March 16, 1943. T. J. JUDGE 2,314,280

CODED TRACK CIRCUIT SIGNALING SYSTEM

Filed July 9, 1941 3 Sheets-Sheet 1

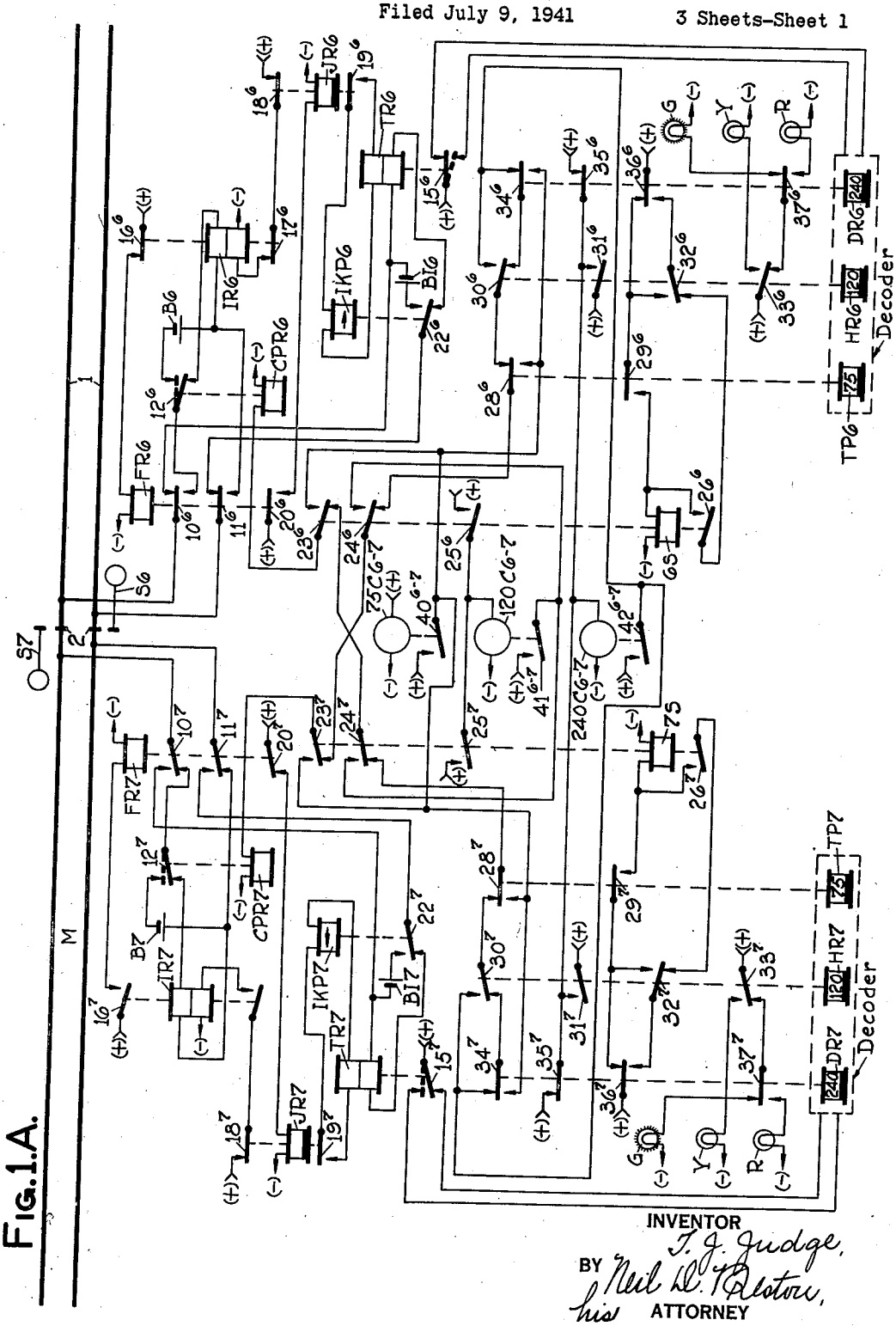


FIG. 1.A.

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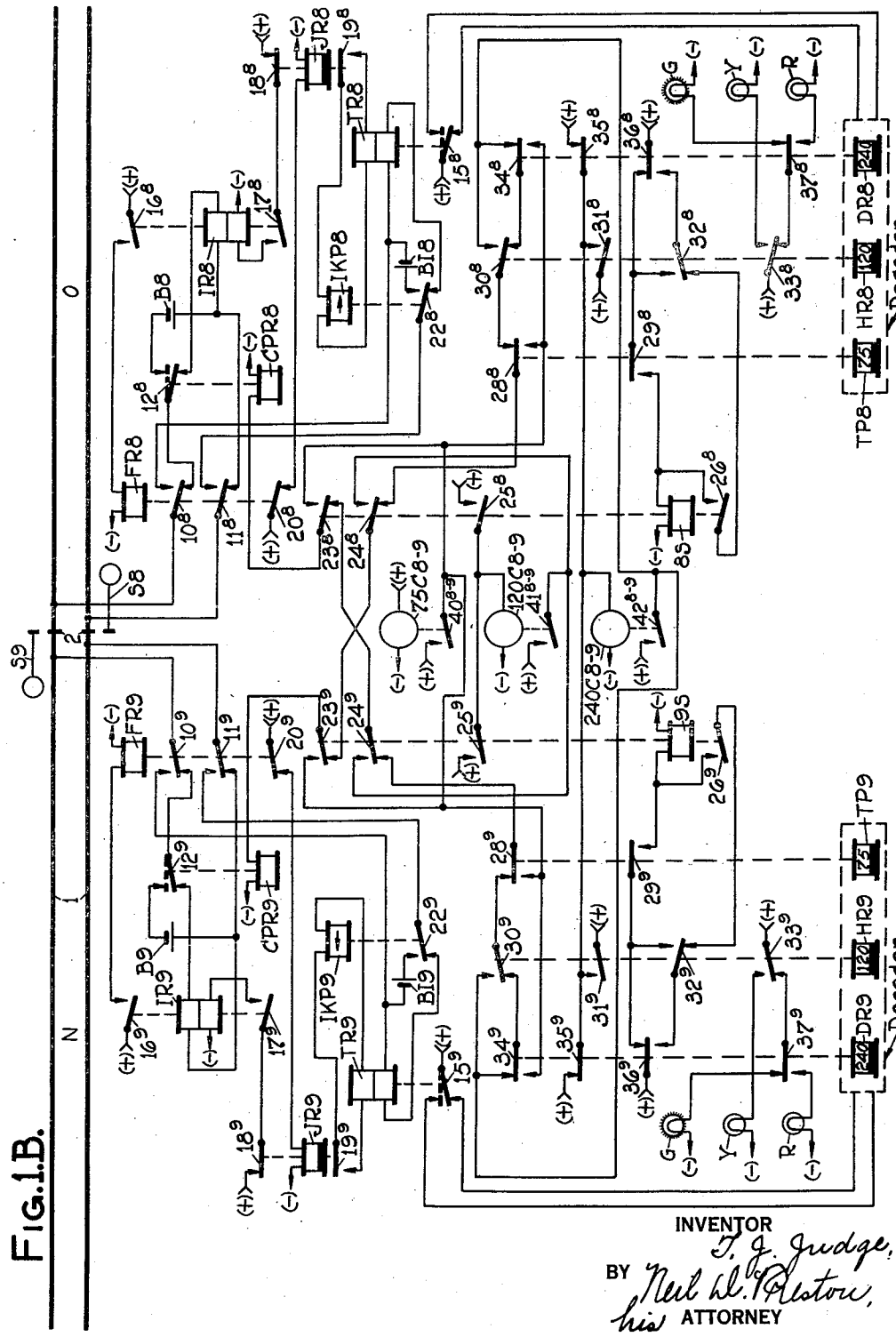


FIG. 1.B.

