Nov. 22, 1949 W. H. REICHARD 2,488,683

APPROACH STARTED CODED TRACK CIRCUIT SIGNALING SYSTEM

Filed Dec. 13, 1944 5 Sheets-Sheet 1

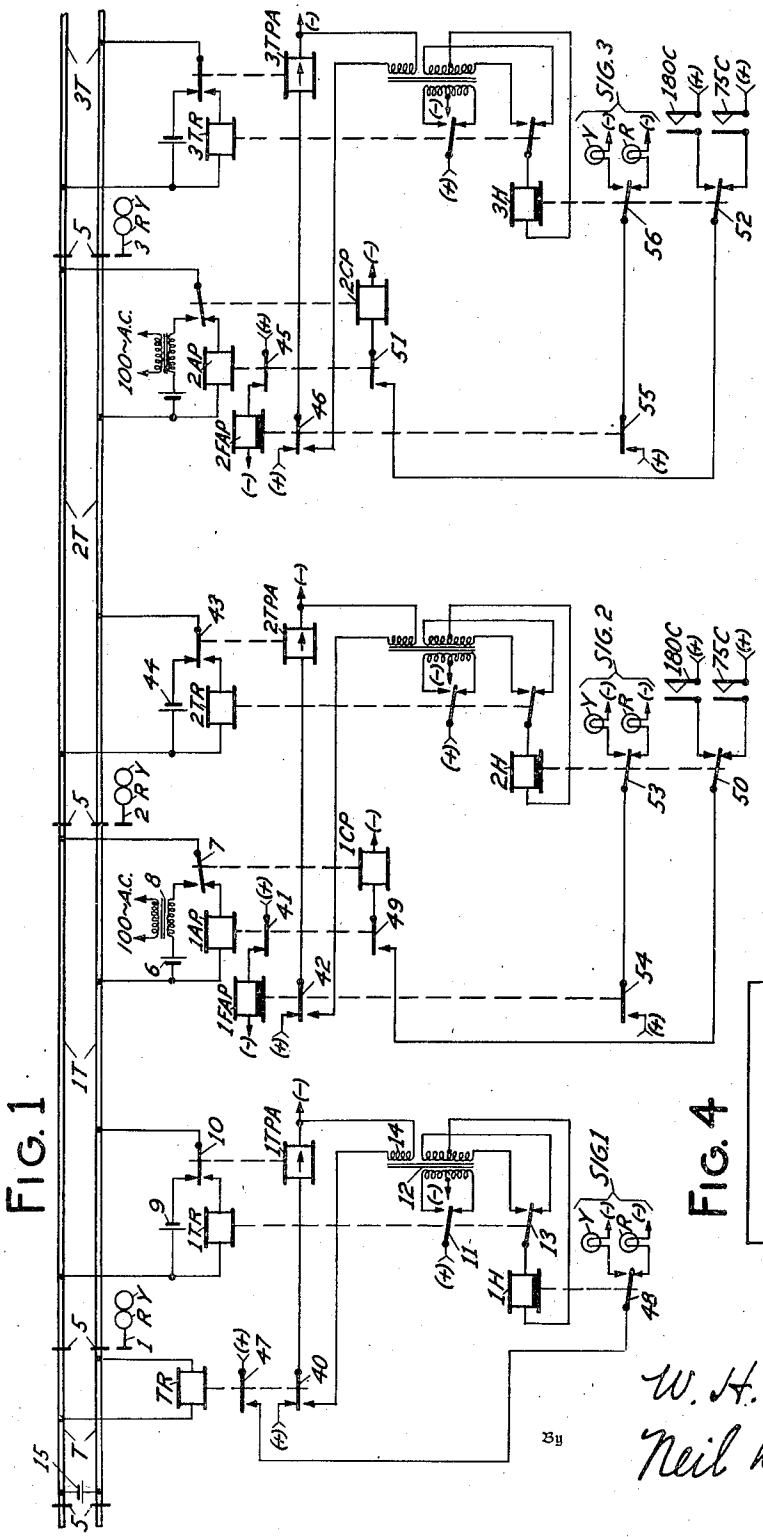


FIG. 1

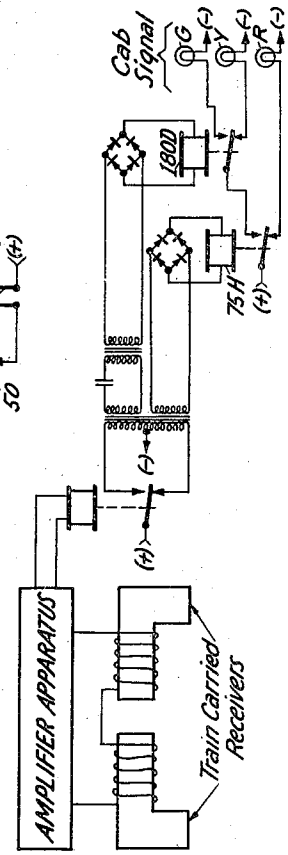


FIG. 4

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APPROACH STARTED CODED TRACK CIRCUIT SIGNALING SYSTEM

Filed Dec. 13, 1944 5 Sheets-Sheet 2

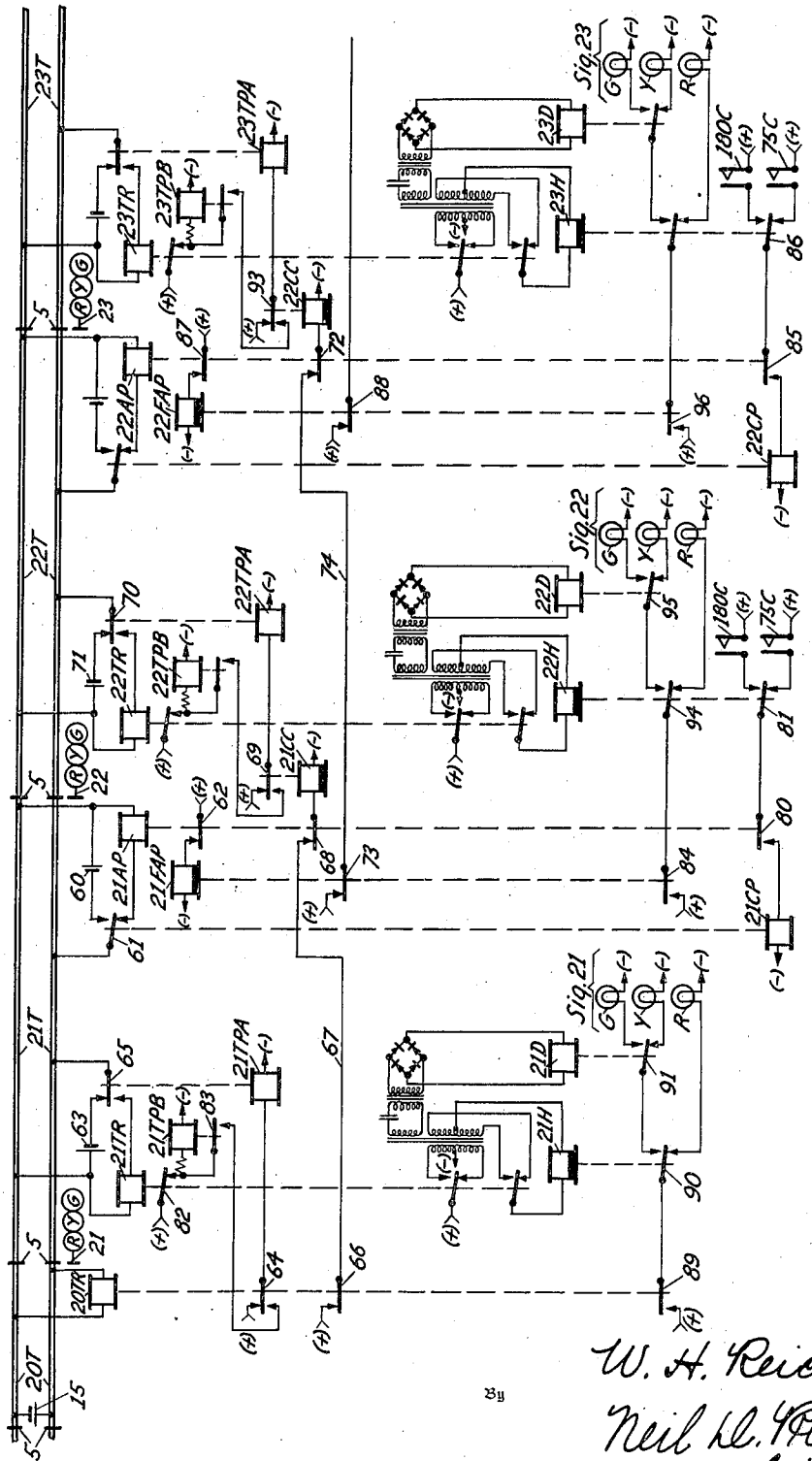


FIG. 2

