oc-

curs, a contact of said repeater device which upon each of said feed back supply interruptions connects said relay winding in direct energy receiving relation with said circuit conductors, and apparatus at said circuit's given end controlled by the said polarized feed back pulses which are there received and selectively responsive according as said reception does or does not take place.

7. In combination, a control circuit that includes a pair of conductors which normally are capable of transmitting energy between given and opposite ends of the circuit but which at times are rendered incapable of such transmission, means at the given end of said circuit for supplying said conductors with master code energy in the form of recurring "on" period pulses that are separated by "off" period intervals and that have positive and negative polarities in alternating sequence, a code following relay at the opposite end of said circuit having a winding which is connected with said conductors and being provided with a contact which responds to each winding-received pulse of said positive polarity master code energy by moving to a first position and which responds to each winding-received pulse of said negative polarity master code energy by moving to a second position, positive and negative sources of feed back energy at said opposite circuit end, means including said relay contact and effective upon each of said first positionings thereof for connecting said positive source with said circuit conductors whereby to supply them with a pulse of positive feed back energy that continues said contact in said first position, means also including said relay contact but effective upon each of said second positionings thereof for connecting said negative source with said circuit conductors whereby to supply them with a pulse of negative feed back energy that continues said contact in said second position, a repeater device for said relay which interrupts each of said feed back supply connections before the end of the master code "off" period during which that connection occurs, and apparatus at said circuit's given end controlled by the said polarized feed back pulses which are there received and selectively responsive according as said reception does or does not take place.

8. In combination, a section of railway track, means including a coding device at the exit end of said section for supplying the section rails with master code energy in the form of recurring pulses that are separated by "off" period intervals, means located at the entrance end of said section and operated by the there received pulses of said master code energy for further supplying said conductors with pulses of feed back energy that recur in step with said master code "off" periods and that have positive and negative polarities in alternating sequence, a code following detector relay at said section's exit end having an operating winding and being provided with a contact which picks up when given-direction current is passed through said winding but which stays released when that winding receives opposite direction current or no current at all, means governed by said coding device for establishing from said rails to said detector relay winding a connection which is direct during each master code "off" period of odd number and reversed during each master code "off" period of even number and over which each conductor-transmitted pulse of said positive polarity feed back energy and of said negative polarity feed back energy flows in said given-direction current through said relay winding and thereby picks

up said relay contact, and apparatus controlled by said detector relay contact and distinctively responsive according as that contact is or is not being repeatedly shifted between its said picked up and released positions.

9. In combination, a stretch of railway track arranged into first and second sections that adjoin at a common point, means at the remote end of said second section for supplying the second section rails with master code energy in the form of recurring pulses that are separated by "off" period intervals and that have positive and negative polarities in alternating sequence, means at the said point of section junction for repeating into the rails of said first section each pulse of said master code energy that is received at that junction point and for coinciding the polarity of each repeated pulse with that of the received pulse by which it is produced, means located at the remote end of said first section and controlled by the said repeated pulses of master code energy that are there received for further supplying said first section rails with recurring pulses of feed back energy that coincide with the "off" period intervals of said repeated master code and that have positive and negative polarities in alternating sequence, further means at the said point of section junction for repeating into said second section rails during the "off" period intervals of said second section master code the pulses of said feed back energy that are there received from said first section rails and for coinciding the polarity of each repeated pulse with that of the received pulse by which it is produced, and apparatus controlled by said repeated feed back pulses and distinctively responsive according as those pulses are or are not being received at the remote end of said second section.

10. In a coded track circuit signalling system for railroads, a section of railway track, means for applying to the rails at one end of the section time-spaced impulses of opposite polarities alternately, a two-position polarized relay connected across the rails at the opposite end of said section, means responsive to each operation of said polarized relay for applying an inverse code pulse to the track rails, and means at said one end of said track section distinctively controlled in accordance with the presence or absence of said inverse code pulses.

11. In a coded track circuit signalling system for railroads, a code transmitting and receiving means comprising, a code following track relay, a source of energy, a transmitting relay operable to its opposite positions at any desired code rate, a two position polarized timing relay, circuit means for operating said timing relay to an opposite position upon each operation of said transmitting relay to an opposite position, and means including contacts of said transmitting relay and said timing relay to normally connect said track relay across the rails of a track section but acting upon each operation of said transmitting relay to disconnect said track relay from said rails and momentarily connect said source across said rails until said timing relay is operated.

12. In combination, a stretch of railway track arranged into first and second sections that adjoin at a common point, means at the remote end of said second section for supplying the second section rails with master code energy in the form of recurring pulses that are separated by "off" period intervals and that have positive and negative polarities in alternating sequence, means at the said point of section junction for repeating into the rails of said first section each pulse of said master code energy that is received at that junction point and for causing said repeated pulses to have positive and negative polarities in alternating sequence, means located at the remote end of said first section and controlled by the said repeated pulses of master code energy that are there received for further supplying said first section rails with recurring pulses of feed back energy that coincide with the "off" period intervals of said repeated master code and that have positive and negative polarities in alternating sequence, further means at the said point of section junction for repeating into said second section rails during the "off" period intervals of said second section master code the pulses of said feed back energy that are there received from said first section rails and for causing said repeated pulses to have positive and negative polarities in alternating sequence, and apparatus controlled by said repeated feed back pulses and distinctively responsive according to those pulses are or are not being received at the remote end of said second section.

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