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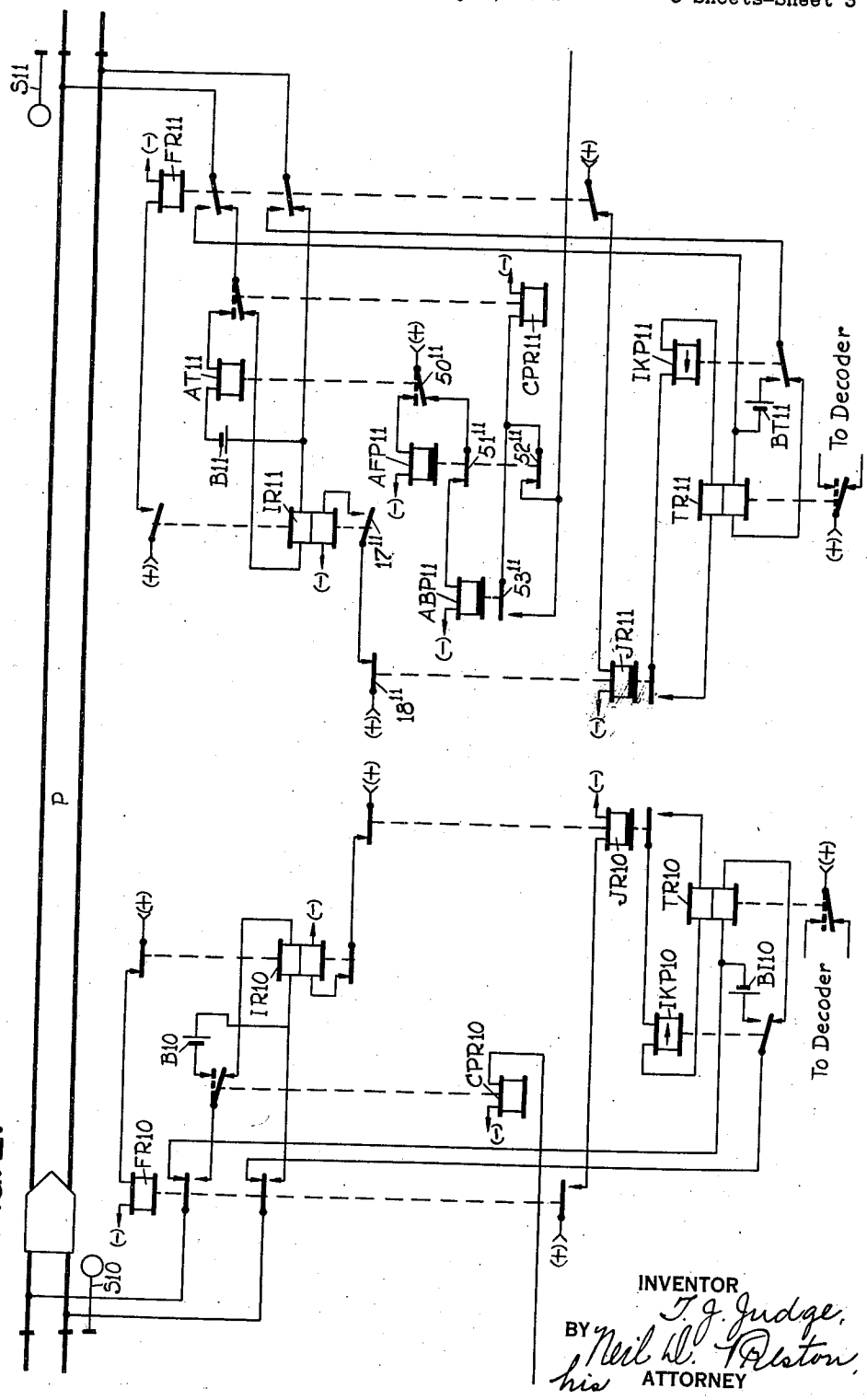


FIG. 2.

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UNITED STATES PATENT OFFICE

2,314,280

CODED TRACK CIRCUIT SIGNALING SYSTEM

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Application July 9, 1941, Serial No. 401,607

22 Claims. (Cl. 246—33)

The present invention relates to signaling systems of the absolute-permissive-block type and more particularly to a double or duplex coded track circuit for such systems, and is an improvement over the systems disclosed in the prior applications of Phinney, Ser. No. 362,636, filed October 24, 1940, now U. S. Patent 2,272,581 granted February 10, 1942, and Phinney et al., Ser. No. 370,186, filed December 14, 1940. By "coded track circuit" is meant a track circuit of the coded type wherein impulses of current are repeatedly applied to one end of the track circuit and suitable code responsive apparatus detects the code and its character at the other end of such track circuit. By "duplex coded track circuit" is meant a track circuit in which codes may be applied at both ends of the section of track and code responsive apparatus may be connected at both ends thereof, wherein each code responsive apparatus only responds to the code applied by the code applying apparatus at the other end of the section and wherein codes are received at both ends of said section substantially continuously. The term "driven code" is used to mean a code which is created by suitable code creating apparatus directly, that is, apparatus which originates the length of impulses and the time spacing between the impulses. By "inverse code" is meant a code which is inserted between the impulses of a driven code and usually originates at the opposite end of the track section. By "inductive kick repeater" relay is meant a relay which responds to an induced current. As shown, the induced current is derived from a winding of another relay TR into which it is induced.

In order to control a signal in accordance with traffic conditions in one or more blocks in advance, without the requirement of signal control line wires, it is desirable to have the track relay, or other code following apparatus, located at that end of the block which is adjacent the entering signal. Obviously, if traffic moves in both directions, as is the case in single track railroads, there should be a signal at each end of such track section for governing traffic into the section at that end, and consequently it becomes necessary, or at least desirable, to have a track relay, or code following means, at each end of the track section to avoid the need of special control line wires. Since traffic conditions in opposite directions from a particular track section may be different, it becomes apparent that the codes transmitted in opposite directions through the same track section may be different, insofar as the length of the impulses or their polarity is concerned or the durations of their spacing. Also, when continuous inductive train control is employed, it is found necessary to apply the code to the exit end of a track section for the particular direction in which the train is moving, so that this code may be detected by suitable receiving apparatus mounted on the locomotive in front of the first axle thereof and in inductive relation to the track rails. In view of these facts it is desirable to employ a duplex track circuit, so to speak, in which a track relay or other code following means at each end of the track section controlled by energy applied to the opposite end of such section is preferably employed.

In accordance with the present invention it is proposed to employ a duplex track circuit arrangement in which complete codes are alternately applied at opposite ends of a track section, each code of which is received and de-coded at the opposite end from that at which it was applied. Also the codes under consideration are of course driven codes, in that the codes are created by special code creating apparatus. In order to keep these code applying apparatuses in such synchronism that they are alternately applied at opposite ends of the track section without interference, it is proposed to employ a so-called "inverse code" which is applied so as to have its impulse occur between the impulses of the driven code, and so that each inverse code impulse controls the apparatus at the driven code end so that the driven code is discontinued shortly after the reception of an inverse code impulse; suitable time measuring apparatus being of course employed to determine the time when such inverse code shall be applied.

