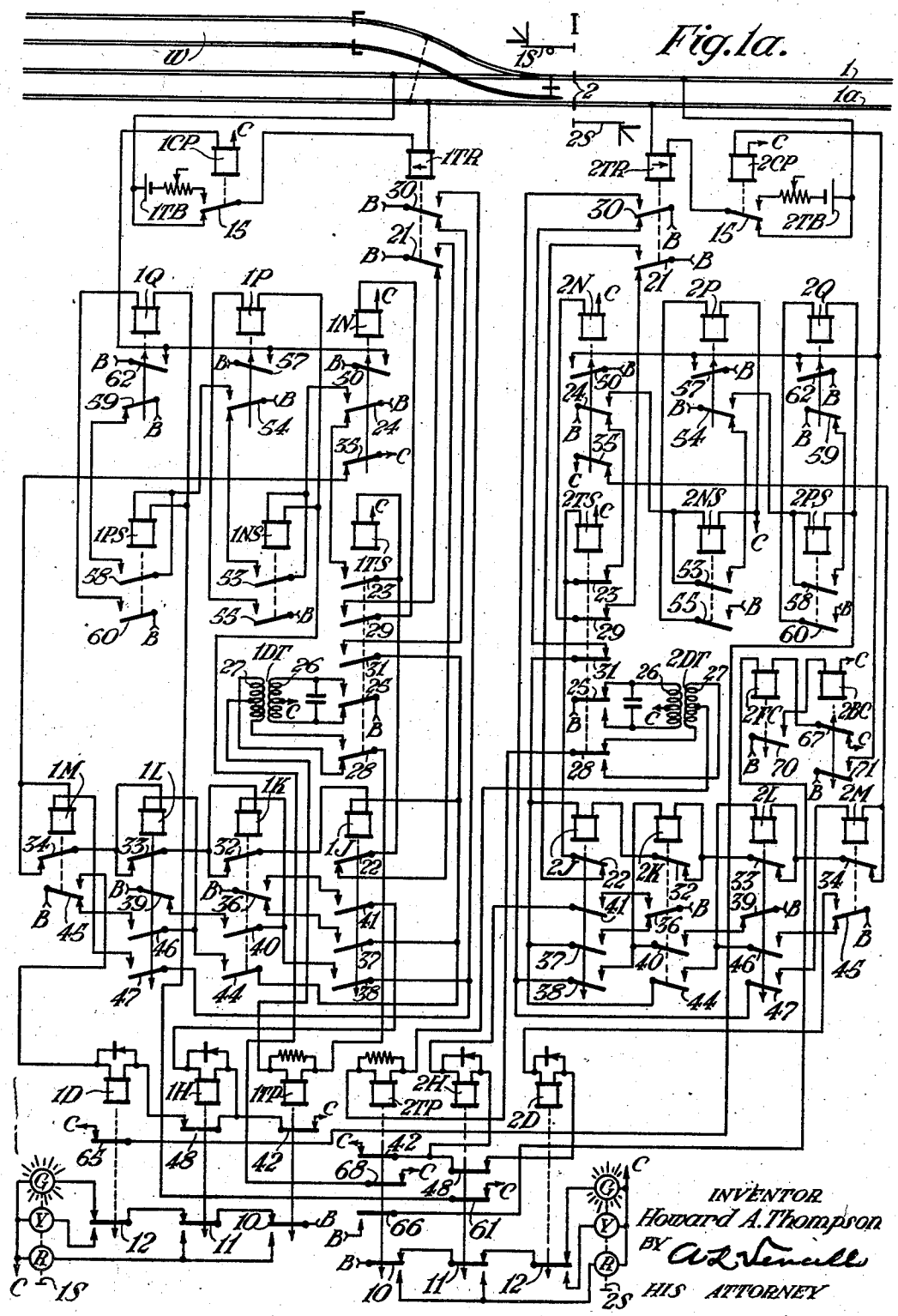
May 28, 1946. H. A. THOMPSON 2,401,201

RAILWAY TRAFFIC CONTROLLING APPARATUS

Filed July 31, 1942 4 Sheets-Sheet 1

Fig. 1a.

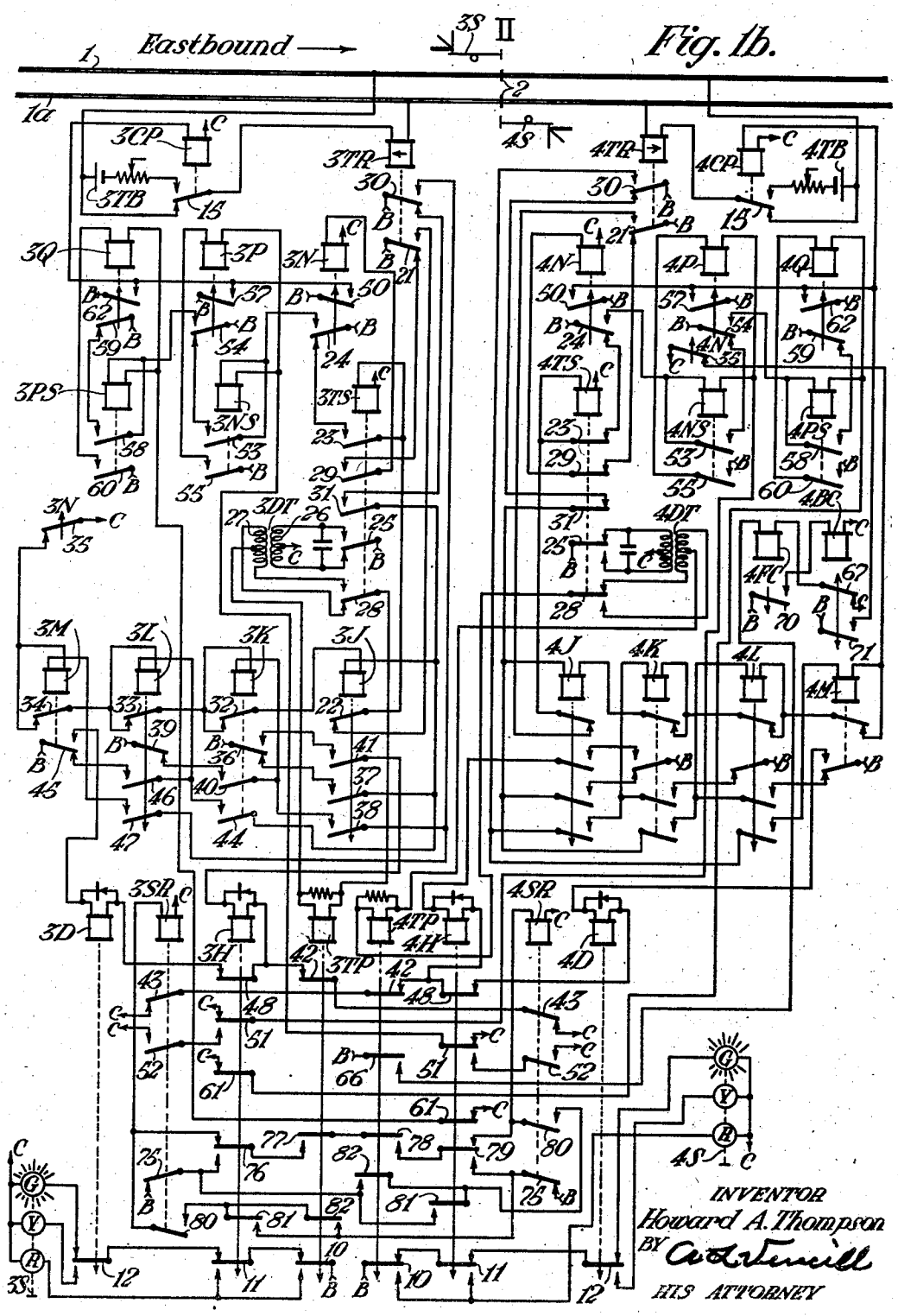


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RAILWAY TRAFFIC CONTROLLING APPARATUS

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Fig. 1b.

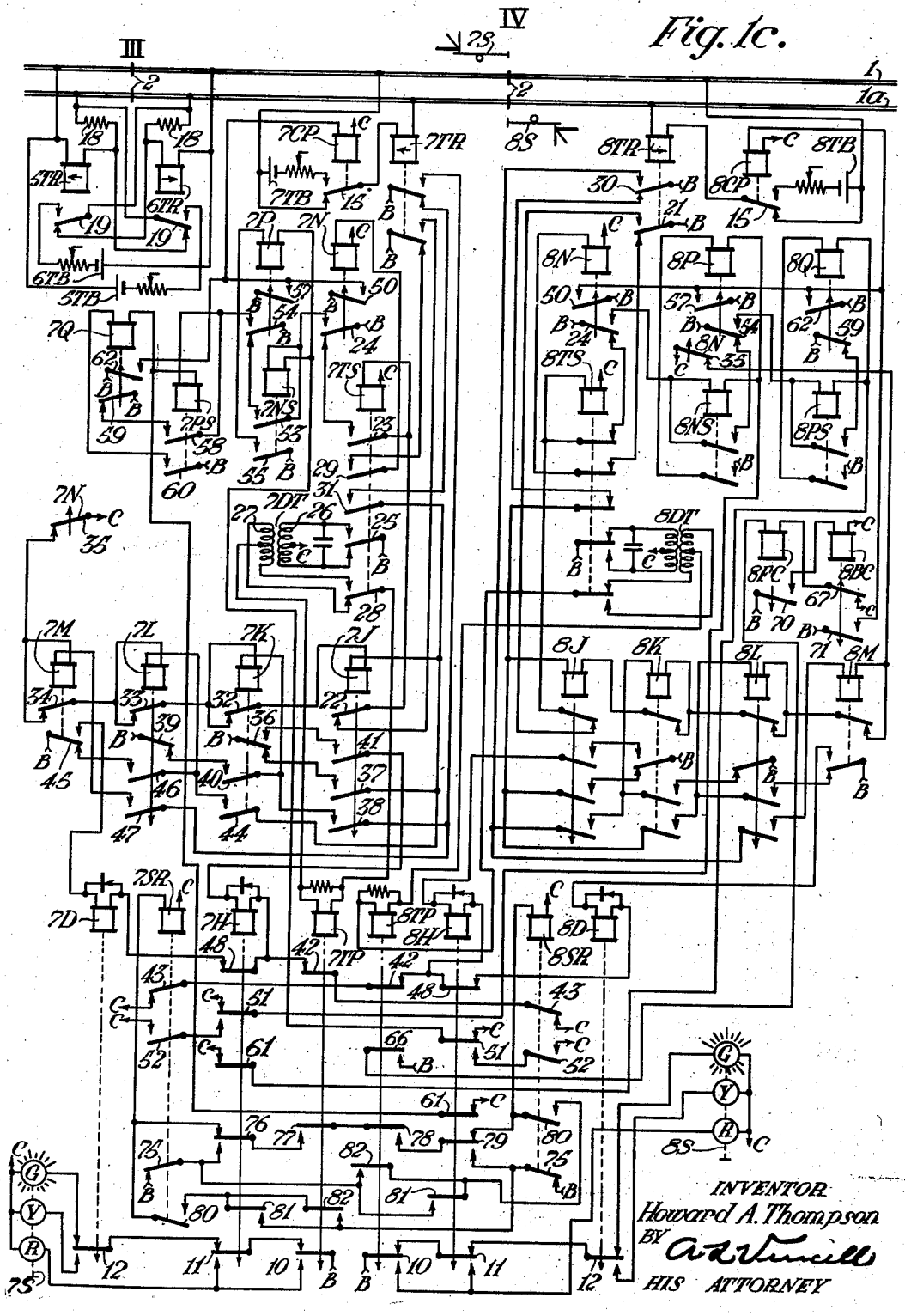


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RAILWAY TRAFFIC CONTROLLING APPARATUS

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Fig. 1c.