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APPROACH STARTED CODED TRACK CIRCUIT SIGNALING SYSTEM

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5 Sheets-Sheet 3

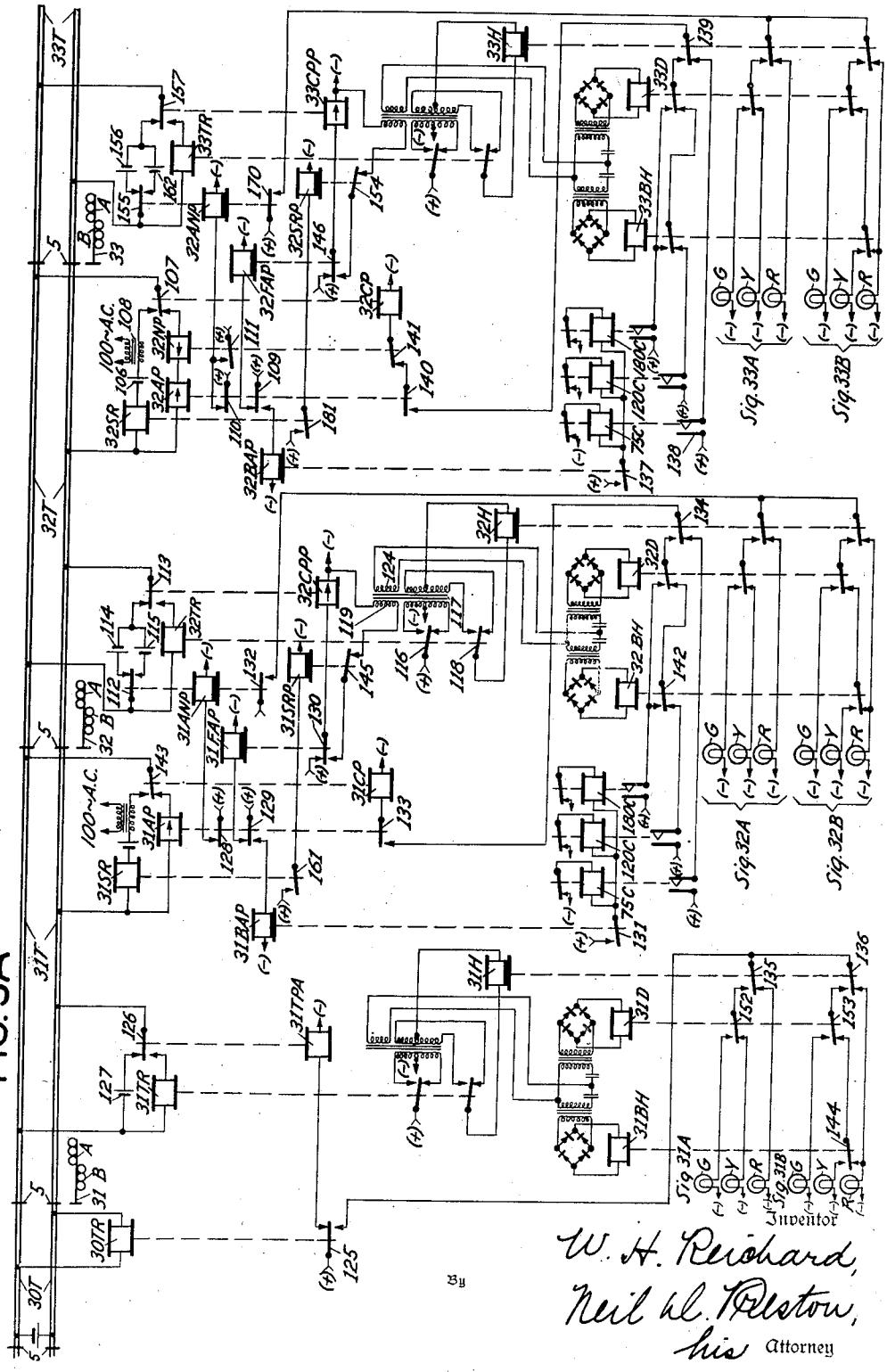


FIG. 3A

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APPROACH STARTED CODED TRACK CIRCUIT SIGNALING SYSTEM

Filed Dec. 13, 1944 5 Sheets-Sheet 4

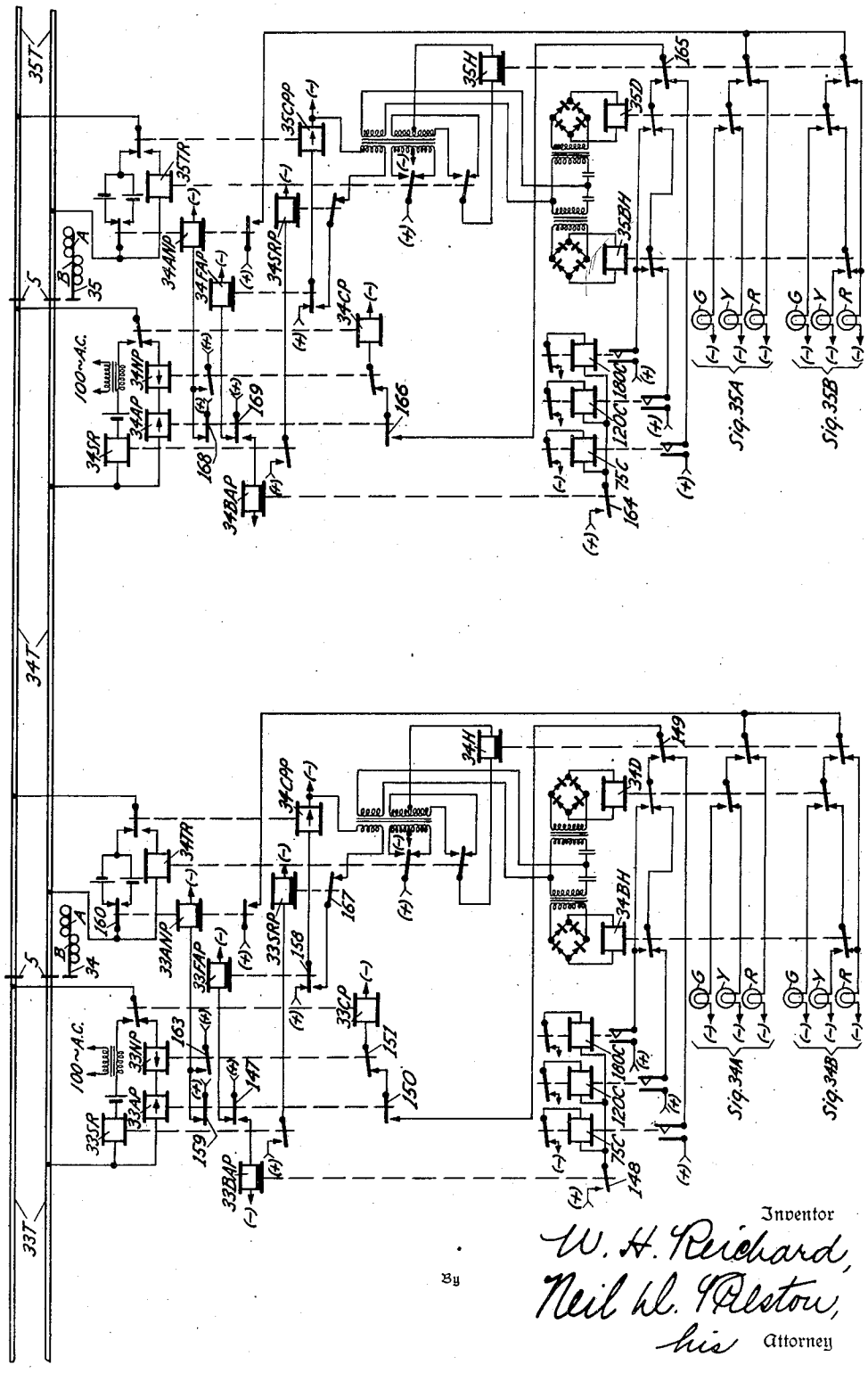


FIG. 3B

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APPROACH-STARTED CODED TRACK CIRCUIT SIGNALING SYSTEM

