

- [54] **JOINTLESS CODED ALTERNATING
CURRENT TRACK CIRCUITS**
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[51] Int. Cl. B611 23/30
[58] Field of Search 246/28, 33, 34 R,
246/34 CT, 36, 37

[56] **References Cited**
UNITED STATES PATENTS

3,575,595 4/1971 Pace 246/36
2,884,516 4/1959 Staples 246/34 R

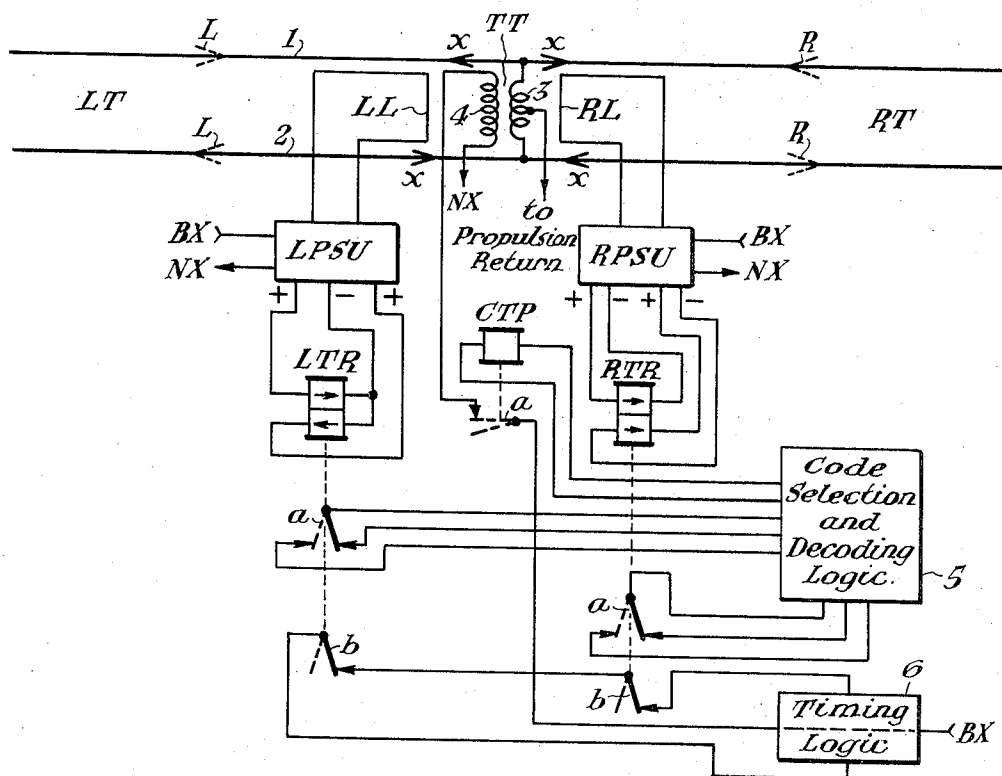
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[57] **ABSTRACT**

Coded alternating current at the same low frequency

is supplied at each location to the rails through a track transformer and transmitted in each direction into the adjoining track sections. The transformer secondary connected across the rails divides the track into sections without insulated joints. At each location, a separate phase sensitive unit is inductively coupled to the rails of each adjoining section to receive energy from the coded track currents. Each phase sensitive unit is also energized from the local alternating current source with the phase relationship so selected that the unit responds only to track current from the distant end and not to the locally transmitted track current. Each phase sensitive unit operates a code following track relay in response to the received distant end coded track current energy and the relay operation is decoded to determine section occupancy and/or advance traffic conditions. A timing logic means controls repeated cycles of alternate reception and transmission of track current at each location to eliminate interference between the local and distant end track currents in each section as received by the phase sensitive unit.