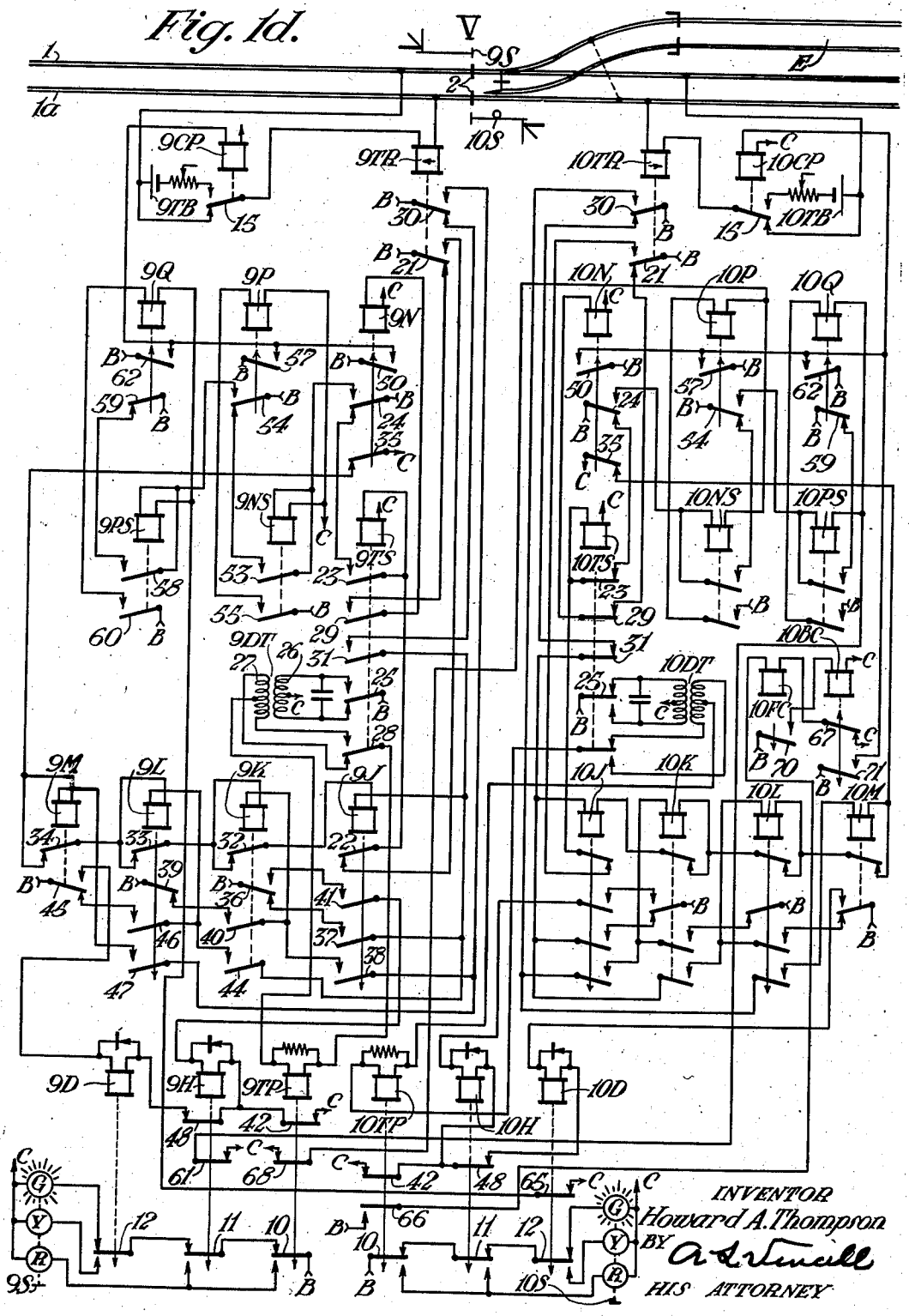


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RAILWAY TRAFFIC CONTROLLING APPARATUS

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Fig. 1d.



Patented May 28, 1946 2,401,201

UNITED STATES PATENT OFFICE

2,401,201

RAILWAY TRAFFIC CONTROLLING APPARATUS

Howard A. Thompson, Edgewood, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application July 31, 1942, Serial No. 452,983

13 Claims. (Cl. 246—33)

My invention relates to railway traffic controlling apparatus, and has particular reference to novel and improved forms of railway traffic controlling systems of the absolute permissive block (A. P. B.) type arranged to control the movement of traffic in either direction over a stretch of single track railway. More particularly, my invention relates to A. P. B. signal systems of the class incorporating coded track circuits arranged to obviate the use in such systems of control line wires.

It has been proposed heretofore to provide A. P. B. signal systems which incorporate coded track circuits arranged in such a manner as to render unnecessary the use of control line wires. One system of this type is disclosed in Letters Patent of the United States No. 2,280,491, granted on April 21, 1942, to Ralph R. Kemmerer. The system of this patent employs two track circuits for each track section, with the coded current (master code) for one track circuit supplied from one end, and the coded current (feed back code) for the other track circuit supplied from the other end of the section, the second track circuit being dependent for its operation upon the supply of code to the first track circuit from a suitable code transmitter or coding device.

It is an object of my present invention to provide a novel and improved A. P. B. signal system which also employs two track circuits per section, but which operate on the "self-generating" code principle disclosed in a copending application, Serial No. 443,240, filed on May 16, 1942, by John M. Pelikan. In accordance with this principle, the codings of the two track circuit energies of a section are made mutually dependent and each coded energy is generated in response to the presence of the other coded energy.

Another object of my invention is the provision of a novel and improved signal system incorporating coded track circuits which are arranged so that in normal operation coded energy is generated without requiring special devices, such as code transmitters.

A further object is the provision of a novel and improved A. P. B. signal system in which traffic in either direction over a stretch of track is controlled by coded track circuit energy of the "count code" type.

An additional object is the provision of a novel and improved form of signal system of the class in which use of all control line wires is made unnecessary by the employment of coded type track circuits.

Another object is the provision, in a signal system of the single track, two direction type, of coded track circuit current having a plurality of code patterns one of which is employed solely to detect the presence of traffic and the others of which are employed to establish control over traffic.

A still further object is the provision of novel and improved track circuits of the self-generating code class.

Another object is the organization of railway traffic controlling apparatus into a novel and improved form of railway signal system.

The above-mentioned as well as other important objects and characteristic features of my invention which will become readily apparent from the following description, are attained in accordance with the invention by organizing into an A. P. B. signal system, apparatus which provides each section of track with two track circuits one for each direction of traffic on the stretch. Each of these track circuits is supplied with coded current, which current reflects traffic conditions in advance for the associated direction of traffic and which is generated in response to the presence of track circuit current in the other track circuit of the section. Incorporated into the system are means for attaining absolute opposing and permissive following protection for trains on the stretch.

Other features of the invention reside in the particular apparatus employed and in the specific arrangement of such apparatus, as will be pointed out in detail hereinafter in the specification and claims.

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

In the accompanying drawings, Figs. 1*a*, 1*b*, 1*c* and 1*d*, when placed side by side with Fig. 1*a* on the left, are a diagrammatic view illustrating apparatus and circuits comprising a portion of an absolute permissive block signal system embodying my invention. In each of the several figures of the drawings, similar reference characters have been employed to designate corresponding parts.

Referring to the drawings, the reference characters 1 and 1*a* designate the track rails of a stretch of railway track connected by track switches with successive passing sidings W and E. The rails of the stretch are divided by insulated joints 2 into a plurality of successive adjoining track sections I—II, II—III, III—IV and IV—V.

The reference characters S with suitably dis-

tinguishing prefixes designate signals for governing traffic operating in either direction over the stretch. For the purposes of the present description, it will be assumed that eastbound traffic is in the direction of the arrow and operates from left to right (as viewed in the drawings) over the stretch. Such traffic is therefore governed by signals having even numbers in their respective prefixes, while traffic operating in the opposite or westbound direction is governed by signals having odd numbered prefixes. In accordance with the usual custom in A. P. B. signaling, signals 2S and 9S at the leaving ends of traffic sidings W and E, respectively, are absolute or "stop and stay" signals and will be termed headblock signals, while the other signals of the stretch are permissive or "stop then proceed" signals.

The signals S may be of any suitable type, but for the purpose of this application it will be assumed that the signals are of the color light type and that each comprises a plurality of lamps G, Y and R effective when illuminated to display a "clear," "approach," or "stop" aspect, respectively. Each signal S has associated therewith a "distant" signal control relay D; a "home" signal control relay H; and a detector control relay TP. The manner in which these relays are controlled will be made clear presently but at this time it should be pointed out that the signal control relays govern local circuits over which the associated signals are respectively controlled. Each signal is caused to display its clear aspect when the associated distant, home and detector relays are picked up; is caused to display its approach aspect when the associated distant relay D is released and its associated home H and detector TP relays are picked up; and is caused to display its stop aspect when its associated distant D and home H relays are released, irrespective of whether the associated detector relay TP is picked up or released. Thus, for example, signal 1S at location I will display its clear aspect when its lamp G is energized over a circuit which may be traced from one terminal B of a suitable source of energy, such as a battery not shown but having its terminals designated by the reference characters B and C, through front contact 10 of relay 1TP, front contact 11 of relay 1H, front contact 12 of relay 1D and the filament of lamp G of signal 1S to the other terminal C of the source of current; the signal will display its approach aspect when lamp Y is energized over a circuit extending from terminal B through front contact 10 of relay 1TP, front contact 11 of relay 1H, back contact 12 of relay 1D and the filament of lamp Y of signal 1S to terminal C; and the signal will display its stop aspect when lamp R is energized over a circuit which extends from terminal B either through front contact 10 of relay 1TP and back contact 11 of relay 1H or through back contact 10 of relay 1TP, then through the filament of lamp R of signal 1S to terminal C.