Filed Dec. 13, 1944 5 Sheets-Sheet 5

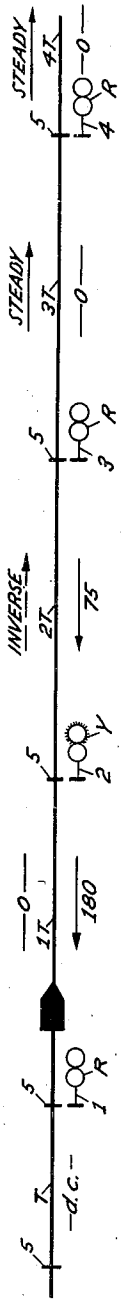


FIG. 5

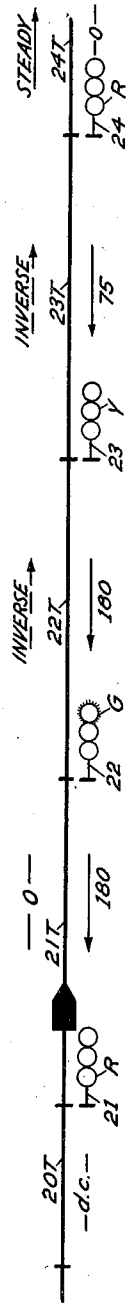


FIG. 6

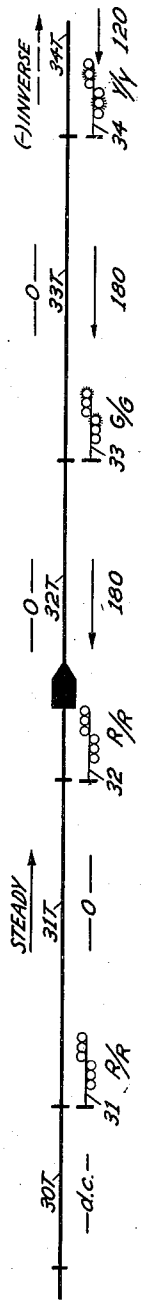


FIG. 7A

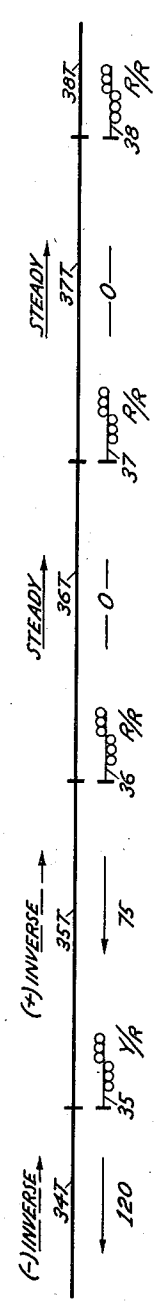


FIG. 7B

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UNITED STATES PATENT OFFICE

2,488,683

APPROACH STARTED CODED TRACK CIRCUIT SIGNALING SYSTEM

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Application December 13, 1944, Serial No. 567,995

18 Claims. (Cl. 246—38)

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This invention relates to automatic block signalling systems for double-track railroads, and more particularly to a signalling system of the coded track circuit type in which the coding equipment is normally inactive but is automatically set into operation upon the approach of a train.

In the usual coded track circuit type of block signalling, each track circuit is intermittently energized by different driven codes in accordance with the traffic conditions in advance of that section; even when there are no approaching trains. It is desirable therefore to conserve the power normally required by the system when there are no trains approaching. The conservation of power is especially desirable on railroads where the traffic is relatively light and the apparatus could be normally at rest for a substantial proportion of the time.