In one form of the invention an approach track relay is employed for preventing a so-called "code fight" after an occupied track circuit has become vacated, this approach series track relay being of the usual type, namely, a series relay included in series with the track battery, this approach track relay in combination with slow dropping repeater relays rendering the driven code creating apparatus inoperative for a short period of time after each occupancy of the track circuit.

Other objects, purposes and characteristic features of the present invention will in part be described in the specification hereinafter and will in part be obvious from the accompanying drawings, in which:

Figs. 1A and 1B, when laid side by side, illustrate the apparatus applied to one block and to

the entrance ends of two adjacent blocks of a preferred embodiment of the present invention; and

Fig. 2 illustrates a modified form of the present invention in which suitable apparatus to prevent a "code fight" is incorporated.

Structure, Fig. 1

Referring to Figs. 1A and 1B, laid side by side and left to right in that order, it will be observed that a railway track having rails 1, divided by insulating joints 2, has been illustrated. The particular stretch of track illustrated includes a block N and the adjacent ends of two blocks M and O. At each of these block junctions is provided a pair of opposite signals, namely, a signal for governing traffic in each direction along the track and located at the same location. The signals for governing east-bound traffic have been designated S6 and S8, whereas the signals for governing west-bound traffic have been designated S7 and S9. Although these signals may be of any suitable construction, such as semaphore signals, search-light signals, position light signals, or multiple aspect color light signals, for convenience only multiple aspect color light signals have been illustrated. At each end of the block N is provided a selecting relay FR which has contacts, such as 10^6 and 11^6 for the relay FR6, which relays determine or select whether code creating apparatus or code receiving apparatus shall be connected to the track rails at that end of the block. The driving code is applied by the code applying relay CPR, which in turn is controlled by one of the coders C illustrated. When the selecting relay FR is energized the track relay TR is through the back contact 22 of relay IKP included directly in the track circuit, whereas if this selecting relay FR is deenergized the coding contact, such as the contact 12^6 for the relay CPR6, is included in the track circuit. Each of the block ends is provided with a main or driven code battery B and with an inverse code battery BI, each of these reference characters B and BI being provided with a suffix corresponding to the suffix of the signal governing traffic into the section at that end. Each of the block ends is provided with an inverse code relay IR, which relay is connected to the track circuit when both the selecting relay FR and the code applying relay CPR assume their deenergized position. Each block end is also provided with a timing relay JR. This relay JR by its drop-away characteristic determines the time during which a driven code may be sent in a particular direction. These timing relays JR when deenergized connect an inductive kick repeater relay IKP in a circuit including an inducing winding of the track relay TR. This inductive kick repeater relay is picked up inductively by the next received driven code element and in turn causes an inverse code element to be sent during the next time space and to the then transmitting end. This inductive kick repeater relay IKP is a polar relay and responds only to current of one polarity and will respond only to current induced therein due to dying flux in the track relay core due to the next preceding code impulse. Also, if desired, a rectifier may be included in series with such relay to block the flow of all currents of another polarity. Since the apparatus illustrated constitutes a portion of an absolute-permissive-block signaling system the usual directional stick relay S has also been illustrated for each signal. Since decoding apparatus is well understood by those skilled in the art and since specific decoding apparatus has been illustrated in the application of Phinney et al., Ser. No. 370,186, above referred to, the decoding track relay TP, the decoding home relay HR, and the decoding distance relay DR have been illustrated conventionally as being controlled by the intermittent operation of the contact 15 of the track relay TR. It may be pointed out that the decoding track relay TP is energized each time a code is received irrespective of whether it is a 75 impulse per minute code, a home code of 120 impulses per minute, or a distant code of 240 impulses per minute, whereas the decoding relays HR and DR respond only to their respective codes of 120 impulses per minute and 240 impulses per minute, respectively.

Referring again to Fig. 1A, the inverse code relay IR6 is provided with a contact 16^6 and a stick contact 17^6, and the timing relay JR6 is provided with control contacts 18^6 and 19^6. The selecting relay FR6 is provided with two transfer contacts 10^6 and 11^6 and with a control contact 20^6. The inductive kick repeater relay IKP6 is provided with a control contact 22^6. The directional stick relay 6S is provided with control contacts 23^6, 24^6 and 25^6 and with a stick contact 26^6. The decoder track relay TP6 is provided with control contacts 28^6 and 29^6, the decoder home relay HR6 is provided with control contacts 30^6, 31^6, 32^6 and 33^6 and the decoder distant relay DR6 is provided with control contacts 34^6, 35^6, 36^6 and 37^6. Only one set of coders C is provided for each pair of opposite signals. The signal location of signals S6 and S7 is provided with coders 75C6—7, 120C6—7 and 240C6—7 having coding contacts 40^{6-7}, 41^{6-7} and 42^{6-7}, respectively. Since the control circuits and apparatus for each of the signals S6, S7, S8 and S9 is the same, like relays and like contacts for these various signals have been designated by like reference characters having distinctive prefixes, suffixes and/or exponents.

Operation of Fig. 1 system

Let us first consider how a driven code is alternately applied at opposite ends of the block N assuming the absence of trains and clear traffic conditions on adjacent tracks in both directions from the block N. It will be observed that the selecting relay FR6 is in its energized position, whereas the selecting relay FR9 is in its deenergized position. It is also readily seen that the selecting relay FR6 is energized because its energizing circuit including the front contact 16^6 of the inverse track relay IR6 is closed, whereas, the corresponding contact 16^9 of the inverse track relay IR9 is open. It is also readily understood that the inverse code relay IR6 is in its energized position because its stick circuit including its stick contact 17^6 and the front contact 18^6 of the timing relay JR6 is closed; whereas a similar stick circuit for the inverse code relay IR9 is open at its stick contact 17^9, although a similar front contact 18^9 in its stick circuit is also closed. Attention is also directed to the fact that the timing relay JR at both ends of the block N assume their energized position even though the energizing circuit for the timing relay JR6 is open (the energizing circuit for the timing relay JR9 being closed). It may be pointed out at this time that although the timing relays JR are rather quick in picking but are exceedingly slow dropping, and will not drop until about three seconds have