The signal control relays are provided with slow releasing features in any suitable manner. Relay 1TP, as shown, may be made slow to release by connecting a resistor across its terminals, while relays 1H and 1D may be made slow to release, as shown, by connecting asymmetrical units across their respective terminals. Other expedients may be employed to provide the slow release features, as for example copper ferrules may be placed on the relay magnetic circuits and/or electrolytic condensers may be connected across the relay terminals in series with a resistor.

The wayside signals S are arranged to be controlled through the medium of the associated control relays in accordance with the usual A. P. B. practice by apparatus arranged to provide each track section with two track circuits, one for each direction of traffic. These track circuits are arranged to incorporate the self-generating code principle of the aforesaid Pelikan application Serial No. 443,240. In general, each section is provided with the following: two sources of track circuit energy, which sources may for example be track batteries designated by the reference character TB with suitably distinguishing prefixes, one battery for each end of a section, respectively; two track relays, designated by the reference character TR with suitably distinguishing prefixes, one relay for each end of a section; decoding means operatively associated with each track relay for detecting and translating the operation of the associated track relay in response to coded current received by the track relay from the rails of the section; and code generating means operatively associated with each track relay for generating coded energy which is applied to that end of the section for causing operation of the track relay at the opposite section end.

The track circuit apparatus of each section is arranged so that the track relay at one end of a section is at times connected through the track rails in series with the track relay and source at the other or opposite section end, while at other times the track relay at said other section end is connected through the track rails in series with the track relay and source at the said one section end.

To effectuate this arrangment, each track relay has associated therewith a code repeater relay, designated by the reference character CP with a suitable distinguishing prefix, arranged when picked up to connect the associated track relay TR and source TB in series with the track rails and effective when released to connect only the track relay TR but not the associated source TB to the rails. Code repeater relay 2CP associated with relay 2TR of section I—II, for example, when picked up establishes a circuit connection which extends from rail 1*a* of section I—II, through the winding of relay 2TR, front contact 15 of relay 2CP, and the battery 2TB to the other rail 1 of the section. When relay 2CP is released, the winding of the associated track relay 2TR is connected across the rails 1 and 1*a* over an obvious circuit which includes back contact 15 of relay 2CP. The other track relay 3TR and battery 3TB of section I—II are similarly connected to rails 1 and 1*a* of the section by the associated code repeater relay 3CP, hence it follows that when code repeater relay 3CP is picked up and relay 2CP is released, both track relays 2TR and 3TR will be connected in series with battery 3TB through the track rails, and when relay 2CP is picked up and relay 3CP is released, both relays 2TR and 3TR will be connected in series with the other battery 2TB through the track rails.

The track batteries TB of a given section are poled in such a manner that the rail current flows in opposite directions in the two track circuits of the section, and the two track relays of such section are of the biased polar neutral type that will respond to current of but one relative polarity. Each of the track relays of a section bears an identifying symbol in the form of an arrow to indicate the polarity of current to which the relay is responsive. Relay 2TR, for example, bears an arrow that points from left to right as

viewed in the drawings and indicates that the relay will respond to current of the polarity that will make the left-hand terminal of the relay positive. The track relays and track batteries are so arranged that each track relay will be non-responsive to current supplied from the associated source at the same end of the section but will respond to current supplied from the source at the opposite section end. Relay 2TR will thus be picked up by energy supplied from battery 3TB but not from battery 2TB, whereas relay 3TR will be picked up by current supplied from battery 2TB but not from battery 3TB.

The code generating means associated with each track relay comprises a plurality of impulse relays, designated by the reference characters N, P and Q, each with a suitably distinguishing prefix; a plurality of stick relays, designated by the reference characters NS and PS, each with a suitably distinguishing prefix; and in addition one track relay of each section has associated therewith code initiating or resetting means comprising two auxiliary relays FC and BC provided for the associated detector control relay TP. The auxiliary relay BC and each impulse relay N, P and Q is effective when picked up to energize and pick up the associated code repeater relay CP, thereby to cause that repeater relay to connect its associated source TB to the track rails and apply an impulse of energy to such rails. The impulse relays N, P and Q are controlled, as will be made clear presently, in such a manner as to cause the energy impulses applied to a track circuit to reflect traffic conditions in advance for the direction of traffic governed by such track circuit. This control of the impulse track current is accomplished by supplying to a track circuit one or another of a plurality of codes of the count code type. These codes are each comprised of impulses of energy that are supplied in recurrent groups of one, two, three, or more impulses per group. The impulses preferably are of approximately equal length and are separated from one another by relatively short "off" periods, while the groups of impulses are separated from each other by an "off" or open circuit interval of relatively longer duration.

The apparatus represented in the drawings embodying the present invention is arranged to employ three different codes of the count code type, but it is to be understood, of course, that a larger or smaller number of such codes may be employed if conditions warrant. One of the three codes employed comprises recurrent groups of three energy impulses; a second code comprises recurrent groups of two impulses; while the third code comprises successive single energy impulses. The first two codes are employed, as will be described in detail hereinafter, to indicate or reflect "clear" and "caution" traffic conditions, respectively, while the third code is employed solely as a detector code and its presence reflects an unoccupied condition of the track.

The decoding means associated with each track relay comprises a track stick relay, designated by the reference character TS with a suitably distinguishing prefix; a decoding transformer, designated by the reference character DT with a suitably distinguishing prefix; a plurality of impulse counting relays, designated by the reference characters J, K, L and M, respectively, each with a suitably distinguishing prefix; and the distant, home and detector control relays D, H and TP, hereinbefore mentioned. These control relays are governed by the associated track stick and impulse counting relays in such a manner that when the associated track relay TR responds to a single pulse of energy recurrently applied to the section rails, detector relay TP only is picked up; when the associated track relay responds to a code pattern comprising recurrent groups of two successive impulses of energy, detector relay TP and home control relay H associated therewith are picked up and the associated signal is conditioned to display its "caution" aspect, as pointed out hereinbefore; and when the code pattern comprises recurrent groups of three successive impulses of energy, the detector control relay TP, home control relay H and distant control relay D associated therewith are all picked up and as a result the associated signal is conditioned to display its "clear" aspect. The particular arrangement of this apparatus and the manner of its operation will be given in the description which follows.

The reference characters SR with suitably distinguishing prefixes designate the usual directional stick relays which are provided in pairs at each signal location other than at a headblock location. These stick relays function to establish directional control of traffic on the stretch in a manner that will be made clear presently.

The system organization may also include cut-section apparatus which is effective to repeat or cascade code energy from one section to the next. A suitable form of such apparatus is represented in Fig. 1c at the cut-section location III. This apparatus comprises two track batteries TB and two track relays TR, one for each section and each connected across the rails of the associated section through a current limiting resistor 18. Each cut-section track relay when released completes through its back contact 19 an obvious shunt circuit around the current limiting resistor 18 of the other cut-section track relay, and each of these track relays when picked up opens the shunt circuit and connects its associated track battery TB to the rails of the other section in multiple with the series combination of the winding of the other cut-section track battery and the associated resistor 18. It is thus readily apparent that each time a cut-section relay is picked up by a code impulse of energy of the proper polarity received from the rails of its associated section, the battery associated with such cut-section relay is then connected to the rails of the adjoining section to impress thereon an impulse of energy. Each cut-section track relay is thus capable of repeating or cascading track circuit code energy from its associated section into the next adjacent section.

The track circuit apparatus embodying my invention is arranged, as stated hereinbefore, to reflect traffic conditions in advance by applying to the rails of each of the sections track circuit energy coded in one or another of a plurality of different manners each indicative of different traffic conditions. In the normal condition of the apparatus such as is illustrated in the drawings and that obtains when the stretch of track is vacant intermediate the first siding (not shown) to the west of siding W and the first siding (also not shown) to the east of siding E, the two track circuits of each section are then supplied with clear track circuit code comprised of successive groups of three energy impulses. This coded energy is applied to the rails and is detected and translated by the track circuit apparatus of a typical one of the track sections, such as section

I—II, arranged and operating in the following manner.

Referring to the drawings, the track circuit apparatus provided at section end I of section I—II is illustrated in Fig. 1*a* in the condition that is established following the receipt of the last impulse of a group supplied from source 3TB at the opposite section end II, and in which condition the apparatus at section end I is arranged to start the transmission of track circuit code energy to the other end of the section. In this condition of the apparatus, track stick relay 2TS is held energized over a stick circuit that extends from terminal B through back contact 24 of relay 2N, front contact 23, and the winding of relay 2TS to terminal C; relays 2TP, 2H and 2D are deenergized but are represented in their picked-up positions wherein they are held by their slow releasing characteristics, with the result that lamp G of signal 2S is energized over its previously traced circuit; and all other relays at location I associated with section I—II are released. With relay 2CP released, battery 2TB is disconnected from the rails, track relay 2TR is connected across the track rails of the section, and relay 2N is energized over a circuit extending from terminal B through back contact 21 of relay 2TR, front contact 29 of relay 2TS, and the winding of relay 2N to terminal C. Relay 2N is so proportioned as to have a predetermined slow pick-up interval and will pick up at the end of such interval, but at this time it is assumed that the relay is released.

Considering now the apparatus at the opposite end II of the section, this apparatus is illustrated in Fig. 1*b* in the condition that exists following the supply of the last impulse of a group from track battery 3TB to the rails of section I—II, and in which condition the apparatus is arranged to receive energy from the track rails. Under such assumed conditions, relays 3TP, 3H and 3D are deenergized but are represented in their picked-up positions wherein they are respectively held by their slow releasing characteristics with the result that lamp G of signal 3S is energized over an easily traced circuit; and all other relays at location II associated with section I—II are released. Since relay 3CP is released, track relay 3TR is connected to the track rails but battery 3TB is disconnected therefrom. At this time, therefore, both track relays 2TR and 3TR of section I—II are connected in series through the section rails, but no energy source is impressed on the rails hence the relays are both released. This condition is maintained until relay 2N at location I picks up to initiate the transmission of energy from battery 2TB.