10 Claims, 3 Drawing Figures



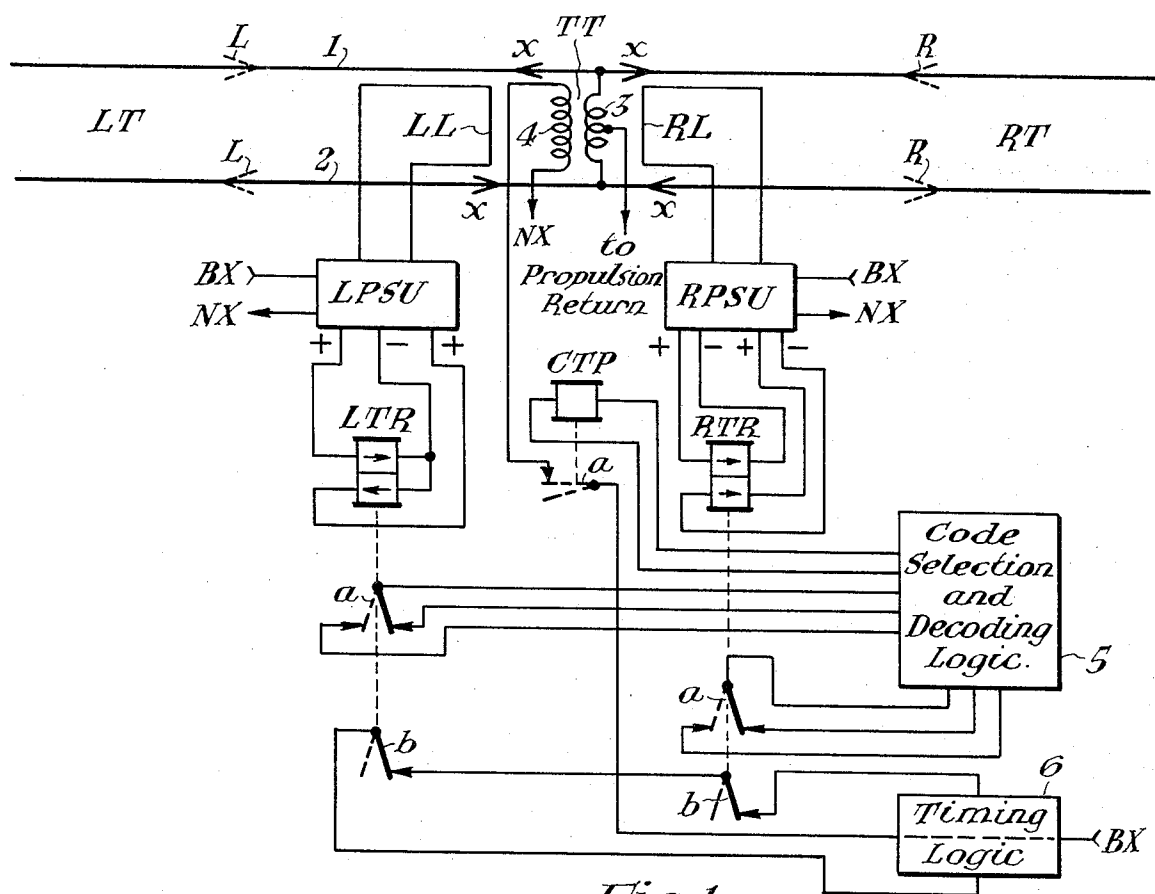


Fig. 1.

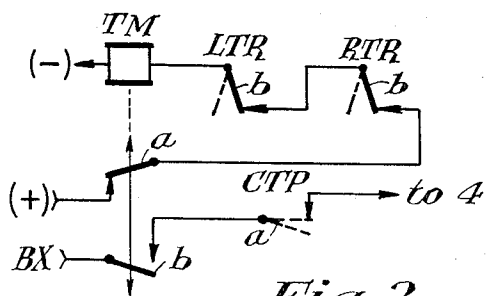


Fig. 2.

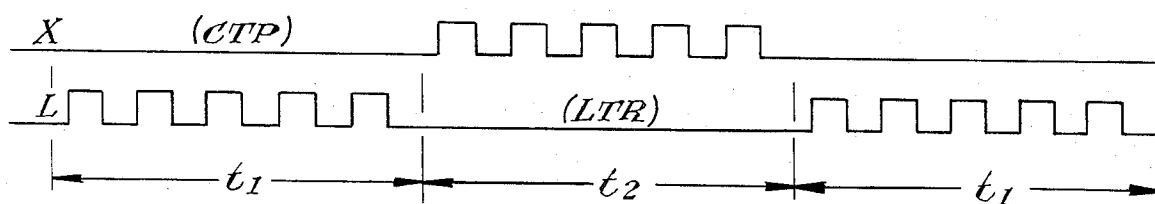


Fig. 3.

JOINTLESS CODED ALTERNATING CURRENT TRACK CIRCUITS

BACKGROUND OF THE INVENTION

My invention pertains to jointless coded alternating current track circuits. More particularly, this invention relates to a coded alternating current track circuit arrangement which avoids interference between adjacent track circuits, even though no insulated joints are used, by phase relationship and timing of the track currents.

One major problem in railway signaling systems is the maintenance of insulated track or rail joints which are used to electrically separate conventional track circuits whether of the coded or noncoded type. The passage of trains along the track causes such insulated joints to wear and thus break down. These joints must then be replaced in order to renew the electrical separation of the adjoining track circuits. This, of course, requires labor and thus increases the maintenance costs. Such joints must also be frequently checked and tightened in a regular maintenance schedule. As in any industry, the use of additional labor always adds to the cost of the system. In addition, the proper positioning of insulated joints for optimum signal locations may not fit into the regular joint spacings, especially where continuous welded rail is in use. The use of continuous welded rail is, of course, increasing since it improves the quality of the track and reduces all track maintenance costs. Jointless track circuits are already known and used in the railway signaling art. At the present, this type of track circuits normally uses a higher frequency than conventional insulated circuits, that is, above the commercial frequency level in the audio or even higher ranges. Such circuits also require that different frequencies be used in order to separate adjoining track circuits so that signal section limits may be accurately detected. The use of different frequencies requires special and extra apparatus to generate such frequencies and also to receive the track currents. Although obviously some means of separating adjoining jointless track circuits is required regardless of the type, an arrangement of track circuits using commercial frequencies, the same in each track circuit, has distinct advantages even though special transmitting provisions must be used to separate or limit the detection ranges of such circuits. Further, since higher frequencies are effective over increasingly shorter length track circuits and thus reduce the selected length of sections in a system, the use of a commercial range frequency will permit longer and thus fewer track circuits in a signal system.