Generally speaking and without attempting to define the nature and scope of the present invention, it is proposed to provide a simple and effective organization of relays and circuits for a normally-at-rest coded track circuit type of signalling system which is initiated into operation upon the approach of a train for a certain number of blocks in advance of such train by the provision of a tumble-down circuit organization which may have what is conveniently termed a limited tumble-down characteristic.

More specifically, it is proposed to provide for the steady energization of each track circuit at its entrance end dependent upon the approach of a train in the preceding track section or sections; and this steady energization of each track circuit at its entrance end renders the coding apparatus at its exit end ineffective to apply driven code to such exit end of the track circuit. Since the application of steady potential to the entrance end of each track section is dependent upon the application of steady potential to each preceding track section, it is apparent that the first track section of the territory employing such a signalling system must be dependent either upon a conventional closed circuit type track circuit or upon some manual control. Also, with such a tumble-down organization, it is apparent that unless some limiting means is employed to limit the extent of tumble-down upon the entrance of a train into the territory, the tumble-down would occur throughout the stretch of track thus equipped.

In accordance with the present invention, it is proposed to provide for the use of inverse codes, that is, code pulses that are transmitted during

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the off periods of the regular driven codes, and in this way control the extent of the tumble-down effect without interfering with the driven codes and their action upon the control of the way-side signals and/or train carried cab signalling.

Another object of the present invention is to disclose an organization of means which is adaptable for providing approach control in advance of a train for any desired number of blocks in accordance with the number of indications that may be employed for the particular signalling used.

A still further object of the invention is to provide a system of approach control in advance of a train passing through territory signalled with coded track circuits of the normally-at-rest type in such a manner that there will be no critical timing conditions involved in the limitation of the extent to which such approach control reaches in advance of the train, and also to provide this organization in such a way that should a train reverse its direction of movement and travel against the normal direction of traffic, the approach control will be withdrawn as the train recedes to thus restore the coding apparatus of the various track circuits to normal inactive conditions without waiting for the train to fully leave the stretch of track thus signalled.

Other objects, purposes and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description of the invention progresses.

In describing the invention in detail, reference will be made to the accompanying drawings, in which like letter reference characters have been used to designate similar parts throughout the several views, and these different letter reference characters have been made distinctive by the use of preceding numerals corresponding to the signals with which the various devices are associated. In the different modifications of the present invention, these preceding numerals have been made distinctive in accordance with the figures of the drawings to which they appertain. With reference to the drawings, it will be noted that—

Fig. 1 shows a signalling system embodying the present invention applied to a stretch of track in a manner to provide for two indication way-side signals and for three indication cab signalling;

Fig. 2 shows another form of a signalling system embodying the present invention applied to a stretch of track for control of three indication way-side signalling;

Figs. 3A and 3B show a still further form of the present invention embodied in a signalling sys-

tem adapted to provide four indication way-side signalling;

Fig. 4 indicates in a diagrammatic manner a typical car-carried apparatus adapted to cooperate with the way-side equipment of Fig. 1 to provide three indication cab signals;

Fig. 5 is a diagram of the signal and track circuit conditions relating to the form of the invention disclosed in Fig. 1;

Fig. 6 is a diagram of the signal and track circuit conditions relating to the form of the invention disclosed in Fig. 2; and

Figs. 7A and 7B are diagrams of the signal and track circuit conditions relating to the form of the invention disclosed in Figs. 3A and 3B.

For the purpose of simplifying the illustration and facilitating in the explanation, the various parts and circuits constituting the embodiment of the invention have been shown diagrammatically and certain conventional illustrations have been employed, the drawings having been made more with the purpose of making it easy to understand the principles and mode of operation, than with the idea of illustrating the specific construction and arrangement of parts that would be employed in practice. Thus, the various relays and their contacts are illustrated in a conventional manner, and symbols are used to indicate connections to the terminals of batteries, or other sources of electric current, instead of showing all of the wiring connections to these terminals.