In describing the operation of the apparatus of section I—II, I shall first describe in detail the manner in which the code generating apparatus at section end I functions to transmit energy to the track rails, and shall then describe how the decoding apparatus at the opposite section end II detects and translates such energy.

Referring again to the apparatus represented at location I in Fig. 1*a* associated with section I—II, relay 2N picks up, at the end of its predetermined slow pick-up interval, to close its front contact 50 and to open the back point of contact 24 and to close the front point of this contact. When the back point of contact 24 opens, it interrupts the previously traced stick circuit of relay 2TS, whereupon that relay releases and operates its contact member 25 from its front to its back point to reverse the direction in which unidirectional current is supplied over an obvious circuit to winding 26 of transformer 2DT. This results in a reversal of flux direction in the transformer and in the induction of an electromotive force in winding 27 which is impressed across relay 2TP over a circuit that extends from one terminal of winding 27 through back contact 28 of relay 2TS and the winding of relay 2TP to a mid-tap of winding 27. This energy impulse applied to relay 2TP energizes the relay and operates to hold up the relay for its predetermined slow release interval.

In addition, the release of relay 2TS results in the opening of its stick circuit at its front contact 23, and in the opening of the previously traced energizing circuit of relay 2N at front contact 29. Relay 2N accordingly becomes deenergized but its front contacts 50 and 24 remain closed long enough (following the brief energization of relay 2N) to enable relays 2CP and 2NS to be picked up, in the following manner. Relay 2CP is picked up over an obvious circuit which includes front contact 50 of relay 2N, and relay 2CP in turn closes its front contact 15 to connect battery 2TB to the rails of section I—II in series with the winding of relay 2TR. The current supplied from battery 2TB has a polarity such that it does not cause relay 2TR to pick up but is effective to pick up relay 3TR at the opposite section end, but since the operation of relay 3TR by this energy will be described hereinafter in connection with the description of the operation of the apparatus at section end II, no further description of the operation of relay 3TR will be given at this time. Relay 2NS also becomes energized at this time, over a circuit which may be traced from terminal B through front contact 24 of relay 2N, and the winding of relay 2NS to terminal C. This relay picks up and closes its front contact 53 to complete a stick circuit that extends from terminal B through back contact 54 of relay 2P, front contact 53 and the winding of relay 2NS, to terminal C. Front contact 55 of relay 2NS also closes and relay 2P becomes energized over an obvious circuit including this contact. Relay 2P is slow to pick up and will pick up at the end of a predetermined time interval which is considerably shorter in duration than the pick-up interval of relay 2N. The slow pick-up interval of relay 2P may be, for example, only a little longer than the time required for relay 2N to release.

After relays 2CP and 2NS have picked up, relay 2N releases and as a result relay 2CP is deenergized and in turn releases to disconnect battery 2TB from the track rails. This terminates the first impulse of energy of the group that is transmitted from battery 2TB to the rails. Relay 2NS does not release since it is held energized over its previously traced stick circuit, hence the energizing circuit of relay 2P is maintained closed and that relay picks up at the end of its slow pick-up interval. When relay 2P picks up, its back contact 54 opens and interrupts the stick circuit for relay 2NS to deenergize this relay, thus causing the energizing circuit of relay 2P to be interrupted at front contact 55. Relay 2P accordingly becomes deenergized but holds its front contacts 54 and 57 closed for an interval sufficient to enable relays 2CP and 2PS to pick up. Relay 2CP picks up over an obvious circuit including front contact 57 of relay 2P, and again closes its front contact 15 to connect battery 2TB to the rails in series with relay 2TR, thereby to initiate the transmission of the second impulse of energy

through the track rails. Relay 2PS picks up over a circuit extending from terminal B through front contact 54 of relay 2P, the winding of relay 2PS, and front contact 65 of relay 1D, to terminal C. It is to be seen that when relay 1D (which detects the three pulse clear code energy in its associated section in a manner substantially corresponding to that hereinafter described in detail in connection with relay 3D of section I—II) is released, then relay 2PS cannot be energized and as a result the coding action of the apparatus at location I and associated with section I—II will then terminate at the end of the second impulse supplied to the track rails. With relay 1D picked up, however, relay 2PS may be energized and it picks up to close its front contact 58 and complete a stick circuit which passes from terminal B through back contact 59 of relay 2Q, front contact 58 and the winding of relay 2PS, and front contact 65 of relay 1D, to terminal C. Front contact 60 of relay 2PS also closes and it completes an energizing circuit for relay 2Q that extends from terminal B through front contact 60 of relay 2PS, the winding of relay 2Q, and front contact 65 of relay 1D to terminal C. Relay 2Q is slow to pick up and does not do so until shortly after relay 2P releases.

After relays 2CP and 2PS pick up, relay 2P releases and as a result relay 2CP releases to disconnect battery 2TB from the track rails. This terminates the second impulse of energy of the group that is transmitted from battery 2TB. Relay 2PS remains energized, however, over its stick circuit until relay 2Q picks up at the end of its slow pick-up period. When relay 2Q picks up, its back contact 59 opens to deenergize relay 2PS, which relay in turn releases and opens its stick circuit and the previously traced energizing circuit of relay 2Q. Relay 2Q holds its front contact 62 closed, however, for an interval sufficient to energize relay 2CP and cause that relay to close its front contact 15 to again connect battery 2TB to the section rails in series with relay 2TR, thereby initiating the transmission of the third impulse of energy to the rails. Relay 2Q releases shortly after relay 2CP picks up, and relay 2CP accordingly releases to disconnect battery 2TB from the track rails and thus terminate the third impulse of energy that is supplied to the track rails. The apparatus at section end I of section I—II now is in the condition wherein all relays are released except relays 2TP, 2H and 2D, hence the apparatus is conditioned to receive track circuit energy from the rails of the section.

From the foregoing description, it is readily apparent that the code generating apparatus provided at end I of section I—II is arranged to apply an energy impulse to the associated track rails each time one of the impulse relays 2N, 2P and 2Q, picks up; and that each impulse relay is picked up over a front contact of a stick relay held energized over a stick circuit that includes a back contact of the impulse relay. Each impulse relay accordingly interrupts its own circuit when it picks up. The first impulse relay (2N) picks up over a back contact of the track relay and requires that contact to be closed for a predetermined interval of time; and each impulse relay (except the last impulse relay 2Q) picks up the stick relay controlling the succeeding impulse relay. It follows that additional code impulses may be provided, if desired, merely by adding additional stick and impulse relays arranged in the manner described.

The code generating apparatus provided at each of the locations represented in the drawings is all arranged to incorporate the features just described and hence each of such arrangements will function, in general, in the manner just stated. In addition, the arrangement of the apparatus represented at headblock signal locations I and V associated with sections I—II and IV—V, respectively, is further characterized by the fact that the third impulse relay (Q) is controlled over a front contact of the distant control relay (D) of the next adjacent section, hence clear or three pulse track circuit code will be applied to the rails of the associated section when relay D of the next adjacent section is picked up, but when that relay is released the track circuit code is then shifted to the caution or two pulse pattern.

The specific arrangement of the code generating apparatus located at the headblock signal locations I and V and associated with the sections that extend respectively to the west of location I and to the east of location V, is characterized by the fact that the second impulse relay P and its associated stick relay NS are controlled over a front contact 68 of the detector control relay (TP) of the next adjacent section, while the third impulse relay Q and its associated stick relay PS are energized over a front contact 61 of the home control relay (H) of the next adjacent section. Thus, for example, relay 1NS at location I is energized over a circuit that extends from terminal B through front contact 24 of relay 1N, the winding of relay 1NS, and front contact 68 of relay 2TP to terminal C; relay 1P is energized over a circuit that may be traced from terminal B through front contact 55 of relay 1NS, the winding of relay 1P, and front contact 68 of relay 2TP to terminal C; relay 1PS is energized over a circuit passing from terminal B through front contact 54 of relay 1P, the winding of relay 1PS, and front contact 61 of relay 2H to terminal C; and relay 1Q is energized over a circuit extending from terminal B through front contact 60 of relay 1PS, the winding of relay 1Q, and front contact 61 of relay 2H to terminal C. It follows, therefore, that when relays 2TP and 2H are picked up, the code generating apparatus at location I is conditioned to apply clear or three pulse code energy to the section that extends to the west of location I; when relay 2TP is picked up but relay 2H is released, then the code supplied to that section is shifted to the two pulse caution pattern; and when relays 2TP and 2H are both released, then the code energy supplied to the section comprises the one pulse detector code.

The specific arrangement of the code generating apparatus located at the intermediate signal locations II and IV, is characterized by the fact that the second impulse relay P and its associated stick relay NS are controlled over a front contact 51 of the home control relay H of the next adjacent section, or alternately over a back contact of that H relay and a front contact 52 of the directional stick relay SR associated with such next adjacent section; while the third impulse relay Q and its associated stick relay PS are controlled over a front contact 61 of the home control relay H of the next adjacent section. For example, the energizing circuit of relay 3NS at location II extends from terminal B through front contact 24 of relay 3N, the winding of relay 3NS, and the front point of contact 51 of relay 4H, or alternately through the back point of contact 51 and front contact 52 of relay 4SR,

to terminal C; relay 3P is energized over a circuit extending from terminal B through front contact 55 of relay 3NS, the winding of relay 3P, and the front point of contact 51 of relay 4H, or the back point of contact 51 and front contact 52 of relay 4SR, to terminal C; while the energizing circuits of relays 3PS and 3Q are similar, respectively, to the circuits previously traced for relays 1PS and 1Q. It is apparent, therefore, that when relay 4H is picked up, three pulse clear code energy will be applied at location II to section I—II; when relay 4H is released and relay 4SR is picked up, two pulse caution code energy will be applied at location II to this section; and when relays 4H and 4SR are both released, then one pulse detector code energy will be applied at location II to the rails of this section.

The arrangement of controls of the clear and caution codes just described is that usually employed in A. P. B. signaling. It will be obvious, however, that the control of clear and caution codes may readily be altered to accommodate various arrangements of A. P. B. control limits as required by any particular arrangement of track and sidings.