elapsed since their energizing circuits have been broken. With the apparatus in the condition illustrated in Figs. 1A and 1B, a driven code is transmitted from the east end or right-hand end of the block N, this code originating insofar as its presence in the track circuit is concerned at the coding contact 12^9 of the code applying relay CPR9. This code applying relay CPR9 is now intermittently energized at the 240 impulse per minute rate through a circuit which may be traced from the terminal plus (+) of a suitable source of current, through front contact 42^{8-9} of the coder 240C8—9, front contact 34^8 of the decoding distant relay DR8, back contact 30^8 of the decoding home relay HR8, front contact 28^8 of the decoding track relay TP8, through back contacts 24^8 and 23^9 of the directional stick relays 8S and 9S, respectively, through the winding of the code applying relay CPR9, to the other terminal minus (—) of the same source of current. The intermittent picking up of the code applying relay CPR9 at the 240 impulse per minute rate causes the track battery B9 to be applied to the track rails to cause current flow through the track rails at the rate of 240 impulses per minute. This code of 240 impulses per minute is, during unoccupied conditions of the block N, applied to the lower winding of the track relay TR6 at the west end of the block N. The intermittent picking up of the contact 15^6 of the track relay TR6 associated with the signal S6 at the 240 impulse per minute rate causes the decoder relays TP6 and DR6 to continuously assume their energized position, whereas the decoder relay HR6 remains in its retracted position. This results in the illumination of the green lamp G of the signal S6, the yellow lamp Y, and the red lamp R remaining deenergized. This transmission of a 240 impulse per minute code from the east end to the west end of the block N continues for a period of about three seconds at the end of which time the deenergized timing relay JR6 assumes its retracted position. When this occurs it opens its front contact 18^6 included in the stick circuit for the inverse code track relay IR6 to cause this relay IR6 to assume its retracted position and open its front contact 16^6 included in the energizing circuit of the selecting relay FR6. Before the selecting relay FR6, however, has had time to drop, the upper winding of the track relay TR6, due to the falling current in its lower winding, induces a current in the winding of the inductive kick repeater relay IKP6. This induction of a current in the relay IKP6 is possible because the back contact 19^6 of the relay JR6 is now closed. This induced current flowing in the winding of the relay IKP6 will pick up this relay upon the termination of an impulse of the driven code only. The picking up of the inductive kick repeater relay IKP6 causes an inverse code element to be transmitted from the inverse code battery BI6 through a circuit including the front contact 22^6 of the inductive kick repeater relay IKP6, the front contacts 10^6 and 11^6 of the selecting relay FR6 and including the back contacts 10^9 and 11^9 of the selecting relay FR9 located at the east end of the block N during an off period of the code applying relay CPR9 (namely, at the time when the back contact 12^9 of the code applying relay CPR9 is closed), thereby causing the inverse track relay IR9 to be picked up by the inverse code current element that was transmitted from the inverse code battery BI6 located at the west end of the block N. This inverse code element applied to the inverse track relay IR9 of course causes this track relay IR9 to pick up and since the front contact 18^9 of the selecting relay JR9 in the stick circuit for this inverse track relay IR9 is closed, the inverse track relay IR9 will be stuck up through its stick circuit the very instant that its stick contact 17^9 closes. The picking up of the inverse track relay IR9 will, of course, at its front contact 16^9 close the energizing circuit for the selecting relay FR9 thereby disconnecting the east-end of the track circuit of the block N from the coding contact 12^9 and connecting this east end of the track circuit to the lower winding of the track relay TR9 through a branch circuit including back contact 22^9 of the inductive kick repeater relay IKP9. The apparatus at the east end of the block N, namely, the apparatus associated with the signal S9, is now ready to receive a driven code from the west end of this block N. Also, since the selecting relay FR6 is a rather quick acting relay it opened its front contacts 10^6 and 11^6 and closed its back contacts 10^6, 11^6 and 20^6 very shortly after the relay IR6 opened its front contact 16^6. Similarly since the selecting relay FR9 is rather quick acting it will pick up very quickly after the inverse track relay IR9 closed its front contact 16^9 due to the reception of an inverse code element transmitted from the inverse code battery BI6. This dropping of the selecting relay FR6 connected the coding contact 12^6 included in series with the track battery B6 to the west end of the track circuit for the block N, so that the code applying relay CPR6 may through the medium of its contact 12^6 apply a code to the west end of the block N in accordance with the particular coder 75C6—7, 120C6—7 or 240C6—7 then connected to the code applying relay CPR6. Similarly the picking up of the selecting relay FR9 connects the lower winding of the track relay TR9 to the east end of the track rails of block N to receive the code applied to the west end of this block by the coding contact 12^6 of relay CPR6. The dropping of the selecting relay FR6 also results in the closure of its back contact 20^6 which results in the reenergization and picking up of the timing relay JR6. The picking up of this timing relay JR6 of course results in the opening of its back contact 19^6 so that the inverse kick repeater relay IKP6 cannot receive an inductive kick from the upper winding of the track relay TR6 until this time relay JR6 has again assumed its retracted position, which is about three seconds after an inverse code element has been transmitted from east to west over the rails of the block N. Also, this picking up of the timing relay JR6 results in the closure of its front contact 18^6. Since, however, the inverse track relay IR6 is now intermittently connected (by back contact 12^6) to the dead track rails of block N and since its stick contact 17^6 is open (and remains open until an inverse code element is transmitted westwardly through the block N) the closure of this front contact 18^6 of the timing relay JR6 performs no particular function.

It will be readily understood that the timing relays JR6 and JR9 for the block N both assume their energized position almost continuously, that is, one relay is in its attracted position because its energizing circuit is closed, and the other is in its attracted position because it has not yet dropped in response to the previous opening of its energizing circuit. The relays JR6 and JR9 are slow to drop and quick to pick up and will stay down only momentarily because the energizing circuit of each is re-closed as soon as the associated selecting relay FR controlled

thereby has responded to the dropping of such relay JR. The decoding relays TP, HR and DR are slightly more slow dropping than the timing relays JR, because it is desirable to have the particular decoding relays which are energized in response to the received code to remain in their energized position until the timing relay JR at the opposite end of the block has assumed its retracted position and has caused a new driven code to be applied at the opposite end of the block. In other words, the structure is such that a driven code is transmitted from one end to the other end of the block for a period of about three seconds after which a driven code is transmitted from such other to said one end of the block and the decoding relays which are picked up by such code remain in their attracted position during the three second interval when no code is received. The apparatus is shown in its normal clear traffic condition with the green lamps G of each of the signals S6, S7, S8 and S9 energized.

Let us now assume that there is an east-bound train moving in the block M. The presence of the train in the block M of course causes continuous deenergization of the track relay TR7, resulting in continuous deenergization of the decoding relays DR7, HR7 and TP7. Since the directional stick relays 7S and 6S are in their normal retracted position, the relay 7S only picking up in response to the movement of a west-bound train by the signal S7 and the relay 6S picking up only in response to the movement of an east-bound train by the signal S6, it will be observed that the code applying relay CPR6 is energized at the coding rate of 75 impulses per minute through a circuit including the control contact 40^{6-7}, the back contact 28^{7} of the relay TP7, the back contact 24^{7} of the directional stick relay 7S, and the back contact 23^{6} of the directional stick relay 6S. A 75 impulse per minute code is therefore transmitted from west to east through the block N, which causes the decoding relays DR9 and HR9 to be deenergized and assume their retracted position, but allows the decoding track relay TP9 to remain in its energized attracted position. Under this condition of the decoding relays associated with the signal S9 it is apparent that the red lamp R of the signal S9 is energized through a circuit including the back contacts 33^{9} and 37^{9} of the relays HR9 and DR9, respectively. In the same way as just explained a 75 impulse per minute code is transmitted from west to east through the block O the code applying relay CPR8 being controlled through back contacts 30^{9} and 34^{9} of relays HR9 and DR9, respectively, instead of through back contact 28 of relay TP, so that the usual tumble down of danger signals is assured.

At the east end of the block M a code of 240 current impulses per minute rate is applied by the coding relay CPR7. It should be noted that under normal clear traffic conditions the coder 240C6—7 is operated through a circuit including the front contact 35^{6} of relay DR6. This relay CPR7 is energized 240 times per minute through a circuit including coding contact 42^{6-7}, front contact 34^{6} of relay DR6, back contact 30^{6} of relay HR6, front contact 28^{6} of relay TP6 and back contacts 24^{6} and 23^{7} of relays 6S and 7S, respectively, control apparatus of the eastbound train in block M will therefore give a clear indication. The signal S6 of course indicates clear by reason of clear traffic conditions ahead as has been assumed.