Accordingly, an object of my invention is an improved jointless track circuit arrangement for railroad signaling systems.

Another object of the invention is a jointless track circuit arrangement in which phase relationship of the track currents is used to maintain separation between adjoining track circuits.

A further object of the invention is a coded phase sensitive, jointless track circuit arrangement for railroad signaling systems.

Yet another object of my invention is a jointless coded alternating current track circuit arrangement using the same low frequency energy in all track circuits.

It is also an object to provide a coded alternating current track circuit arrangement for two-direction signaling without requiring insulated joints and yet capable

of distinguishing between the advance traffic conditions for each direction of train movement.

Still another object of my invention is a phase sensitive, jointless, coded alternating current track circuit arrangement using a track transformer to couple the low frequency alternating current source to the rails at each section location, and with phase sensitive track receivers coupled to the rails by loops on each side of the transformer to discretely receive and respond only to coded track current transmitted from the other end of the corresponding section and yet remain nonresponsive to the locally transmitted track current.

Also an object of my invention is a jointless track circuit arrangement in which coded low frequency alternating current is alternately transmitted and received at each between-section location, the transmitter and receiver elements being coupled to the rails by a track transformer and wire loops, respectively, the receivers being phase sensitive so as to respond only to track current transmitted from the next location transmitter at the other end of the associated track section.

Other objects, features, and advantages of my invention will become apparent from the following specification when taken in connection with the accompanying drawings and appended claims.

SUMMARY OF THE DISCLOSURE

In practicing the invention, a stretch of railroad track having electrically continuous rails is divided into track sections by connecting the secondary of a track transformer across the rails at selected locations, generally those at which wayside signals are positioned. Each such between-section or signal location includes the energy source for track circuits which extend in each direction and the receiver elements for other track circuits having sources of energy at the far ends of the two adjoining track sections. A source of alternating current energy is connected, through a coding contact, to the primary of the track transformer and thus coupled to the rails to transmit coded track current in each direction from the location. This is a low frequency current, the same at each location, either obtained from the commercial power source at regular commercial frequencies or, if electric propulsion is in use, possibly obtained through frequency doubler apparatus from the propulsion source. In electric propulsion territory, the transformer secondary also serves as a cross bond to balance the propulsion return current and is provided with a center tap to connect to bonds in other tracks and/or to the propulsion return leads.

A separate receiver means is coupled to the rails on each side of the transformer secondary by a wire loop positioned so as to be in inductive relationship with each rail. Although herein only a wire loop pickup means is illustrated, it will be obvious that equivalent devices, such as a pair of receiver coils placed adjacent the rails, may be substituted. Each receiver means includes a phase sensitive unit which controls a code following track relay. Each phase sensitive unit is also supplied with local energy from the alternating current source, so connected that the phase relationship with respect to the energy received through the rail coupling is such that the phase sensitive unit responds only to the track current transmitted through the rails from the coded current transmitter at the far end of the corresponding track section and not to the locally transmitted track current. In other words, the local track cur-

rent transmitter circuitry is so connected that the phase of the local track current is reversed with respect to the phase sensitive unit so that the track relay is not operated by the local track current but follows only the coded track current transmitted from the distant end. In this manner separation between the adjoining track circuits is maintained and the occupancy of either section by a train is separately determined or detected. However, to avoid other types of interference between the track currents from the different sources, they are applied alternately at adjacent locations. The principal interference which may be encountered is a cancelling effect due to the opposite flow of current in the rails. Thus the transmitting period at the location alternates with the receiving period so that the two currents do not simultaneously appear in the rails. This alternate application of the different track currents through the rails is controlled by a timing logic means at each location which energizes the local coded current source and then deenergizes it for equal periods. An interlock arrangement between the received coded current, the timing means, and the transmitted coded energy assures the alternate operation. The track relay associated with each phase sensitive unit follows the received code from the other end of the corresponding section during the assigned timing period. Although not shown in detail, the code rate is registered, decoded, and the wayside signals actuated accordingly for either direction of traffic. Such decoding and signal control, of course, are conventional, as will be shortly discussed.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

I shall now describe in greater detail the apparatus and the operation of one track circuit arrangement embodying the details of my invention, and will then point out the novelty in the appended claims. During the detailed description, reference will be made from time to time to the accompanying drawings in which:

FIG. 1 is a diagrammatic illustration of apparatus at one between-track-section or signal location in a track circuit arrangement embodying one form of my invention.

FIG. 2 is a circuit diagram of a simple form of timing logic usable in the arrangement of FIG. 1.