I shall now describe in detail how the decoding means at location II associated with section I—II functions to detect and translate the coded energy that is applied at the opposite section end I by the code generating apparatus thus located. Referring now to the apparatus represented at location II, that apparatus remains in the condition illustrated (relays 3TP, 3H, and 3D picked up but deenergized and all other relays released) until the first impulse of energy is applied from battery 2TB to the rails of section I—II at its opposite end I. When this happens, the energy impulse is transmitted through the track rails of the section to relay 3TR and since it is of the proper polarity to operate relay 3TR, that relay picks up and closes its front contact 21, whereupon track stick relay 3TS picks up over a circuit that extends from terminal B through front contact 21 of relay 3TR, back contact 22 of relay 3J and the winding of relay 3TS, to terminal C. Relay 3TS closes its front contact 23 and completes a stick circuit that extends from terminal B through back contact 24 of relay 3N, front contact 23, and the winding of relay 3TS to terminal C. This stick circuit obviously is effective to maintain relay 3TS picked up until relay 3N is caused to pick up and open its back contact 24.

Relay 3TS also operates its contact 25 from its back to its front point and thereby reverses the direction in which unidirectional current is supplied over an obvious circuit to primary winding 26 of transformer 3DT. This, in turn, reverses the direction of the flux in the transformer and causes an electromotive force to be induced in secondary winding 27, which induced energy impulse is supplied to relay 3TP over a circuit that extends from one terminal of winding 27 through front contact 28 of relay 3TS, the winding of relay 3TP and to the mid-tap of winding 27. This energy impulse energizes relay 3TP and is effective to hold up the relay for its predetermined slow release interval.

At the end of the first track energy impulse, relay 3TR releases and closes its back contact 30 to pick up relay 3J over a circuit that may be traced from terminal B through back contact 30 of relay 3TR, front contact 31 of relay 3TS, the winding of relay 3J, back contact 32 of relay 3K, back contact 33 of relay 3L, back contact 34 of relay 3M, and back contact 35 of relay 3N (which contact is represented remote from relay 3N but bears the reference character 3N to indicate that it is controlled by that relay) to terminal C. It is to be noted that this circuit includes a back contact of each of the relays 3K, 3L, 3M and 3N, thereby checking that such relays are all released before relay 3J can be energized. When relay 3J picks up, it closes its front contact 37 and completes a stick circuit for itself that extends from terminal B through back contact 36 of relay 3K, front contact 37 and the winding of relay 3J, and back contacts 32, 33, 34 and 35 of relays 3K, 3L, 3M, and 3N, respectively, to terminal C.

Relay 3TR in releasing also closes its back contact 21 and relay 3N becomes energized over a circuit extending from terminal B through back contact 21 of relay 3TR, front contact 29 of relay 3TS and the winding of relay 3N to terminal C. Relay 3N is slow to pick up and is proportioned to have a pick-up interval such that the relay will not pick up unless relay 3TR is released for an interval greater than the interval between successive impulses of a group. If, therefore, the energy applied to the track rails is of the single pulse detector type, then relay 3N would pick up at the end of its predetermined pick-up interval following each release of track relay 3TR at the end of each of the single impulses which comprise that type of code. Under such assumed conditions, only detector control relay 3TP would be energized by the operation of relays 3TR and 3TS in response to the coded energy, and relays 3H and 3D would be deenergized to cause the associated signal to display its stop aspect. The energization of relay 3TP accordingly is effective to detect the single pulse detector code energy.

When, however, the energy in the track rails is of the type (as has been assumed) that is comprised of more than a single pulse in each group, then relay 3TR will pick up in response to the second impulse of the group, prior to relay 3N picking up. When relay 3TR picks up, its back contact 21 opens to deenergize relay 3N, and its front contact 30 closes to energize relay 3K over a circuit that passes from terminal B through front contact 30 of relay 3TR, front contact 38 of relay 3J (which relay is now held energized over its stick circuit), the winding of relay 3K, and back contacts 33, 34 and 35 of relays 3L, 3M and 3N, respectively, to terminal C. Relay 3K accordingly picks up and closes its front contact 40 to complete a stick circuit that extends from terminal B through back contact 39 of relay 3L, front contact 40 and the winding of relay 3K, and back contacts 33, 34 and 35 of relays 3L, 3M and 3N, respectively, to terminal C. Relay 3K also opens its back contacts 32 and 36 to open the previously traced stick circuit of relay 3J, which relay is slightly slow to release and holds its front contact 41 closed for an interval during which relay 3H becomes energized over a circuit extending from terminal B through front contact 36 of relay 3K, front contact 41 of relay 3J, the winding of relay 3H, front contact 42 of relay 3TP, and back contact 43 of relay 4SR to terminal C. This energy is effective to maintain relay 3H in its picked-up position for its predetermined slow release interval after relay 3J releases.

At the end of the second energy impulse received from the section rails, relay 3TR releases and closes its back contact 30 to complete a circuit that extends from terminal B through back contact 30 of relay 3TR, front contact 31 of relay

3TS, front contact 44 of relay 3K, the winding of relay 3L, and back contacts 34 and 35 of relays 3M and 3N, respectively, to terminal C, whereupon relay 3L picks up and closes its front contact 46 to complete a stick circuit that extends from terminal B through back contact 45 of relay 3M, front contact 46 and the winding of relay 3L, and back contacts 34 and 35 of relays 3M and 3N, respectively, to terminal C. Relay 3L also opens its back contacts 33 and 39 whereupon relay 3K becomes deenergized and releases to interrupt the energization of relay 3H.

At this time, relay 3N is energized over its previously traced circuit including back contact 21 of relay 3TR, but due to its slow pick-up characteristics, relay 3N does not pick up immediately and will not do so unless relay 3TR remains released, as stated hereinbefore, for an interval greater than the intervals between successive impulses of a group. Thus, for example, should the energy in the track rails be of the two pulse caution type, then relay 3N would pick up at the end of its predetermined pick-up interval following each release of track relay 3TR at the end of each of the second impulses of the groups which comprise the caution code type of energy. In such an event, the detector control relay 3TP and home control relay 3H would be intermittently energized by the operation of relays 3TR, 3TS, 3J and 3K effected by such two pulse coded energy, but relay 3D would be continuously deenergized and would be released with the result that signal 3S would be caused to display its caution aspect. In addition, it is to be noted that relay 3H is controlled over a back contact 43 of stick relay 4SR associated with the next adjacent section II—III, hence it follows that if relay 4SR is picked up, relay 3H cannot be energized and under such conditions signal 3S would be caused to display its stop aspect even though caution or clear code energy might be available in section I—II for operating relay 3TR.

When, however, the code energy in the track rails is of the three pulse clear code type (as has been assumed), then relay 3TR is caused to pick up in response to the third impulse of the group, prior to relay 3N picking up. When relay 3TR picks up, relay 3N is deenergized and relay 3M picks up over a circuit that may be traced from terminal B through front contact 30 of relay 3TR, front contact 47 of relay 3L, the winding of relay 3M and back contact 35 of relay 3N to terminal C. When relay 3M picks up, it opens its back contacts 45 and 34 to deenergize relay 3L, and relay 3M also closes its front contact 45 to energize relay 3D over a circuit that extends from terminal B through front contact 45 of relay 3M, the winding of relay 3D, front contact 48 of relay 3H, front contact 42 of relay 3TP and back contact 43 of relay 4SR to terminal C. It is to be noted that this circuit also includes a back contact 43 of stick relay 4SR, thus requiring that relay to be released in order to enable relay 3D to be energized when the clear code energy is available in its associated section I—II to operate relay 3TR.

At the end of the third energy impulse of a group, relays 3TR and 3M release, and energy is removed from relay 3D, which relay is then maintained in its picked-up position, due to its slow releasing characteristics, for its predetermined release interval. Relay 3N is now energized and will pick up at the end of its slow pick-up interval.

When relay 3N picks up, it will initiate the transmission of code energy from battery 3TB to the rails of section I—II, which coded energy will be generated by the code generating apparatus at location II in a manner that has been made clear hereinbefore. This coded energy will have the proper polarity to cause relay 2TR to pick up, and the decoding means associated with relay 2TR will function to detect and translate such energy in a manner that substantially corresponds to the manner just described for the decoding apparatus at location II associated with relay 3TR.

From the foregoing description, it is readily apparent that the decoding apparatus provided at location II associated with relay 3TR is arranged to pick up the track stick relay 3TS and supply an energizing impulse to detector control relay 3TP whenever relay 3TR is picked up by the first energy impulse of a group received by the track relay; impulse counting relay 3K is picked up to supply an energizing impulse to home control relay H whenever track relay 3TR is picked up by the second impulse of a group and relay 3J is picked up due to the release of relay 3TR following the first energy impulse; and that impulse counting relay 3M is picked up to supply an energizing impulse to distant control relay 3D whenever track relay 3TR is picked up by the third impulse of a group and relay 3L is picked up due to the release of relay 3TR following the receipt of the second energy impulse of the group. It follows, therefore, that the first energy impulse of a group is detected by relay 3TP which is supplied with energy through the medium of the track stick relay 3TS and decoding transformer 3DT; and each of the succeeding impulses of a group is detected by the control relays H and D which are supplied with energy over circuits controlled by impulse counting relays arranged to be sequentially energized, with the first counting relay being energized over a contact of the track stick relay, a contact of the track relay and back contacts of each of the other counting relays. The succeeding impulse counting relays are each energized over a contact of the track relay, a front contact of the impulse counting relay that immediately precedes it in the chain, and back contacts of the counting relays that follow in the chain. It can be seen, therefore, that additional impulses of a group can readily be detected by providing additional counting relays, two for each of the additional impulses, and by arranging the relays in the manner just described.

The decoding apparatus provided at each of the locations represented in the drawings is all arranged to incorporate the features just described and such apparatus will function, in general, in the manner described in detail hereinbefore. Specifically, the decoding apparatus provided at the intermediate signal locations II and IV is all arranged substantially as described hereinbefore and each group of apparatus will function substantially as has been described in detail. The decoding apparatus at the headblock signal locations I and V is characterized by the omission of the directional stick relays SR and hence such apparatus is not governed by such stick relays. Specifically, control relays H and D at such locations are controlled over circuits which correspond to the circuits previously traced for the corresponding relays 3H and 3D at location II, with the exception that at the headblock locations the control circuits do not include the back contact 43 of the directional stick relay SR such

as is employed in the control of the relays 3H and 3D at location II.

As stated hereinbefore, in the normal condition of the apparatus such as is illustrated in the drawings, the two track circuits of each section are supplied with three pulse clear track circuit code, with the result that the three control relays TP, H and D of each section are picked up and each associated signal S is caused to display its clear aspect. These track circuits are arranged to cooperate with the usual directional control means to provide an A. P. B. signal system which functions in the following manner.