Let us now assume that the east-bound train under consideration accepts and passes the clear signal S6. This advance of the train into the block N causes the decoding track relay TP6 to assume its retracted position before the distant decoding relay DR6 assumes its retracted position as a result of which the directional stick relay 6S has its pick-up circuit including the front contact 36^{6} of the relay DR6 and the back contact 29^{6} of the relay TP6 closed at least momentarily. The directional stick relays are sufficiently slow dropping so that they will not drop during the movement of the contact 36 from the position in which it is included in the pick-up circuit to the position where it is included in the stick circuit for such stick relay. The directional stick relay 6S upon the dropping of the distant decoding relay DR6 is therefore energized through a stick circuit including its own stick contact 26^{6} and the back contacts 32^{6} and 36^{6} of the relays HR6 and DR6, respectively, in series. With the directional stick relay 6S now energized the closure of its front contact 25^{6} applies energy to the motor of the coder 120C6—7 so that this coder delivers its code of 120 impulses per minute. Also, with the directional stick relay 6S now in its attracted position and with the directional stick relay 7S in its retracted position the code applying relay CPR7 is intermittently energized at the 120 impulse per minute code rate, and as soon as the rear end of the train leaves the block M, this 120 impulse per minute code rate of current is applied to the east end of the block M through a circuit including coding contact 41^{6-7}, front contact 24^{6} of stick relay 6S and back contact 23^{7} of directional stick relay 7S, thereby causing the signal next in the rear of the signal S6 to assume its caution indicating condition. The coder 120C6—7 is operated only if one of the stick relays 6S or 7S assumes its energized position as, for instance, through front contact 25 of either of these stick relays.

The entrance of the east-bound train into the block N, of course, results in the continuous deenergization of the track relays TR6 and TR9 at the two ends of the block N, so that all of the decoding relays TP6, HR6, DR6, DR9, HR9 and TP9 assume their retracted position.

Let us assume, for convenience, that the relays FR6, IR6, JR6, FR9, IR9 and JR9 assume the positions illustrated in the drawings the moment the east-bound train entered the block N. It is, of course, readily seen that the code which was then applied by the code applying relay CPR9 at the east end of the block N could not reach the track relay TR6 located at the west end of the block N because this coded track circuit current was shunted away by the wheels and axles of the train under consideration. This is also true of the code impulses transmitted in an east-bound direction through the block N. After a short interval of time (about three seconds after its circuit was broken) the timing relay JR6 will, of course, assume its retracted position and will close a circuit for the inductive kick repeater relay IKP6. This will, however, be of no avail because there is no current change in the lower winding of the track relay TR6 so that no current can be induced in the inductive kick repeater relay IKP6. For this reason, no inverse code is applied to the west end of the track circuit for the block N, and even if such inverse code were applied it could not reach the relay IR9 at the east end of the block N, because of the presence of the east-bound train in the block N, which, of course, shunts such current applied to the track circuit at one end away from the opposite end of such track circuit. In other words, the dropping

of the timing relay JR6 will merely result in the deenergization and dropping of the relays IR6 and FR6. After a very short interval of time the timing relay JR6 will again be picked up by reason of the closure of the back contact 20^6 of the relay FR6. The relays FR, IR and JR of both ends of the block N therefore assume like positions, that is, relays JR are energized and assume their energized positions and the relays FR and IR assume their deenergized positions. With the relay FR6 now in its deenergized position the code applying relay CPR6 will continue to apply code to the west end of the block N in accordance with traffic conditions in advance of the signal S7 in the same manner as code applying relay CPR9 applies a code to the east end of the block N in accordance with traffic conditions in advance of the signal S8.

At the east end of the block N no change in the positions of relays FR9, IR9 and JR9 will take place because the inverse code element is not transmitted, which in the absence of the train would have been transmitted and would have picked up the inverse track relay IR9. Since this inverse code was not transmitted and therefore left the inverse track relay IR9 deenergized and this left the selecting relay FR9 in its retracted position no change in the code transmitting apparatus at the east end of the block N took place. In other words, a code is applied ahead of the east-bound train in the block N in accordance with traffic conditions in advance of the signal S8 through the medium of the code applying relay CPR9 so that if suitable train control apparatus were present on the train the conditions of traffic could be continuously inductively detected in accordance with code current flowing in the track rails and indicated by suitable cab signals in the cab of such train. In the same way coded current reflecting conditions of traffic in advance of the signal S7 is applied to the west end of the block N so that traffic conditions in advance of a west-bound train may also be visually indicated on the train.

Let us now assume that the east-bound train under consideration advances into the block O. This, of course, results in the picking up of the directional stick relay 8S, which relay 8S is thereafter maintained energized through its stick circuit hertofore traced. Also, the picking up of the directional stick relay 8S with the directional stick relay 9S deenergized causes a code of 120 impulses per minute to be applied to the east end of the block N as soon as the rear end of the east-bound train has moved entirely out of the block N. As already pointed out a code is applied to the west end of the block N in accordance with traffic conditions in advance of the signal S7. The simultaneous application of codes at opposite ends of the block N, as is now the case, may result in impulses being applied at both ends of the block N at the same instant. Since, however, the batteries B6 and B9 are poled to oppose each other no particular harm is done because if these impulses are applied at exactly the same instant and remain applied for exactly the same durations no current flow to any appreciable extent results. Such a code fight, so to speak, can however not last very long because the coders would either be applying different codes which would bring them out of inverse synchronism, or if they happen to be applying the same code they would soon be out of step because the apparatuses would at best be slightly different in construction. Under the conditions assumed the inverse code relay IR at one end or the other of the block N would be picked up in response to the driven code applied to the opposite end of such block N the moment a slight change in phase relation between the operation of the relays CPR takes place, and thereafter the selecting relays FR6 and FR7 will be alternately energized and picked up for reasons already explained. It is, of course, readily understoood that the end at which the inverse track relay IR is picked up becomes the receiving end of the then applied driven code and that thereafter codes will be alternately applied to opposite ends of the block N for repeated three second intervals in a manner as heretofore described.

Reviewing now briefly the system illustrated in Figs. 1A and 1B, this sytem is an absolute-permissive-block signaling system employing a track circuit of the duplex rocking type. The word "duplex" signifies that traffic conditions are manifested at both ends of the track section by separate track circuits including separate track relays and the same track rails. The word "rocking" signifies that these track circuits are rendered available alternately at such a fast rate that the track relay and its associated decoding means of each track circuit substantially continuously manifests traffic conditions in that block and in blocks beyond the opposite end of such block. The construction of the system is such that during both occupancy and unoccupancy of a particular block codes of current impulses are applied at both ends of the block, these codes being of a nature to manifest traffic conditions beyond that end. It is thus seen that for each direction of movement of a train through such block coded current will flow in the track rails ahead of the train coded in accordance with traffic conditions in advance of such train. These codes are alternately applied so long as the block is unoccupied in order to avoid conflict or interference between these codes. When, however, a particular block is occupied both of the codes are applied to the two ends simultaneously, each coding circuit extending from the source end of the track circuit down one rail through the wheels and axles of the train and back through the other rail. Since each of these coding circuits have currents therein coded in accordance with traffic conditions ahead of the train, cab signals controlled in accordance with the codes in these coding circuits as inductively detected will manifest in the cab traffic conditions ahead. When a block becomes unoccupied the relays FR and IR will assume their deenergized position and the relays JR will assume their energized position at both ends of the track circuit. If both of the code applying relays CPR operated in perfect synchronism opposing impulses of current would be applied at both ends of the track section resulting in zero current flow. Such synchronism can, however, not continue long, especially if the timing of the coders C at opposite ends of each section is slightly different. If desired, the coders at opposite ends of the same track section may be especially timed to avoid such synchronous operation. After a short time of such synchronous operation of the code applying relays CPR one or the other of the inverse track relays IR will be picked up by the impulse applied at the opposite end of the track section. When this occurs the relays IR and FR at that end will continuously assume their energized position and their associated relay JR will be deenergized, but due to its slow dropping characteristic will not drop

for a period of about three seconds, at which time it will drop to close its back contact 19 included in the circuit of the inductive kick relay IKP. During and following the next received impulse, the relay FR not yet having dropped in response to the dropping of the associated relay JR, an inverse code element is transmitted through front contact 22 of the relay IKP to the opposite end of the track section, and this inverse code impulse changes the apparatus at such opposite end from transmitting apparatus to receiving apparatus. It is thus seen that the apparatus at one end is changed from receiving apparatus to transmitting apparatus by dropping of the timing relay JR and that this results in the transmission of a single inverse code impulse to the opposite end of the track section which then picks up the inverse track relay IR to convert such opposite end from constituting a transmitting apparatus to constituting a receiving apparatus. In other words, synchronization of the apparatuses at opposite ends of a track section is accomplished by transmitting a synchronizing impulse through the same track rails which constitute a portion of each of the duplex track circuits.