FIG. 3 is a chart illustrating the timing between the transmitted and received coded track currents at the location illustrated by the apparatus of FIG. 1.

In each of the drawings, similar reference characters designate or refer to similar items of apparatus.

Referring to FIG. 1, across the top the two parallel lines designate rails 1 and 2 of a stretch of track which extends in each direction, for example, between station locations on the railroad. In other words, only a small portion of the stretch of track is shown but it is to be understood that similar signal locations, such as illustrated here, are located along the track to the right and left of the drawing. Each of the rails 1 and 2 is electrically continuous, that is, no insulated joints are used to separate the track into track sections. However, at selected locations, such as illustrated in FIG. 1, the stretch is divided into track sections by cross bonds, such as winding 3, connected between the rails. Winding 3 is actually the second of track transformer TT which has a primary winding 4. Winding 3 provides a shunt between the two rails and thus a completed cir-

cuit path for track currents flowing in the rails from locations to the left and right of the illustrated location. Where electric propulsion is used for the trains, winding 3 also provides a path to equalize the propulsion return current in the rails and may be center tapped, as illustrated, to provide a connection to propulsion return leads and/or to similar cross bond paths in other parallel tracks. Winding 3 thus serves as a marker or divider between track sections RT and LT to its right and left, respectively. In other words, the location at which wayside signals may be located is designated by the connection of winding 3 between the rails and such signals provide controls for traffic moving in either direction along the stretch of track. Such signals are conventional, and likewise their control arrangement, and thus are not shown since they do not form a part of my invention and are not needed for an understanding thereof.

Each track section is provided with a track circuit supplied with alternating current through transformer TT, at the location shown, and also through a similar transformer at the signal location at the opposite end of each section. Thus each track circuit has a two-directional form. Track circuit energy is supplied from an alternating current source whose terminals are designated by the references BX and NX. It is a feature of the invention that such energy may be derived from the commercial power source and thus is of low frequency, for example, 60 Hz. An alternate possibility is that the alternating current source, designated by the terminals BX and NX, may be derived from the alternating current propulsion energy, in electrified territory, through frequency doubler apparatus or an equivalent arrangement. In this type of installation, the low frequency for the track circuits will be in the range from 50 to 120 Hz. The propulsion current and track circuit currents must obviously be distinguishable from each other by having different frequencies even though the track current source is derived from a propulsion source.

Track circuit energy is applied to primary winding 4 of the transformer and is thus coupled to the rails. This energy is coded or modulated in any well-known manner. In the specific illustration, the track current is shown as being coded by code transmitter repeater relay CTP which is driven by code pulses at a rate selected in accordance with the advance traffic conditions by the code selection and decoding logic apparatus, shown as a conventional block 5. In other words, the single contact *a* of relay CTP continually operates between its picked-up and released positions, closing in the former position the front contact circuit at the selected code rate. Such continuous coding operation is indicated in a conventional manner by showing the contact armature dotted in each position to designate that contact *a* of relay CTP has no normal position but continually operates between its two extreme positions. The code rate selection for driving relay CTP is illustrated only in a conventional manner since the selection of such code rates in accordance with advance traffic conditions in the selected direction of movement is well known and frequently used in the art. This code rate selection forms no part of my invention.

The alternating current energy supplied to winding 4 and thus to the rails is also periodically interrupted in a pattern illustrated in the upper line of the chart in FIG. 3. This is controlled by the timing logic apparatus illustrated by a conventional block 6 with a specific

simple example shown in FIG. 2. The description of the operation of the timing logic and the requirements for this operation will be included later. The instantaneous flow of the track current supplied by transformer TT is shown by the arrows X superposed on the rail symbols 1 and 2 in the vicinity of winding 3. It will be obvious that energy induced in winding 3 causes current to flow in each direction in the rails from this location. The significance of illustrating the instantaneous polarities will appear hereinafter when the matter of separating the response of the receiving apparatus for each section is explained.

The equivalent instantaneous flow of track current resulting from the energy supplied to the rails at the opposite ends of sections LT and RT is indicated by the arrows superposed on the rail symbols 1 and 2 and designated, respectively, L and R. The circuit for the flow of these currents is completed by winding 3 connected between the rails at this location. Arrows L and R also indicate the instantaneous polarity of these other track currents if they are applied at the same time as the current designated by the arrows X. Track energy received from the opposite end of each section is received by a receiver means coupled to the rails by a wire loop and comprising a phase sensitive unit designated by the general reference PSU and a track relay generally referenced TR. Specifically, for track section LT, the wire loop is designated LL, the phase sensitive unit is shown by a conventional block LPSU, and the track relay is LTR. A portion of each wire loop, as schematically shown, is laid in close proximity to and parallel with each of the rails so as to be in inductive relationship therewith. The loop is closed by a cross connection between the parallel wires placed as close as possible to the rail connections for winding 3. The entire length of each wire loop is normally sufficient to pick up by induction the required amount of energy for operation of the associated unit PSU, although a shorter loop and amplifier element may be used if such is more desirable. Obviously, each wire loop will have induced therein energy as a result of the flow of any of the track currents in the rails of the corresponding section.