In describing the operation of the signal system embodying my invention, I shall assume that with the apparatus in its normal condition as illustrated in the drawings, an eastbound train enters the first section (not shown) to the east of the first siding (also not shown) to the west of siding W represented in Fig. 1*a*. When this happens, the code pattern available in the track circuit associated with relay 1TR is shifted from the clear (three pulse) to the caution (two pulse) code, in a manner to be made clear hereinafter and substantially corresponding to the manner in which code energy applied at location V to the section extending to the east thereof is shifted from the three pulse to the two pulse pattern when the eastbound train enters section I—II. With relay 1TR responding to two pulse code, relay 1D at loctaion I releases and signal 1S is therefore caused to display its caution aspect. In addition, relays 2PS and 2Q associated with relay 2TR have their respective control circuits opened at front contact 65 of relay 1D, with the result that the coded energy supplied from battery 2TB to the rails of section I—II is shifted at this time from the clear (three pulse) to the caution (two pulse) pattern. Relay 3D at location II thereupon releases and signal 3S is caused to display its yellow or caution aspect.

This condition of the apparatus is maintained until the train enters the section (not shown) immediately in the rear or to the west of siding W, and it provides the usual overlap protection found in A. P. B. systems. When the train enters the section in the rear of the section with which relay 1TR is associated, the track circuit code available for relay 1TR is shifted from the caution (two pulse) to the detector (one pulse) pattern, in a manner corresponding to that hereinafter pointed out whereby the code pattern of energy supplied at location V to the section extending to the east of that location is similarly shifted when the eastbound train enters section IV—V. Relay 1H at location I accordingly releases and signal 1S is caused to display its red aspect. This condition obtains until the train enters the section with which relay 1TR is associated, whereupon relay 1TR is shunted and becomes inactive and relay 1TP is caused to release.

When the train enters section I—II, both relays 2TR and 3TR are shunted and become inactive. Control relays 2TP, 2H and 2D associated with relay 2TR accordingly release and cause signal 2S to display its stop aspect; while control relays 3H and 3TP associated with relay 3TR likewise are released and cause the associated signal 3S to display its stop aspect. In addition, the energizing circuits of relays 4PS and 4Q are held open at front contact 61 of relay 3H; while the energizing circuits of relays 4NS and 4P are held open at front contact 51 of relay 3H. With these relays incapable of being energized, the track circuit code supplied at location II to section II—III is shifted from the clear (three pulse) to the detector (one pulse) pattern, and this code is repeated from section II—III into section III—IV by the cut section apparatus at location III, with the result that relay 7TR at location IV follows the detector code and relays 7H and 7D associated therewith become released, thereby causing signal 7S to display its stop aspect. With relays 7H and 7D released, the energizing circuits of relays 8P, 8NS, 8Q and 8PS are held open and the track circuit code that is supplied at location IV to the rails of section IV—V accordingly is shifted from the three pulse (clear) pattern to the one pulse (detector) pattern, to cause relay 9TR to operate in response thereto and in turn cause relays 9H and 9D to release and cause signal 9S to display its stop aspect. Front contact 61 of relay 9H is now open and it interrupts the energizing circuit of relays 10PS and 10Q, whereupon the track circuit code supplied at location V to the section that has its eastbound entrance end at this location, is shifted from the clear (three pulse) to the caution (two pulse) pattern. This caution code energy will be effective to set the westbound signal at the opposite end of passing siding E to caution, thus providing that signal with the form of overlap control that corresponds to that previously described for the control of westbound signal 1S at passing siding W.

From the foregoing, it is apparent that when an eastbound train enters the first section intermediate two successive passing sidings, all of the opposing signals up to the next passing siding are set to stop, while the opposing signal at the opposite end of the next passing siding is placed at caution. In addition, the westbound signal in the rear of the last mentioned signal will also be placed at caution, in a manner corresponding to that hereinbefore described whereby signal 3S is caused to display caution when signal 1S is first shifted to display its caution indication.

At this time, relay 2H holds open its front contact 61 to open at that point the energizing circuits of relays 1PS and 1Q, while relay 2TP holds open its front contact 68 to open the energizing circuits of relays 1NS and 1P. With relays 1P and 1Q held deenergized, the track circuit apparatus at location I that supplies track circuit energy to the section that extends to the west of that location is therefore conditioned to supply energy of the one pulse (detector) code pattern to the track rails, and will do so after the section becomes vacant and relay 1TR initially responds to an initiating code impulse. This initiating impulse is supplied in a manner substantially corresponding to that hereinafter explained in detail in connection with the code initiating apparatus of section I—II. The supply of the one pulse detector code to the rails of the section associated with relay 1TR will cause operation of the decoding means at the opposite section end and, in a manner to be made clear presently, will cause the code generating apparatus at such opposite section end to transmit three pulse clear track circuit code to relay 1TR, whereupon relays 1D, 1H and 1TP will pick up and cause signal 1S to display its clear aspect.

The previously mentioned code initiating apparatus of section I—II is now active to apply single pulses of code initiating or restoring energy to the rails of the associated section. This apparatus comprises a relay 2FC which is energized over a circuit extending from terminal B through back contact 66 of relay 2TP, the winding of relay 2FC and back contact 67 of relay 2BC to terminal C. When relay 2FC picks up, its front

contact 70 closes to energize relay 2BC over an obvious circuit, and when relay 2BC picks up its back contact 67 opens to deenergize relay 2FC while its front contact 71 closes to complete an obvious circuit for relay 2CP whereupon that relay is caused to pick up and close its front contact 15. When this happens, battery 2TB is connected to the track rails in series with the winding of relay 2TR, thereby applying to such rails an energizing impulse that is maintained until relay 2BC releases due to the release of relay 2FC. When relay 2BC releases, its back contact 67 closes to again complete the energizing circuit for relay 2FC whereupon that relay picks up and again closes its front contact 70 to energize relay 2BC. This cycle of operation is repeated as long as back contact 66 of relay 2TP is closed, and it is effective to cause relay 2BC to intermittently pick up and release and thereby energize relay 2CP to cause that relay in turn to recurrently impress battery 2TB across the track rails. Relays 2FC and 2BC are provided with slow acting characteristics selected so as to provide relatively long intervals between successive pick-up intervals of relay 2BC, whereby there are impressed at this time upon the track rails successive pulses of energy that are separated from each other by relatively long intervals during which no energy is present in the track rails. At this time, of course, this energy impressed upon the track rails is shunted away from relay 3TR by the train and such energy has no function.

When the train enters section II—III, both relays 4TR and 5TR are shunted and become inactive. Relays 4TP, 4H, and 4D associated with relay 4TR accordingly release, and signal 4S is caused to display its stop aspect. Relay 4H is made slightly slower to release than relay 4TP, hence directional stick relay 4SR becomes picked up over a circuit extending from terminal B through back contact 75 of relay 3SR, back contact 76 of relay 3H, back contact 77 of relay 3TP, back contact 78 of relay 4TP, front contact 79 of relay 4H and the winding of relay 4SR to terminal C. After relay 4SR picks up and closes its front contact 80, a stick circuit is then completed which extends from terminal B through back contact 75 of relay 3SR, back contact 82 of relay 4TP in multiple with back contact 81 of relay 4H, and front contact 80 and the winding of relay 4SR to terminal C.

With relay 5TR at location III released, energy from section II—III is not, of course, repeated or cascaded into section III—IV, and relay 7TR accordingly becomes inactive to cause relay 7TP also to release.

When the train clears section I—II, the coded energy that is intermittently impressed on the rails of this section at location I by the associated code initiating apparatus is transmitted through the track rails and the first pulse thereof is effective to pick up relay 3TR, which relay in turn picks up the associated stick relay 3TS. At the end of the first code initiating impulse received by relay 3TR, that relay releases to complete the energizing circuit of relay 3N. The code initiating apparatus at location I is arranged to apply a code to the track rails comprising "on" intervals of energy separated from each other by "off" intervals longer than the full pick-up interval of relay 3N, hence that relay will pick up prior to the time that the code initiating means at location I supplies the succeeding code impulse. When relay 3N picks up, it will of course start the transmission of code energy from battery 3TB to the rails of section I—II at location II. At this time, stick relay 4SR is picked up but relay 4H is released, hence relays 3NS and 3P may be energized (over back contact 51 of relay 4H and front contact 52 of relay 4SR) but relays 3PS and 3Q cannot be energized. It follows, therefore, that the code energy applied at location II to the rails of section I—II is of the caution (two pulse) pattern and this energy when received by relay 2TR causes operation of that relay, which in turn causes relays 2TP and 2H to pick up. The energization of the code initiating apparatus of section I—II is terminated when relay 2TP opens its back contact 66, while signal 2S is caused to display its caution aspect. In addition, when relay 2TP picks up, it conditions the energizing circuit of relays 1NS and 1P to be completed, while when relay 2H picks up it conditions the energizing circuits of relays 1PS and 1Q to be completed, whereupon the code transmitting apparatus associated with relay 1TR is rendered effective to transmit clear (three pulse) coded energy to the associated section.

The operation of relay 2TR by the coded energy available in section I—II causes the code generating means associated therewith to operate to apply coded energy to the rails of the section. This code generating apparatus is conditioned to apply three pulse (clear) track circuit code to the track rails, since at this time relay 1D is picked up and all of the impulse relays 2N, 2P and 2Q are conditioned to be energized. This three pulse code energy is transmitted through the rails of section I—II where it causes operation of relay 3TR, but at this time only relay 3TP but not relays 3H and 3D may be picked up. Relays 3H and 3D are held released even though their associated track relay responds to three pulse code energy, due to the fact that directional stick relay 4SR is picked up and holds open the energizing circuits of relays 3H and 3D at its back contact 43. The directional stick relay 4SR thus functions to retain the opposing signal 3S at stop in the rear of the train, as is the usual practice in A. P. B. signaling.

When the train vacates section II—III, relay 5TR responds to the code initiating pulses of energy that are applied at location II to section II—III, and this relay functions to repeat the code initiating pulses of energy into section III—IV, but with the train in that section, these impulses are shunted away from relay 7TR and have no useful function at this time.

When the train enters section IV—V, relays 8TR and 9TR are shunted and become inactive. Relays 8TP, 8H and 8D associated with relay 8TR accordingly release to cause signal 8S to display its stop aspect, and relay 8SR is caused to pick up over a pick-up circuit which substantially corresponds to the pick-up circuit hereinbefore traced for relay 4SR at location II. The code initiating apparatus at location IV is now active and applies to the rails of the section single pulses of code energy that are shunted away from relay 9TR by the train.