Structure of Fig. 2

The apparatus illustrated in Fig. 2 of the drawings is identical to the structure shown in Figs. 1A and 1B of the drawings insofar as the apparatus associated with the signal S10 is concerned, a portion of this structure having, however, been omitted for convenience. The structure associated with the signal S11 in Fig. 2 of the drawings, however, differs from the structure associated with the signal S9 of Fig. 1B of the drawings by the addition of an approach track relay AT11 included in series with the main battery B11 and by the addition of the front contact repeater relay AFP11 and the back contact repeater relay ABP11 controlled by this approach track relay AT11 and further by the addition of the control contacts 52^{11} and 53^{11} controlled thereby. It is readily seen that the front contact repeater relay AFP11 will pick up and remain in its energized position continuously during intermittent closure of front contact 51^{11} of the approach track relay AT11 and that the back contact repeater relay ABP11 will continuously assume its energized position in response to intermittent closure of back contact 50^{11} of the approach track relay AT11 provided that the front contact repeater relay AFP11 is then assuming its energized position and maintains its front contact 51^{11} closed.

It should be observed that back contact 53^{11} of relay ABP11 and front contact 52^{11} of relay AFP11 are included in multiple in the energizing circuit of the code applying relay CPR11. From the construction illustrated it will be observed that the energizing circuit for relay CPR11 will be open at contacts 52^{11} and 53^{11} only for a short time following each occupancy of the track section or block P, that is, following the instant of unoccupancy of such section. In other words, the apparatus at the east end of the track section extending from signal S10 to signal S11 cannot transmit a code immediately after the track section P is vacated, whereas the apparatus at the west end can, the west end apparatus not including a series approach relay AT and associated relays controlled thereby. The relays AT, ABP and AFP may, therefore, be considered to be suppressing or lock-out apparatus to suppress the operation of the code applying apparatus at the east end of the block P for a time long enough to allow the code applying apparatus at the west end of block P to transmit a code element to pick up the relay IR11 and in turn the selecting relay FR11 at the east end, after which codes will be applied alternately at opposite ends of the block P.

Operation of Fig. 2

The apparatus illustrated in Fig. 2 functions in exactly the same way as does the apparatus illustrated in Figs. 1A and 1B, except for a moment following the unoccupancy of the block P. As heretofore pointed out in connection with the operation of the system illustrated in Figs. 1A and 1B, a code is applied at both ends of the block P during occupancy of this block P. Since the approach track relay AT11 is a series approach relay of the usual construction this relay AT11 remains in its deenergized position even though it is intermittently weakly energized by the driven code which flows from the main battery B11. Thus the approach track relay AT11 is a marginal relay which will not be picked up under unoccupancy of the block P, but which will intermittently pick up during occupancy of the block P in response to the intermittent picking up of the code applying relay CPR11. With the block P now occupied, as has just been assumed, the approach track relay AT11 is intermittently picked up in response to the impulses of the driven code which is derived from the battery B11 and which flows through this approach relay AT11 to the track rails at the east end of the track circuit for block P. This intermittent picking up and dropping of the approach track relay AT11 causes the slow dropping code repeater relays AFP11 and ABP11 to both assume their energized position continuously as illustrated in Fig. 2 of the drawings, so that the front contact 52^{11} of the relay AFP11 is closed and the back contact 53^{11} of the relay ABP11 is open. It is thus seen that the code applying relay CPR11 may be energized through the front contact 52^{11} of the front approach coding relay AFP11. Let us now assume that the train under consideration moves out of the block P and leaves this block P unoccupied. Since the approach relay AT is only provided at the east end of the block P it is readily seen that the movement of the train out of the block P causes different action at one end than at the other end of the block P, in that the approach relay AT11 assumes its retracted position continuously as a result of which the relays AFP11 and ABP11 are deenergized and dropped away in sequence in that order. It is also readily seen that the relay ABP11 will not start dropping until the relay AFP11 has actually moved to its deenergized position from which it becomes apparent that the front contact 52^{11} of the relay AFP11 opens before the back contact 53^{11} of the relay ABP11 closes. In other words, the code applying relay CPR11 remains deenergized during the drop-away time of the approach track repeater relay ABP11. During this time when the code applying relay CPR11 has its energizing circuit open the inverse track relay IR11 is connected to the east end of the track circuit for the block P. At the west end, however, since no such approach relay AT is provided at that end, the code applying relay CPR 10 continues to be intermittently picked up to transmit a driven code from the west end to the east end of the block P. This driven code will, of course,

pass through the upper winding of the inverse track relay IR11, thereby causing this relay IR11 to be picked up. With the relay IR11 once up it is stuck up through its stick circuit including the stick contact 17^{11} and the front contact 18^{11} of the timing relay JR11. With the inverse track relay IR11 at the east end of the block P now energized, and with the corresponding inverse track relay IR10 at the west end deenergized, a driven code is transmitted only from the west end to the east end through the block P. This west-to-east code continues only for its usual three second interval which is then followed by the transmission of a driven code from east to west through the track circuit of the block P. It is thus seen that the approach track relay AT11 at the east end of the block P serves to prevent a code fight, because the code applying relay CPR11 has its energizing circuit broken at that time when ordinarily a code fight would take place. That is, the structure is such that one end of a particular block is momentarily rendered incapable of transmitting a driven code as a result of which a driven code is first transmitted from the opposite end of such block and no code fight therefore takes place.

Having thus illustrated several embodiments of the present invention, one of which includes means to prevent a code fight, and having illustrated these embodiments of the invention rather conventionally, it is desired to be understood that the particular embodiments illustrated and the manners in which they have been illustrated have been selected for the purpose of enabling a clear disclosure of the invention to be made and without any intent of illustrating its scope or the specific construction preferably employed in practicing the invention, and it should further be understood that various changes, modifications, and additions may be made to adapt the invention to the particular problem encountered in practicing the same, all without departing from the spirit or scope of the invention except as demanded by the scope of the appended claims.

What I claim as new is:

1. In a coded track circuit; the combination with a section of track; a driven code transmitter and a track relay at each end of said section; a selecting means at each end of said section for connecting either said track relay or said driven code transmitter for that end of said section to the track rails; means including timing means at each end of said section effective after an interval of time to apply an inverse code impulse to said track section immediately after the reception of a driven code impulse and to then actuate said selecting means to substitute the driven code transmitter for said track relay; and means at each end of said section responsive to an inverse code impulse to actuate the selecting means so as to substitute the track relay for the driven code transmitter.

2. In a coded track circuit for transmitting codes in opposite directions through the rails of a section of railway track alternately, the combination with a section of track divided from the remaining track by insulating joints, a driven code generator at each end of said section for generating a multiple impulse driven code, an inverse impulse generator at each end of said section for generating an inverse impulse during an off period of such driven code transmitted from the opposite end of said section, timing means at each end of said section for rendering said inverse impulse generator effective, code responsive means at each end of said section, and means at each end of said section responsive to the reception of an inverse impulse to substitute said code responsive means for said driven code generator and also responsive to said timing means to substitute said driven code generator for said code responsive means.