The induced energy received in each track loop is supplied to the associated phase sensitive unit PSU, which in turn controls a track relay TR. Specifically, energy induced in loop LL is applied to unit LPSU which then controls the code following operation of relay LTR. Each unit PSU, shown by a conventional block, is similar to that shown in my prior U.S. Pat. No. 2,884,516, issued Apr. 28, 1959, for a Phase Sensitive Alternating Current Track Circuit. Particular reference is made to FIG. 1 of this prior patent. The input from the track loop, such as LL, is applied to winding 12, shown in the prior patent, while energy from the local source, as shown by terminals BX and NX at left of block LPSU, is applied to winding 15. The unit direct current outputs from the rectifiers K1 and K2 are designated by the positive (+) and negative (-) signals associated with each output lead except that, for purposes of an alternate illustration, the two negative leads from the rectifiers are combined in a single output lead for unit LPSU.

Each track relay TR is a magnetic stick type relay illustrated by symbols designating two-winding relays although for relay LTR the upper and lower winding right-hand terminals are joined so that in effect a single winding with a center tap results. Such magnetic stick

type relays are well known and have the operating characteristic that, when a current flows through either or both windings in the direction of the arrow symbol shown therein, the relay operates its contacts to a normal or herein illustrated left-hand position. When current flows in either or both windings in a direction opposite to the arrow symbol within that winding, the relay contacts are then operated to the reverse or right-hand position. When energy is removed from the windings, the contacts remain in the position to which last operated. It is to be noted that the contacts of these relays are shown with their movable portion or armature in a substantially vertical alignment, as is conventional for such relays. The armatures are shown solid in the reverse position and dotted in the normal position to signify that, when operating, these relays follow code. As already mentioned, relay RTR is shown as having two separate windings. Each is separately connected to a pair of output leads from the associated unit RPSU, whereas relay LTR, shown by a similar symbol, is in effect a single winding relay with the ends of the windings connected to the positive output terminals of unit LPSU and the winding center tap connected to the common negative terminal. It is to be understood that two-winding relays or single-winding relays with winding center tap may be used for each of the relays LTR and RTR, and that there is no requirement that the relays be of different types, as herein illustrated in order to cover both types of relays and connections to the associated PSU units.

As explained in my cited prior patent, the instantaneous polarity of the connections to the local source terminals BX and NX is carefully selected for each unit PSU to produce a coded output for operating the associated relay TR only when the received current from the track has the prior instantaneous polarity of phase relationship. Specifically, the phase relationships of the connections are selected to allow the operation of relay TR only when track current is received through the corresponding track section, that is, from the transmitter at the opposite end, and not when energy is induced in the track loop by the transmission of current through the local track transformer TT. In other words, unit LPSU provides an output for operating relay LTR to its normal position only when energy is received as a result of the flow of track current, designated by arrows L, from the opposite end of section LT. At other times unit LPSU responds to the application of energy from the local source to hold relay LTR in its reverse position. Since current designated by the arrows L occurs in a coded pattern, that is, alternately "on" and "off," the output of unit LPSU is such as to cause relay LTR to operate alternately between its normal and reverse positions following the coded track current. A similar operation of relay RTR is controlled by unit RPSU when it receives coded track current, designated by the arrows R, from the opposite end of section RT.

The code following operation of contact *a* on either relay TR is decoded by the decoding logic portion of the conventional block 5, as designated by the typical connections from contact *a* of relay LTR to block 5. A simple means of decoding such operation is shown in my cited prior patent which merely detects that the track relay TR is following code or is not following code and thus determines the occupancy condition of the section. However, more elaborate decoding networks are known and will be required if wayside signal-

ing indications are to be determined by the received code rate which reflects the advance traffic conditions in the corresponding direction of train movement. Since such decoding arrangements and the control of wayside signals are well known and conventional and are not part of my invention, the schematic illustration connecting contact *a* of each track relay TR to the decoding logic block 5 is sufficient for an understanding of the arrangement.

As already explained the selected phase relation of the connections to the local source terminals BX and NX for each unit PSU are such that the transmission of current from the same location, as designated by the arrows X superposed upon the rail symbols, will not actuate either phase sensitive unit to operate the associated track relay in a code following operation. However, the simultaneous transmission of the local current with the reception of either or both currents from opposite ends of the illustrated track sections may interfere with the pickup of energy by loop LL and RL and the corresponding response of the associated unit PSU. For example, the opposite phase of currents X and L may cancel the energy pickup in loop LL so that no track energy is applied to unit LPSU. Thus a time separation, illustrated by the chart of FIG. 3, is necessary to avoid interference and to enable the proper reception of the incoming track current. As illustrated in the lower line of the chart of FIG. 3, track current L is received during period t_1 and unit LPSU responds to this reception of current as picked up by loop LL to operate relay LTR in a code following operation. The operation of relay LTR ceases at the end of the period t_1 and the timing logic 6 then enables the transmission of coded track current X by the local transmitter means.