The code energy applied at location V to the section that has its eastbound entrance end at this location is now shifted from the caution (two pulse) to the detector (one pulse) pattern, since with relay 9TR shunted and inactive, relays 9D, 9H and 9TP associated therewith are released and front contact 68 of relay 9TP holds open the energizing circuit of relays 10NS and 10P, thereby causing the code transmitting apparatus associated with relay 10TR to supply single pulse

code to the rails of the associated section. This code energy is of course effective to place at stop the westbound signal at the opposite end (not shown) of passing siding E, thereby providing a control for that signal corresponding to the control hereinbefore described whereby signal 1S is caused to assume its stop position when the train enters the section to the west of passing siding W.

When the train vacates section III—IV, the code initiating pulses of energy applied at location II to section II—III and repeated by relay 6TR into section III—IV, thereupon become effective to operate relay 7TR. When this relay picks up on the first of such pulses, relay 7TS is picked up, and then when relay 7TR releases at the end of the first impulse, relay 7N picks up to condition the code transmitting apparatus associated with relay 7TR to supply coded energy to the rails of section III—IV. As stick relay 8SR is now picked up, relays 7NS and 7Q may be energized even though relay 8H is released, hence the code initiating apparatus associated with relay 7TR functions to supply caution or two pulse pattern code energy to section III—IV. This code energy is repeated by relay 6TR into section II—III where it causes operation of relay 4TR and energization of relays 4TP and 4H. The following operations will now take place: signal 4S is caused to display its caution aspect; operation of the code initiating apparatus, comprising relays 4FC and 4BC, is terminated when back contact 66 of relay 4TP picks up; relay 4SR is released since its stick circuit is now open at the multiple-connected back contacts 81 and 82 of relays 4H and 4TP, respectively; relays 3H and 3D are picked up since their respective energizing circuits are completed at back contact 43 of relay 4SR; signal 3S is caused to display its clear aspect; and the energizing circuits of all of the relays incorporated into the code transmitting apparatus associated with relay 3TR, are conditioned to be completed with the result that such apparatus is effective to transmit clear (three pulse) code energy to section I—II. This energy causes operation of relay 2TR and effects the energization of relay 2D which with the previously energized relays 2H and 2TP causes signal 2S to display its proceed aspect.

With relay 4TR responding to coded energy available in the section rails, and relay 3H picked up to close its front contacts 51 and 61, all of the impulse relays 4N, 4P and 4Q are conditioned to be energized and as a result the code generating means associated with relay 4TR operates to apply three pulse clear code energy to the track rails. This energy is repeated by relay 5TR into section III—IV where it causes operation of relay 7TR, but with relay 8SR picked up to hold open its back contact 45, both relays 7H and 7D are released and signal 7S accordingly is held at stop.

When the section in advance of section IV—V is entered by the train, relay 10TR is shunted and relays 10TP, 10H and 10D release to set signal 10S to stop. Then, after the train vacates section IV—V, relay 9TR responds to the code initiating pulse of energy available in the section, and relays 9TS and 9N are sequentially picked up to condition the code transmitting apparatus associated therewith to transmit coded energy to section IV—V. The energizing circuits of relay 9PS and 9Q are now open at front contact 65 of relay 10D and the code transmitting apparatus associated with relay 9TR accordingly is conditioned to transmit the two pulse caution code to the rails of section IV—V, whereupon relay 8TR responds to such code to pick up relays 8TP and 8H. Signal 8S accordingly is caused to display its caution indication; stick relay 8SR releases; relays 7H and 7D pick up; and signal 7S is caused to display its clear aspect. The code generating apparatus associated with relay 7TR is now conditioned to transmit to the rails of the associated section III—IV three pulse code energy, which energy is repeated by relay 6TR into section II—III where it causes response of relay 4TR and the resultant energization of relay 4D. Signal 4S accordingly is caused to display its clear aspect.

The code generating apparatus associated with relay 8TR is now conditioned to transmit three pulse clear code energy to the track rails, and relay 9TR operates in response thereto and picks up relay 9D to cause signal 9S to display its clear aspect.

The initiating code energy applied at location V to the section which has its eastbound entrance end at that location is effective when that section becomes vacant to cause the code transmitting apparatus (not shown) at the opposite end of the section to transmit detector code to the section in a manner which will be clear from the previous description presented in connection with the application of detector code to the section with which relay 1TR is associated. This detector code is received by relay 10TR and causes this relay to operate in such a manner as to pick up relay 10TP, thereby deenergizing the code initiating apparatus associated with relay 10TP. The code generating apparatus associated with relay 10TR is now conditioned to transmit the three pulse clear code energy to the rails of the associated section and these impulses will of course maintain operation of the code transmitting apparatus at the opposite section end.

When the train clears the next adjoining section, the coded current that is applied to the section which begins at location V is then shifted from the one pulse (detector) pattern to the three pulse (proceed) pattern and relay 10TR accordingly operates to pick up the associated relays 10H and 10D to cause signal 10S to go to clear. In addition, when relay 10D picks up it closes its front contact 65 to condition the energizing circuits of relays 9PS and 9Q to be completed, whereupon the coded current that is supplied at location V to section IV—V is then shifted from the two pulse to the three pulse pattern. Relay 8TR follows this three pulse code pattern and causes relay 8D to pick up and cause signal 8S to display its proceed indication. The apparatus represented in the drawings accordingly is restored to its normal condition wherein clear (three pulse) coded current is applied to each of the two track circuits of each section.

From the foregoing description, it is readily apparent that the apparatus embodying my invention is arranged in such a manner that when an eastbound train operates between passing sidings, that train is provided with absolute protection against opposing train movements while permissive protection is afforded for following train movements. It is also apparent that such protection is provided without the use of line wires by means of track circuits, two for each section and each supplied with coded energy that is generated in response to the presence of coded energy in the other track circuit of the section. In addition, it is apparent that while my invention has been described in connection with an A. P. B.

system wherein the signals are arranged to provide definite limits of control adjusted to a particular track layout, the system is inherently flexible and may be arranged to provide a wide variety of control limits each adjusted to the particular track layout that exists at the point of application.

It is believed that the operation of the apparatus embodying my invention for a westbound train movement will be readily apparent from an inspection of the drawings taken with the foregoing description of the operation for an eastbound train, and further detailed explanation of the apparatus is deemed unnecessary.

Although I have described my invention as applied to a signal system of the A. P. B. type, it will be apparent that my invention is not limited to such systems but is broadly useful in other single track, two direction systems, whether controlled manually from a remote location, or automatically by the approach of a train.

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

Having thus described my invention, what I claim is:

1. In combination, a section of railway track, two track relays of the biased polar neutral type, one for each end of said section, two sources of energy one for each track relay, means controlled by one of said track relays for connecting the windings of both of said track relays in a track circuit including the rails of said section and the source associated with said one track relay poled to supply current having a polarity effective to pick up the other but not the said one track relay, and means controlled by the said other track relay for connecting the windings of both of said track relays in another track circuit including said section rails and the other of said sources poled to supply current having a polarity effective to pick up the said one but not the said other track relay.

2. In combination, a section of railway track, means for intermittently applying a first source of current across the rails at one end of said section, a track relay responsive to current of a given relative polarity only, a repeating relay, a circuit including a back contact of said repeating relay for connecting the winding of said track relay across the said track rails at the opposite end of said section for deriving therefrom current of said given relative polarity, a second source of current, another circuit including a front contact of said repeating relay for connecting said second source in series with the winding of said track relay across the rails at said opposite section end with said second source poled to supply energy having a polarity opposite to said given relative polarity, a track stick relay, an impulse relay, a pick-up circuit for said track stick relay including a front contact of said track relay, a stick circuit for said track stick relay including its own front contact and a back contact of said impulse relay, an energizing circuit for said impulse relay including a front contact of said track stick relay and a back contact of said track relay, an energizing circuit for said repeating relay including a front contact of said impulse relay, and means controlled by energy of said opposite relative polarity supplied from said second source to said track rails for controlling the intermittent application of energy from said first source to said track rails.

3. In combination, a section of railway track, a track relay responsive only to current of a given relative polarity and connected to the rails at one end of said section, a code repeating relay, a source of current, a circuit including a front contact of said code repeating relay for connecting said source to said rails at said one section end with said source poled to supply rail current which is of the opposite relative polarity with respect to said track relay, a stick relay, a pick-up circuit for said stick relay including a front contact of said track relay, an impulse relay, a stick circuit for said stick relay including a front contact of said stick relay and a back contact of said impulse relay, an energizing circuit for said impulse relay including a front contact of said stick relay and a back contact of said track relay, an energizing circuit for said repeating relay including a front contact of said impulse relay, and means governed by said rail current for impressing other rail current at the opposite end of said section having said given relative polarity with respect to said track relay.

4. In combination, a section of railway track, a track relay responsive only to current of a given relative polarity and connected to the rails at one end of said section, a stick relay, a pick-up circuit for said stick relay including a front contact of said track relay, an impulse relay, a stick circuit for said stick relay including its own front contact and a back contact of said impulse relay, an energizing circuit for said impulse relay including a back contact of said track relay and a front contact of said stick relay, a source of current, means controlled by said impulse relay when picked up for connecting said source to the rails at said one section end with said source poled to supply rail current having the opposite relative polarity with respect to said track relay, and means governed by said rail current for supplying other rail current at the opposite end of said section having said given relative polarity with respect to said track relay.

5. In connection, a stretch of railway track including a track circuit section, a track relay receiving energy from the rails at one end of said section and responsive only to current of a given relative polarity, a first stick relay having a pick-up circuit including a front contact of said track relay, a first slow pick-up impulse relay, a stick circuit for said first stick relay including its own front contact and a back contact of said first impulse relay, an energizing circuit for said first impulse relay including a front contact of said first stick relay, a second stick relay having a pick-up circuit including a front contact of said first impulse relay and governed by traffic conditions on said stretch to be effective only when certain conditions exist, a second slow pick-up impulse relay, a stick circuit for said second stick relay including its own front contact and a back contact of said second impulse relay, an energizing circuit for said second impulse relay including a front contact of said second stick relay, a third stick relay having a pick-up circuit including a front contact of said second impulse relay and governed by traffic conditions on said stretch to be effective only when given conditions exist, a third slow pick-up impulse relay, a stick circuit for said third stick relay including its own front contact and a back contact of said third impulse relay, an energizing circuit for said third im-

pulse relay including a front contact of said third stick relay, a source of current, means controlled by each of said impulse relays for connecting said source to the rails at said one section end with said source poled to apply energy thereto having a polarity opposite to said given polarity, and means at the opposite section end selectively responsive to said opposite polarity current for governing traffic in said section and for supplying rail current having said given relative polarity with respect to said track relay.