3. In a duplex track circuit including code transmitting and code receiving means for each end of the track section track circuited by such duplex track circuit, a selecting relay at each end of said section which when in its energized position connects its associated code receiving means across the track rails at that end and when in its deenergized position connects its associated code transmitting means across the track rails at that end, control means for controlling said selecting relays to cause deenergization of both selecting relays for a particular track section when such track section is occupied and to cause alternate energization of said selecting relays so long as such section is unoccupied, each period of energization of said selecting relays being long enough to transmit a multiple element code, and railway signals controlled by said code receiving means.

4. In a duplex track circuit, the combination with a railway track section isolated from adjacent track sections, multiple impulse code creating means including a coding contact at each end of said section, a main track relay and an inverse track relay for each end of said track section, a main track source for each end of said track sections, a selecting relay for each end of said track sections having front contacts included in a circuit including said main track relay and the rails of said section and having back contacts included in series with the rails of said section and in series with two multiple circuits one including a front point of said coding contact and said track source and the other including a back point of said coding contact and said inverse track relay, and control means for controlling said selecting relays to cause deenergization of both selecting relays for said section when said section is occupied and to cause alternate energization of said selecting relays so long as such section is unoccupied, each period of energization of a selecting relay being long enough to transmit a complete multiple element code.

5. In combination with a section of track divided from adjacent track by insulating joints, of a multiple impulse code applying apparatus at each end of said section, multiple impulse code receiving apparatus at each end of said section, selecting means at each end of said track section for connecting either the code applying apparatus for transmitting a main code or the code receiving apparatus to the rails at that end of the track section, and control means for controlling said selecting means so that only one of said selecting means is effective at a time to connect its associated code receiving apparatus to the track rails, each of said control means being controlled by an inverse code element transmitted from the opposite end of the track section and constituting a current impulse transmitted during the off period of the main code then transmitted toward such opposite end of the track section.

6. In combination with a section of track isolated from adjacent track sections, coding means at each end of said section for creating a multiple element code which may be applied to said section and in which the code elements are separated by time spaces, code responsive apparatus

at each end of said section, a selecting relay at each end of said section for when assuming its energized position connecting the associated code responsive apparatus to the track rails and when assuming its deenergized position connecting the associated coding means to the track rails at that end, means effective if a code impulse is received during a time space of a transmitted code received at a particular end and while the selecting relay at such particular end is assuming its deenergized position for picking up such selecting relay and causing that end of the section to be connected to the associated code responsive means, and code alternating means controlled in part by the code responsive means at the opposite end for transmitting a code impulse during the time space of a transmitted code transmitted from the particular end of said section.

7. In a duplex track circuit for a track section; the combination with a main track relay, an inverse track relay, an inductive kick relay, a main track source, an inverse track source and a coding contact for each end of said track section; a selecting relay for each end of said track section which when in its energized position connects the main track relay for that end to the rails of said section through a back contact of said inductive kick relay and when in its deenergized position connects the inverse track relay for that end to the track rails through a contact closed when said coding contact is open; a timing relay for each end of said section controlled by the associated selecting relay and effective a predetermined time after such selecting relay has geen energized to inductively connect the associated inductive kick relay to the energizing circuit of its associated main track relay, said inductive kick relay when momentarily assuming its energized position in response to a current impulse induced therein substituting the associated inverse track source for the associated main track relay to transmit an inverse code element to the opposite end of the track section; and a contact on the inverse track relay located at the opposite end of said track section closed in response to such inverse code element and included in the energizing circuit for the selecting relay at such other end of said track section, whereby the actuation of said timing relay at one end of said section results in the operation of the selecting relays at both ends of said track section.

8. In a duplex track circuit; the combination with a track section; a main track relay, an inverse track relay, an inductive kick repeater relay, a coding contact, a track current source and a selecting relay at each end of said track section; a branch circuit for connecting said main track relay to the track rails when its associated selecting relay assumes its energized position and its associated inductive kick repeater relay assumes its retracted position; a second branch circuit for connecting the track current source to the track rails when the associated selecting relay assumes its deenergized position and the associated coding contact is closed; a third branch circuit for connecting the inverse track relay to the track rails when the associated selecting relay assumes retracted position and the associated coding contact is open; timing means at each end of said track section which if rendered active causes the transmission of an inverse code element to the opposite end of said track section and then operates its associated selecting relay to its retracted position; and means controlled by the inverse track relay at such opposite end of said section, upon its response to such inverse code element, for actuating its associated selecting relay to its energized position.

9. In a coded track circuit; the combination with a section of track, a driven code transmitter, an inverse code transmitter and a track relay at each end of said section; a selecting means at each end of said section for connecting either said track relay or said driven code transmitter for that end of said section to the track rails; timing means at each end of said section effective after an interval of time to apply an inverse code impulse to said track section immediately after the reception of a driven code impulse and to then actuate said selecting means to substitute the driven code transmitter for said track relay; means at each end of said section responsive to an inverse code impulse to substitute the track relay for the driven code transmitted, and decoding means at each end of said section controlled by the associated track relay.

10. In a coded track circuit for transmitting codes in opposite directions through the rails of a section of railway track alternately, the combination with a section of track divided from the remaining track by insulating joints, a driven code generator at each end of said section for generating a multiple impulse driven code, an inverse impulse generator at each end of said section for generating an inverse impulse during an off period of such driven code transmitted from the opposite end of said section, timing means at each end of said section for rendering said inverse impulse generator effective, code responsive means at each end of said section, means at each end of said section responsive to the reception of an inverse impulse to substitute said code responsive means for said driven code generator and also responsive to said timing means to substitute said driven code generator for said code responsive means, and a signal at each end of said section to govern the entrance of traffic into said section from that end and controlled by the associated code responsive means.

11. In a duplex track circuit including code transmitting and code receiving means for each end of the track section track circuited by such duplex track circuit, a selecting relay at each end of said section which when in its energized position connects its associated code receiving means across the track rails at that end and when in its deenergized position connects its associated code transmitting means across the track rails at that end, control means including an inverse code element transmitting and an inverse code element receiving means for controlling said selecting relays to cause deenergization of both selecting relays for a particular track section when such track section is occupied and to cause alternate energization of said selecting relays so long as such section is unoccupied, each period of energization of said selecting relays being long enough to transmit a multiple element code, and railway signals controlled by said code receiving means.

12. In a duplex track circuit, the combination with a railway track section isolated from adjacent track sections, multiple impulse code creating means including a coding contact at each end of said section, a main track relay and an inverse track relay for each end of said track section, a main track source for each end of said track section, a selecting relay for each end of said track section having front contacts included

in a circuit including said main track relay and the rails of said section and having back contacts included in series with the rails of said section and in series with two multiple circuits one including a front point of said coding contact and said track source and the other including a back point of said coding contact and said inverse track relay, control means for controlling said selecting relays to cause deenergization of both selecting relays for said section when said section is occupied and to cause alternate energization of said selecting relays so long as such section is unoccupied, each period of energization of a selecting relay being long enough to transmit a complete multiple element code, and a signal at each end of said track section governing the entrance of trains into said track section and controlled by its associated main track relay.