The symbols (+) and (−) are employed to indicate the positive and negative terminals respectively of suitable batteries, or other sources of direct current; and the circuits with which these symbols are used always have current flowing in the same direction. The terminals having alternating current connections have suitable legends applied thereto with the letters "A. C."

With reference to Fig. 1 of the accompanying drawings, the track rails of a stretch of track are shown divided by the usual insulated joints 5 into track sections, of which the track sections T, 1T, 2T and 3T are shown, it being assumed for simplicity that these track sections will be long enough to constitute the usual block between signal locations, although it should be understood that the same principles may be applied to blocks consisting of two or more separate track sections. At the entrance to each track section or block, is a suitable signal indicated for convenience as being of the color light type, and of which signals 1, 2 and 3 have been shown. Each of these signals in this form of the invention is capable of displaying proceed and stop indications displayed by yellow and red color light indications.

Considering briefly the organization of parts associated with each block or track section of a system embodying this invention, each of the different devices for each block has been given distinctive letter reference characters having a preceding numeral corresponding to the number of its associated signal governing traffic in that block. More specifically, a code transmitting relay 1CP is located at the exit end of the track section 1T and is effective to alternately connect a track battery 6 and an approach track relay 1AP across the track rails by operation of its contact 7. A suitable transformer 8 having its primary winding supplied with 100 cycle alternating current, has its secondary winding included in series with the track battery 6 for supplying an alternating current component in the code pulses applied by the operation of the code transmitting relay 1CP, which alternating current component is for acting upon the train carried receivers of the cab signalling apparatus diagrammatically illustrated in Fig. 4.

The approach track relay 1AP is provided with a slow-acting front contact repeater relay 1FAP for governing the application of steady current to the next track section in advance and also for governing the application of inverse code pulses to that track section, all in a manner which will be presently described in detail. This repeater relay 1FAP is also employed to control the approach lighting of the signal 2.

At the entrance end of track section 1T is a track relay 1TR which is normally disconnected from the track rails by the steady energization of an associated repeater relay 1TPA, as will be later described. This relay 1TPA causes steady current potential to be applied to the track section 1T from the battery 9, due to the closure of front contact 10, but when the back contact 10 is closed, the track relay 1TR is connected across the track rails and thus receives the driven code pulses transmitted by the operation of the transmitter relay 1CP.

The track relay 1TR through a contact 11 acts to energize the primary windings of a decoding transformer 12 in opposite directions alternately which through its secondary winding and rectifying contact 13 acts to energize the slow-acting home relay 1H whenever the track relay 1TR is being operated by either a 75 driven code or a 180 driven code. The decoding transformer 12 also has a secondary winding 14 which at times supplies impulses to the track repeating relay 1TPA for applying inverse code pulses from battery 9 to the track section 1T to act on relay 1AP, as will be presently described.

It should be noted that the relay 1TPA, for example, is of the polar-biased type, that is, its contact 10 is normally biased towards a dropped away position, and is picked up only when the relay is energized in a direction indicated by the associated arrow. This is necessary so that the relay 1TPA will respond to impulses of only a particular polarity as supplied from the secondary winding 14 of transformer 12.

Although the track relays, such as relay 1TR for example, and the approach track relays, such as relay 1AP for example, have been shown as neutral relays, it is to be understood that these relays could be polar-biased relays if desired. The use of polarized relays with track sections having the polarity of their batteries staggered is usually for the purpose of providing broken-down insulated joint detection.

Although only three track sections have been indicated in the drawings as having code track circuit apparatus associated therewith, it is to be understood that there may be many such track sections through an extensive stretch of track and that each such track section is equipped as typically shown in this Fig. 1 and as typically described above for track section 1T.

At the entrance to a stretch of track thus equipped, suitable means is provided for controlling the apparatus in accordance with the approach of a train. This means may be manually controlled or may be automatically effective. For convenience in the disclosure of Fig. 1, an approach track section T of the normally closed circuit track circuit type has been shown as having a track battery 15 and a track relay TR.