In FIG. 1, the timing logic is shown as enabling the transmission of current X by the completion of the circuit connection from terminal BX of the local source through coding contact *a* of relay CTP, and thus the supply of such coded energy to winding 4 of track transformer TT. As an alternate, timing logic 6 could enable the transmission of the local current by completing the control circuit from the code selection portion of block 5 which controls the code following operation of relay CTP. In this arrangement, it is to be noted that, if relay CTP is held released, its contact *a* opens the supply of energy to track transformer winding 4. In either arrangement, track current X is then supplied by the code following operation of contact *a* of relay CTP during the period t_2 immediately subsequent to the aforementioned period t_1 . These periods are substantially equal and the cycle repeats as illustrated by the subsequent period t_1 during which track current L is again received. It is to be noted that the specific number of pulses of track currents X and L shown during periods t_1 and t_2 are by way of illustration only and do not specifically designate that only five pulses will occur. The length of the time period as well as the selected code rate at each location will determine the number of track current pulses.

A simple timing logic arrangement is shown in FIG. 2 which would find use principally if coded track circuits are used only for train detection and signal indications and/or traffic direction are controlled other than by the code rate. However, the same type of timing logic circuit is adaptable with modifications for a full coded track signaling system. In the arrangement of FIG. 2, a timing relay TM is provided which has slow

pickup and release characteristics, as designated by the upward and downward pointing arrows drawn through the movable portions of the relay contacts. This relay is controlled by a circuit extending between the positive and negative terminals, designated by appropriate symbols, of a local direct current source and including back contact *a* of relay TM itself and reverse contacts *b*, in series, of relays LTR and RTR. Thus relay TM cannot pick up if either associated track relay is in its normal position so that its reverse contact *b* is open. When relay TM picks up, the closing of its front contact *b* completes a connection from terminal BX of the local alternating current source to contact *a* of relay CTP and thus allows a supply of coded energy to winding 4 of track transformer TT. The pickup time of relay TM is set to be slightly longer than the off period of the coded current received through either track section LT or RT. Thus, for relay TM to pick up, relays LTR and RTR must simultaneously occupy their reverse positions, closing corresponding contacts *b*, for a period slightly longer than the normal off time of their code following operation.

At the end of period t_1 , illustrated in FIG. 3, after the final pulse of track currents L and R is received, relay TM picks up to close its front contact when a period slightly in excess of the coding off time of relay LTR/RTR has elapsed. The release time of relay TM is set to be substantially equal to the time period t_2 . Since this time period begins as soon as relay TM picks up to open its back contact *a* in its energizing circuit, front contact *b* of relay TM will remain closed for a period equal to period t_2 . Coded current, designated by the arrows X, will be transmitted during this period. When relay TM releases, the transmission of this track current is interrupted. A similar timing logic arrangement at each location at the opposite ends of the sections LT and RT will thus be activated shortly after the end of period t_2 since the relay TM at these locations will have the same pickup time and thus track currents L and R will shortly be transmitted. In other words, the pickup of relay TM at alternate locations occurs during alternate timing periods illustrated in FIG. 3.

In connection with this type of coded track current operation, the decoding of the received current, that is, the decoding of the operation of relay LTR and/or RTR by the decoding logic portion of block 5, requires special timing in order to bridge the long off period, that is, period t_2 as illustrated in FIG. 3. For example, if the simple decoding arrangement of my previously cited prior U.S. Pat. No. 2,884,516 is used, an extended slow release time of the two decoding relays would provide a bridging of the long off period. Such an arrangement is shown, for example, in my prior U.S. Pat. No. 2,496,607, issued Feb. 7, 1950, for Coded Signaling Apparatus. Similar principles are applicable to more elaborate decoding arrangements. For example, a signaling system using a slow code in each direction requiring a separation of the directional code and special decoding arrangement to bridge such long periods is shown in U.S. Pat. No. 2,728,851, issued Dec. 27, 1955 to Charles B. Shields for a Single Track Railroad Signal System Using Coded Track Circuits. Although the arrangements shown in these cited patents are not identical to the present condition, they illustrate that similar timing principles are known and may be adapted to provide decoding logic for my present arrangement.

Briefly describing the operation of the arrangement, coded track current flows from the transmitters at the opposite ends of the sections LT and RT. These currents, designated by the arrows L and R, have the proper phase relationship to cause units LPSU and RPSU, respectively, to respond and in turn control relays LTR and RTR to operate to follow the received code. The operation of each relay is decoded to determine the track occupancy of the corresponding section and/or the advance traffic conditions in the corresponding direction. Depending upon the type of signal system in use, the establishment of a traffic direction through the stretch of track may inhibit the response of the track relay for the opposite direction. For example, if traffic is established from right to left through the stretch, the response of relay RTR to coded track current R received through section RT may be inhibited since it would not be pertinent to the signal indication displayed for a train moving in the established direction. Alternately, the control of the opposing wayside signal by the decoding logic in accordance with the operation of relay RTR may be inhibited and the operation of relay RTR retained for approach control of cab signal current or the lamps of the pertinent wayside signal when the approach of the train in section RT is detected.