13. In a duplex track circuit, the combination with a railway track section isolated from adjacent track sections, multiple impulse code creating means including a coding contact at each end of said section, a main track relay and an inverse track relay for each end of said track section, a main track source for each end of said track section, a selecting relay for each end of said track section having front contacts included in a circuit including said main track relay and the rails of said section and having back contacts included in series with the rails of said section and in series with two multiple circuits one including a front point of said coding contact and said track source and the other including a back point of said coding contact and said inverse track relay, control means for controlling said selecting relays to cause deenergization of both selecting relays for said section when said section is occupied and to cause alternate energization of said selecting relays so long as such section is unoccupied, each period of energization of a selecting relay being long enough to transmit a complete multiple element code, decoding means at each end of said track section controlled by its associated main track relay, and a signal at each end of said track section governing the movement of traffic into said section governed by its associated decoding means.

14. In combination with a section of track divided from adjacent track by insulating joints, of a multiple impulse code applying apparatus at each end of said section, multiple impulse code receiving apparatus at each end of said section, selecting means at each end of said track section for connecting either the code applying apparatus for transmitting a main code or the code receiving apparatus to the rails at that end of the track section, control means for controlling said selecting means so that only one of said selecting means is effective at a time to connect its associated code receiving apparatus to the track rails, each of said control means being controlled by an inverse code element transmitted from the opposite end of the track section and constituting a current impulse transmitted during the off period of the main code then transmitted toward such opposite end of the track section, and signals at each end of said section for governing the movement of traffic into said section and controlled by its associated code receiving apparatus.

15. In combination with a section of track isolated from adjacent track sections, coding means at each end of said section for creating a multiple element code which may be applied to said section and in which the code elements are separated by time spaces, code responsive apparatus at each end of said section, a selecting relay at each end of said section for when assuming its energized position connecting the associated code responsive apparatus to the track rails and when assuming its deenergized position connecting the associated coding means to the track rails at that end, means effective if a code impulse is received during a time space of a transmitted code received at a particular end and while the selecting relay at such particular end is assuming its deenergized position for picking up such selecting relay and causing that end of the section to be connected to the associated code responsive means, code alternating means controlled in part by the code responsive means at the opposite end for transmitting a code impulse during the time space of a transmitted code transmitted from the particular end of said section, and timing means for controlling said code alternating means.

16. In combination with a section of track isolated from adjacent track sections, coding means at each end of said section for creating a multiple element code which may be applied to said section and in which the code elements are separated by time spaces, code responsive apparatus at each end of said section, a selecting relay at each end of said section for when assuming its energized position connecting the associated code responsive apparatus to the track rails and when assuming its deenergized position connecting the associated coding means to the track rails at that end, means effective if a code impulse is received during a time space of a transmitted code received at a particular end and while the selecting relay at such particular end is assuming its deenergized position for picking up such selecting relay and causing that end of the section to be connected to the associated code responsive means, code alternating means controlled in part by the code responsive means at the opposite end for transmitting a code impulse during the time space of a transmitted code transmitted from the particular end of said section, timing means for controlling said code alternating means, and signals controlled by said code responsive apparatus.

17. In a duplex track circuit for a track section; the combination with a main track relay, an inverse track relay, an inductive kick relay, a main track source, an inverse track source and a coding contact for each end of said track section; a selecting relay for each end of said track section which when in its energized position connects the main track relay for that end to the rails of said section through a back contact of said inductive kick relay and when in its deenergized position connects the inverse track relay for that end to the track rails through a contact closed when said coding contact is open; a timing relay for each end of said section controlled by the associated selecting relay and effective a predetermined time after such selecting relay has been energized to inductively connect the associated inductive kick relay to a winding of its associated main track relay, said inductive kick relay when momentarily assuming its energized position in response to a current impulse induced therein substituting the associated inverse track source for the associated main track relay to transmit an inverse code element to the opposite end of the track section; a contact on the inverse track relay located at the opposite end of said track section closed in response to such inverse code element and included in the energizing circuit for the selecting relay at such other end of

said track section, whereby the actuation of said timing relay at one end of said section results in the operation of the selecting relays at both ends of said track section, and signals controlled by said main track relays.

18. In a duplex track circuit; the combination with a track section; a main track relay, an inverse track relay, an inductive kick repeater relay, a coding contact, a track current source and a selecting relay at each end of said track section; a branch circuit for connecting said main track relay to the track rails when its associated selecting relay assumes its energized position and its associated inductive kick repeater relay assumes its retracted position; a second branch circuit for connecting the track current source to the track rails when the associated selecting relay assumes its deenergized position and the associated coding contact is closed; a third branch circuit for connecting the inverse track relay to the track rails when the associated selecting relay assumes retracted position and the associated coding contact is open; timing means at each end of said track section which if rendered active causes the transmission of an inverse code element to the opposite end of said track section and then operates its associated selecting relay to its retracted position; means controlled by the inverse track relay at such opposite end of said section, upon its response to such inverse code element, for actuating its associated selecting relay to its energized position, and signals controlled by said main track relays.

19. In an absolute-permissive-block signaling system; the combination with a single track stretch divided into blocks; a signal at the entrance end of each block for governing the movement of traffic into the block from that end; decoding means for each signal; a directional stick relay for each signal including a pick-up circuit closed when a train passes that signal in the direction such signal governs traffic and including a stick circuit closed so long as the block in advance of such signal is occupied; a main code transmitter for each signal controlled in accordance with the condition of occupancy of the block in advance of the block with which it is associated and in accordance with the condition of energization of the directional stick relay associated with the signal governing the movement of traffic in the same direction and into the block next in advance; and means including an inverse code transmitter and an inverse code receiver for alternately rendering the main code transmitter at one end and the decoding means at the other end and the decoding means at said one end and the main code transmitter at said other end effective.

20. In an absolute-permissive-block signaling system; the combination with a single track stretch divided into blocks; a signal at the entrance end of each block for governing the movement of traffic into the block from that end; decoding means for each signal; a directional stick relay for each signal; a main code transmitter for each signal controlled in accordance with the condition of occupancy of the block in advance of the block with which it is associated and in accordance with the condition of energization of the directional stick relay associated with the signal governing the movement of traffic in the same direction and into the block next in advance; and means including timing means, an inverse code transmitter and an inverse code receiver for alternately rendering the main code transmitter at one end and the decoding means at the other end effective for a time period and then rendering the decoding means at said one end and the main code transmitter at said other end effective for substantially the same period of time.

21. In combination with a section of track divided from adjacent track by insulating joints, of a multiple impulse code applying apparatus at each end of said section, multiple impulse code receiving apparatus at each end of said section, a selecting relay at each end of said section for when in its deenergized position connecting the code applying apparatus for transmitting a code to the opposite end of said section to the rails of said section and for when in its energized position connecting the code receiving apparatus to the rails of the track section, timing means at each end of said section, and control relays for controlling said selecting relays to their energized and their deenergized positions successively in such manner that only one of said selecting relays is effective at a time to connect its associated code receiving apparatus to the track rails, each of said control relays being controlled to one position from the opposite end of the track section by the timing means located at such opposite end and being controlled to another position by its associated timing means.

22. In combination with a section of track divided from adjacent track by insulating joints, of a multiple impulse code applying apparatus at each end of said section, multiple impulse code receiving apparatus at each end of said section, selecting means at each end of said section for connecting either the code applying apparatus for transmitting a code to the opposite end of said section or the code receiving apparatus to the rails at that end of the track section, control means at each end of said section having an energized position and a deenergized position for controlling the associated selecting means, timing means at each end of said section for controlling the control means at that end of said section to its deenergized position and controlling the control means at the other end of said section to its energized position substantially simultaneously, and means for controlling each timing means by its associated selecting means.

THOMAS J. JUDGE.