6. In a railway signal system of the A. P. B. class wherein a stretch of railway track is divided into a plurality of successive adjoining track sections each provided with two track circuits one for each direction of train movement in such section, the combination of means for applying to each of the track circuits of each of said sections track circuit energy that is coded at one or another of a plurality of different manners in accordance with traffic conditions on said stretch in advance for the direction of the associated track circuit and which energy is generated in each of the two circuits of a section in response to the presence of coded energy in the other circuit of the associated section, and means controlled by said track circuits effective upon a train entering said stretch and shunting the rails of the first section thereof for controlling the generation of the coded energy applied to each of the track circuits associated with the direction opposite to that of the train movement to supply such circuits with energy coded in a manner indicative of the approach of a train.

7. In combination with a stretch of railway track divided into a plurality of successive adjoining track sections, a first direction track circuit for each of said sections comprising a first generating means at the sections' given end effective at times for applying to the section rails energy impulses in groups having one or another of a plurality of different number of impulses in each group and a first means receiving energy from the rails at the opposite end of the section and including a first decoding means selectively responsive to the number of impulses in the groups there received, means controlled by the first decoding means of each section for reflecting traffic conditions in the opposite-to-given direction by selecting the number of impulses in the groups comprising the track circuit energy applied to the said given end of the section next adjacent to that section's said opposite end, means controlled by the first decoding means of each section in accordance with the number of impulses in the groups received by such means for governing traffic in the associated section moving in said opposite to given direction, a second direction track circuit for each section comprising a second generating means at the section's said opposite end rendered effective by that section's said energy receiving means following the receipt of the last impulse of each group there received for applying to the section rails energy impulses in groups having one or another of a plurality of different number of impulses in each group and a second means receiving energy from the rails at the section's said given end and including a second decoding means selectively responsive to the number of impulses in the groups there received, means controlled by the second decoding means of each section for reflecting traffic conditions in the given-to-opposite direction by selecting the number of impulses in the groups comprising the track circuit energy applied to the said opposite end of the section next adjacent to that section's said given end, means controlled by the second decoding means of each section in accordance with the number of impulses in the groups received by such means for governing traffic in the associated section moving in said given-to-opposite direction, and other means controlled by the said second energy receiving means of each section for rendering effective that section's first generating means following the receipt of the last impulse of each group there received.

8. In combination with a stretch of railway track divided into a plurality of successive adjoining track sections, a first direction track circuit for each of said sections comprising a first generating means at the section's given end effective at times for applying to the section rails energy impulses in groups having one or another of a plurality of different number of impulses in each group and a first means receiving energy from the rails at the opposite end of the section and including a first decoding means selectively responsive to the number of impulses in the groups there received, means controlled by the first decoding means of each section for reflecting traffic conditions in the opposite-to-given direction by selecting the number of impulses in the groups comprising the track circuit energy applied to the said given end of the section next adjacent to that section's said opposite end, means controlled by the first decoding means of each section in accordance with the number of impulses in the groups received by such means for governing traffic in the associated section moving in said opposite-to-given direction, a second direction track circuit for each section comprising a second generating means at the section's said opposite end rendered effective by that section's said energy receiving means following the receipt of the last impulse of each group there received for applying to the section rails energy impulses in groups having one or another of a plurality of different number of impulses in each group and a second means receiving energy from the rails at the section's said given end and including a second decoding means selectively responsive to the number of impulses in the groups there received, means controlled by the second decoding means of each section for reflecting traffic conditions in the given-to-opposite direction by selecting the number of impulses in the groups comprising the track circuit energy applied to the said opposite end of the section next adjacent to the section's said given end, means controlled by the second decoding means of each section in accordance with the number of impulses in the groups received by such means for governing traffic in the associated section moving in said given-to-opposite direction, other means controlled by the said second energy receiving means of each section for rendering effective that section's first generating means following the receipt of the last impulse of each group there received, and code initiating means associated with one of the two track circuits of each section effective when both of such circuits are shunted by a train in such section for applying to the section rails code initiating impulses which are effective after said section becomes vacant to actuate the energy receiving means of such one track circuit, whereby to restore both of such circuits to their respective normal condition wherein the code energy applied to each circuit is generated in response to the receipt of code energy from the other of such circuits.

9. In combination with a stretch of railway

track divided into a plurality of successive adjoining track sections, a first direction track circuit for each of said sections comprising a first generating means at the section's given end effective at times for applying to the section rails energy impulses in groups having one or another of a plurality of different number of impulses in each group and a first means receiving energy from the rails at the opposite end of the section and including a first decoding means selectively responsive to the number of impulses in the groups there received, means controlled by the first decoding means of each section for reflecting traffic conditions in the opposite-to-given direction by selecting the number of impulses in the groups comprising the track circuit energy applied to the said given end of the section next adjacent to that section's said opposite end, means controlled by the first decoding means of each section in accordance with the number of impulses in the groups received by such means for governing traffic in the associated section moving in said opposite-to-given direction, a second direction track circuit for each section comprising a second generating means at the section's said opposite end rendered effective by that section's said energy receiving means following the receipt of the last impulse of each group there received for applying to the section rails energy impulses in groups having one or another of a plurality of different number of impulses in each group and a second means receiving energy from the rails at the section's said given end and including a second decoding means selectively responsive to the number of impulses in the groups there received, means controlled by the second decoding means of each section for reflecting traffic conditions in the given-to-opposite direction by selecting the number of impulses in the groups comprising the track circuit energy applied to the said opposite end of the section next adjacent to that section's said given end, means controlled by the second decoding means of each section in accordance with the number of impulses in the groups received by such means for governing traffic in the associated section moving in said given-to-opposite direction, other means controlled by the said second energy receiving means of each section for rendering effective that section's first generating means following the receipt of the last impulse of each group there received, and means controlled by said track circuits and effective when a train enters said stretch and shunts the rails of the first-encountered one of said sections for selecting the number of impulses of the groups supplied to each of the track circuits associated with the direction opposite to that of the train movement to cause the associated traffic governing means to prevent traffic movements in such opposite direction.

10. In combination with a stretch of railway track divided into a plurality of successive adjoining track sections, a first direction track circuit for each of said sections comprising a first generating means at the section's given end effective at times for applying to the section rails energy impulses in groups having one or another of a plurality of different number of impulses in each group and a first means receiving energy from the rails at the opposite end of the section and including a first decoding means selectively responsive to the number of impulses in the groups there received, means controlled by the first decoding means of each section for reflecting traffic conditions in the opposite-to-given direction by selecting the number of impulses in the groups comprising the track circuit energy applied to the said given end of the section next adjacent to that section's said opposite end, means controlled by the first decoding means of each section in accordance with the number of impulses in the groups received by such means for governing traffic in the associated section moving in said opposite-to-given direction, a second direction track circuit for each section comprising a second generating means at the section's said opposite end rendered effective by that section's said energy receiving means following the receipt of the last impulse of each group there received for applying to the section rails energy impulses in groups having one or another of a plurality of different number of impulses in each group and a second means receiving energy from the rails at the section's said given end and including a second decoding means selectively responsive to the number of impulses in the groups there received, means controlled by the second decoding means of each section for reflecting traffic conditions in the given-to-opposite direction by selecting the number of impulses in the groups comprising the track circuit energy applied to the said opposite end of the section next adjacent to that section's said given end, means controlled by the second decoding means of each section in accordance with the number of impulses in the groups received by such means for governing traffic in the associated section moving in said given-to-opposite direction, other means controlled by the said second energy receiving means of each section for rendering effective that section's first generating means following the receipt of the last impulse of each group there received, code initiating means associated with one of the two track circuits of each section effective when both of such circuits are shunted by a train in such section for applying to the section rails code initiating impulses which are effective after said section becomes vacant to actuate the energy receiving means of such one track circuit, whereby to restore both of such circuits to their respective normal conditions wherein the code energy applied to each circuit is generated in response to the receipt of code energy from the other of such circuits, and means controlled by said track circuits and effective when a train enters said stretch and shunts the rails of the first-encountered one of said sections for selecting the number of impulses of the groups supplied to each of the track circuits associated with the direction opposite to that of the train movement to cause the associated traffic governing means to prevent traffic movements in such opposite direction.

11. In a coded track circuit signaling system for railroads, the combination with a track section, of means at each end of said section comprising a source of current, a code following track relay, a transmitter relay effective when energized for impressing energy from the associated source across the track rails of said section and when deenergized for connecting the associated track relay to receive energy over the track rails of said section from the opposite end, a timing relay having a first and a second position and controlled by the associated track relay to operate from its first to its second position when said track relay remains released for an interval equal to the timing interval of said timing relay, and means rendered effective upon op-

eration of said timing relay to its said second position for supplying the associated transmitting relay with a plurality of energy impulses with the impulses separated from each other by an interval shorter in duration than the timing interval of said timing relay.

12. In a coded track circuit signaling system for a stretch of railway track including a track section, the combination with said track section, of means at each end of said section comprising a source of current, a code following track relay, a transmitter relay effective when energized for impressing energy from the associated source across the track rails of said section and when deenergized for connecting the associated track relay to receive energy over the track rails of said section from the opposite end, a timing relay having a first and a second position and controlled by the associated track relay to operate from its first to its second position when said track relay remains released for an interval equal to the timing interval of said timing relay, means rendered effective upon operation of said timing relay to its said second position for supplying the associated transmitting relay with a group of energy impulses having one or another of a plurality of different number of impulses with the impulses in the group separated from each other by an interval shorter in duration than the timing interval of said timing relay, and means controlled by traffic in said stretch beyond the associated end of the section for selecting the number of impulses in the group supplied by said last mentioned means to said transmitting relay.

13. In a coded track circuit signaling system for a stretch of railway track including a track section, the combination with said track section, of means at each end of said section comprising a source of current, a code following track relay, a transmitter relay effective when energized for impressing energy from the associated source across the track rails of said section and when deenergized for connecting the associated track relay to receive energy over the track rails of said section from the opposite end, a timing relay having a first and a second position and controlled by the associated track relay to operate from its first to its second position when said track relay remains released for an interval equal to the timing interval of said timing relay, means rendered effective upon operation of said timing relay to its said second position for supplying the associated transmitting relay with a group of energy impulses having one or another of a plurality of different number of impulses with the impulses in the group separated from each other by an interval shorter in duration than the timing interval of said timing relay, means controlled by traffic in said stretch beyond the associated end of the section for selecting the number of impulses in the group supplied by said last mentioned means to said transmitting relay, and decoding means operated by the associated track relay and selectively responsive to the number of impulses in the group operating the associated track relay.

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