At the end of time period t_1 of FIG. 3, coded track currents L and R are removed at the opposite ends. Relays LTR and RTR remain in their reverse position since the associated phase sensitive unit in each case responds to the application of only local current to operate and hold the relay in its reverse position. The timing logic detects the simultaneous halt of the code following operation of both relays LTR and RTR and enables the transmission of coded track current X by relay CTP through track transformer TT. At the end of timing period t_2 , the timing logic then inhibits the transmission of track current X from the local transmitter means. Shortly, the transmission of the currents from the opposite end of each track section resumes as the timing logic at those locations detects the half of current X and these alternate transmission cycles repeat. The operation of relay LTR or RTR, in accordance with the established traffic direction, is then decoded by the decoding logic to control the signal indication displayed for a train moving in the established traffic direction. The selection of the code rate for the operation of relay CTP is also determined by the decoding logic to reflect the advance traffic conditions and to cause the display of the appropriate signal indication at the next location in approach in the traffic direction.

The arrangement of my invention thus provides a convenient method of using jointless track circuits, yet supplying each with the same low frequency alternating current energy. With this feature, commercial power sources or simple apparatus for deriving the source from electric propulsion energy may be used for the track circuit supply. Track circuit operation is separated from that of the adjoining sections by a combination of phase relationship and timing of the track currents and the local supply. Each track circuit will basically support two-direction train operation but may be modified for single-direction operation only. Separate train detection is accomplished in each track section and the traffic condition in the advance section may be determined at each signal location. In addition, code control of the wayside signal indications in accordance

with the advance traffic conditions may be utilized by providing different code rates in a well-known manner. All apparatus required to provide the arrangement is of standard type known in the art and requires no unusual design. An efficient and economical jointless track circuit system is thus provided using standard equipment and known signaling practices.

Although I have herein shown and described but one jointless coded alternating current track circuit arrangement embodying the features of my invention, it is to be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. At each of selected locations along a stretch of railroad track having electrically continuous rails, jointless track circuit apparatus comprising in combination,
 - a. a cross bond connected between rails to shunt current supplied by distant sources for dividing said stretch into two adjoining track sections extending to the next adjacent locations,
 - b. a local source of alternating current having the same frequency as the corresponding source at each adjacent location,
 1. said source coupled to the associated cross bond for supplying to said rails track current having a first predetermined phase relationship to the track currents supplied at each adjacent location,
 - c. a separate track receiver means coupled to the rails on each side of the rail connections of said cross bond for receiving energy in accordance with the track current flowing in the rails at any instant,
 1. each track receiver means also connected to said local source for receiving supplemental energy at another predetermined phase relationship with said track energy and jointly controlled thereby for responding only to track current supplied to the rails at the other end of the corresponding section, and
 - d. a timing means controlled by each receiver means for periodically operating on a repeated cycle between a first and a second condition as a receiver means is responding or both receivers are not responding to track current, respectively,
 1. said timing means having connections for inhibiting the supply of track current from said local source when in its first condition,
 - e. each receiver means further operable for registering a nonoccupied and an occupied condition of the corresponding track section as track current is received and not received, respectively, from the other end of that section.
 2. Track circuit apparatus as defined in claim 1 in which,
 - a. said cross bond is the secondary winding of a track transformer, and
 - b. said local source is connected to the primary winding of said track transformer for supplying said track current having said first predetermined phase relationship.
 3. Track circuit apparatus as defined in claim 2 which further includes,
 - a. a coding means connected for modulating the energy supplied from said local source to said track transformer primary winding, and

- b. a decoding means controlled by each receiver means for demodulating the energy received from the corresponding track section for registering the occupancy condition of that section.
- 4. Track circuit apparatus as defined in claim 3 in which each receiver means comprises,
 - a. phase sensitive device coupled to said rails for receiving track energy and also connected to said local source for receiving said supplemental energy at said other predetermined phase relationship, and
 - b. a track relay control by said phase sensitive device for alternately operating between a first and a second position in response to the reception of coded track energy only when said other predetermined phase relationship exists,
 - c. said track relay controlling the associated decoding means to register a nonoccupied condition of the corresponding section only when said relay alternately operates between its two positions, and an occupied condition when said relay remains in its second position.
- 5. A jointless track circuit arrangement for a stretch of railroad track having electrically continuous rails, comprising in combination at each of selected locations,
 - a. a track transformer means having a primary and a secondary winding, said secondary winding connected between the rails to divide said stretch into adjoining track sections,
 - b. a source of alternating current having the same frequency as each adjacent location source,
 - c. a code transmitter means connected between said source and said primary winding for supplying a coded track current having a predetermined phase relationship to the coded track current similarly supplied to the rails at each adjacent location,
 - d. a separate receiver means coupled to said rails on each side of the secondary winding rail connections for receiving coded energy from the track current then flowing,
 - 1. each receiver means also controlled by said alternating current source for responding only to energy received from track current transmitted through the rails from the other end of the corresponding track section to register the absence of any train in that section, and
 - e. timing logic means connected to said source and controlled by both receiver means for periodically alternating the supply of coded track current from that location with the reception of track current transmitted from the other end of each adjoining section.
- 6. A track circuit arrangement as defined in claim 5 in which each receiver means comprises,
 - a. phase sensitive apparatus operable to supply a first output signal only when local and track input signals have a predetermined phase relationship and a second output signal at other times,
 - b. said phase sensitive apparatus connected to receive local input signals from said alternating current source and coupled to said rails in the vicinity of said secondary source winding rail connections to receive track input signals from the track current then flowing, said source selectively connected so that said predetermined phase relationship exists only when said track input signals result

- from track current transmitted from the other end of the corresponding track section,
- c. a track relay connected for receiving output signals from said phase sensitive apparatus and operable periodically between first and second positions, respectively, when said first and second output signals alternate periodically as coded track current is received through the rails from the other end of said corresponding section,
- d. said track relay further connected for registering a nonoccupied condition indication for the corresponding section when operating alternately between its first and second position and an occupied condition indication when remaining in its second position.
- 7. A track circuit arrangement as defined in claim 6 in which said timing logic means comprises,
 - a. a slow acting relay having a preselected pickup time longer than a coded track current off time and a preselected release timing period longer than a selected plurality of coded track current cycles, and
 - b. a control circuit for said slow acting relay including in series a second position contact of each track relay and a released position contact of said slow acting relay,
 - c. the connections between said source and said track transformer primary winding further including a picked up position contact of said slow acting relay for interrupting the supply of coded track current from that location when said slow acting relay is released.
- 8. A track circuit arrangement as defined in claim 5 which further includes at each location,
 - a. a track loop positioned in inductive relationship with the rails of each adjoining track section in the vicinity of the secondary winding rail connections for receiving induced energy in accordance with the track current flowing at any instant in the corresponding section,
 and in which each receiver means comprises,
 - b. phase sensitive apparatus first connected to the corresponding track loop for receiving the energy induced therein by the existing track current and further selectively connected to said alternating current source to receive supplemental operating energy having a second predetermined phase relationship with the track currents such that said phase sensitive apparatus produces a coded output energy only when the energy received from the associated track loop is that induced by coded track current transmitted from the other end of the corresponding section, and
 - c. a track relay controlled by said phase sensitive apparatus for operating between first and second positions to register a nonoccupied section indication only in response to coded output energy from the phase sensitive apparatus and for holding in its second position to register an occupied section indication when track current from said other end is not received.
- 9. A track circuit arrangement as defined in claim 8 in which,
 - a. said timing logic means is operable to a first and a second condition to inhibit and enable, respectively, the supply of track current from the associated location,

13

- b. said timing logic means controlled by both associated track relays, when either follows a code output from the corresponding phase sensitive apparatus, for remaining in its first condition,
 - c. said timing logic means operable to its second condition a preselected time period after said track relays cease code following operation, longer than a track code off time, and self-controlled to subsequently remain in said second condition for a second preselected time period longer than a selected plurality of track code cycles.
10. A jointless coded track circuit arrangement for a stretch of railroad track having electrically continuous rails, comprising in combination,
- a. a track transformer at each location between track sections having a primary winding and a secondary winding connected across the rails to divide the track into sections without insulated joints,
 - b. a source of alternating current at each location having the same frequency as each other source,
 - c. a code transmitter means at each location connected to the associated primary winding and said location source for supplying coded alternating track current at a selected rate to the rails for transmission into each adjoining track section,
 - 1. the track current transmitted from each location having a predetermined phase relationship to the track currents transmitted from each adjacent location,
 - d. a separate phase sensitive unit coupled to the rails on each side of the secondary winding rail connections at each location for receiving first input signals from the track currents flowing in the rails of

14

the corresponding section,

- 1. each phase sensitive unit also connected for receiving section input signals from the associated alternating current source,
- 2. said second input signals having another predetermined phase relationship to the track currents such that each phase sensitive unit provides a first output signal only when said first input signal results from track current transmitted from the other end of the corresponding section and a second output signal at all other times,
- e. a separate track relay connected for receiving the output signals from each phase sensitive unit at each location and operable to a first and a second position as first and second output signals, respectively, are received,
- f. a decoding means at each location controlled by both track relays for registering a nonoccupied indication for an adjoining track section when the corresponding track relay operates alternately between its first and second positions, as coded track current from the other end of that section flows in the section rails, and an occupied indication as that relay remains in its second position, and
- g. timing logic means at each location connected to the associated alternating current source and controlled by both associated track relays for periodically alternating the supply of coded track current from that location with the reception of coded track currents transmitted from the outer ends of said adjoining sections.

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