Each of the signal locations, except the first

(see signal 1 of Fig. 1), is provided with suitable coding contacts which are operated at different rates in order to provide the different codes applied to the track rails. For convenience in the disclosure of the principles of the invention as embodied in Fig. 1 of this application, these coding contacts have been designated 75C and 180C, and are assumed to respectively operate at the 75 and 180 code pulse per minute rate. Also, the apparatus for driving these contacts has not been shown, and it is assumed for the purposes of this form of the invention that such apparatus is in continuous operation, although it should be understood that certain principles of control for such apparatus may be applied to this form of the invention as disclosed in Figs. 3A and 3B. This feature of shutting down the coding contacts when their operation is not required as shown in Figs. 3A and 3B may be applied to Figs. 1 and 2 but has been omitted from these forms of the invention for the sake of simplicity in the disclosure. These coding contacts 75C and 180C may be driven by any suitable mechanism which may be of the motor type or of the balance type such as disclosed for example in the prior Patent No. 2,351,588 granted June 20, 1944 to O. S. Field.

It is believed that the nature of the invention disclosed in Fig. 1, its characteristic features and advantages will be best understood by further description of this form of the invention being given from the standpoint of operation.

Operation of Fig. 1

Under normal conditions, the code transmitting and receiving apparatus for each track section of the system is normally at rest with energy steadily applied at the entrance end of each track section. More specifically, the track relay TR for track section T is normally energized so that the relay 1TPA is energized by a circuit closed from (+), and including front contact 40 of relay TR, and windings of relay 1TPA, to (—). This causes front contact 10 of relay 1TPA to be closed to apply steady energy to the track section 1T from the track battery 9.

Such steady energization of the track section 1T causes the steady energization of the relay 1AP at its exit end by reason of the closed condition of back contact 7 of relay 1CP, which in turn holds relay 1CP deenergized because of open back contact 49. The steady closure of front contact 41 of relay 1AP, maintains its slow-acting repeater relay 1FAP in an energized condition. Thus, the relay 2TPA is in turn energized through a circuit including front contact 42 of relay 1FAP.

With relay 2TPA picked up, its front contact 43 causes steady potential to be applied to the track section 2T from the track battery 44 which acts to steadily energize the relay 2AP. The steady closure of front contact 45 of relay 2AP maintains the relay 2FAP picked up so that front contact 46 can maintain energized the relay 3TPA to cause steady energy to be applied to the track section 3T in an obvious manner. In this way, steady energy is caused to be applied to each track section in turn dependent upon the steady energy in the preceding track section throughout the stretch of track provided with signalling constructed in accordance with the present invention. The steady energy applied to each track section acts through the back contact of its associated relay AP to prevent operation of its associated code transmitting relay CP although the coding contacts 75C and 180C are in continuous operation.

Let us assume that an eastbound train enters the track section T shunting the track relay TR. The closure of back contact 47 immediately causes the signal 1 to be illuminated which initially displays a red indication because of the closed condition of back contact 48 of relay 1H. The opening of front contact 40 deenergizes the relay 1TPA which in turn deenergizes the relay 1AP. As soon as back contact 49 of relay 1AP is closed, the code transmitting relay 1CP is intermittently energized at the 75 code rate by reason of the closed condition of back contact 50 of relay 2H. This operation of the relay 1CP causes a driven code to be applied to the track section 1T at the 75 code rate, each impulse of which includes its alternating current component by reason of the transformer 8 having its secondary winding connected in series with the track battery 6.

The reception of the driven code of the 75 rate at the entrance end of track section 1T causes the track relay 1TR to be operated at the 75 code rate which acts to energize the relay 1H closing front contact 48 so that signal 1 displays a yellow indication. This yellow indication at a signal advises a train that it may proceed prepared to stop at the next signal. With back contact 40 of relay TR closed, upon the cessation of each driven track code pulse, the polarized relay 1TPA is momentarily energized by the impulse created in the secondary winding 14 of the transformer 12. This impulse created by the deenergization of relay 1TR is of the proper polarity to pick up relay 1TPA, but the picking up of relay 1TR creates an impulse of a polarity to which relay 1TPA will not respond. Such momentary energization of the relay 1TPA causes an inverse code pulse to be applied to the track section 1T through front contact 10. This inverse code pulse acts to energize the relay 1AP, but since it is a temporary impulse of relatively short duration it ceases and allows back contact 49 to close before it is time for the energization of relay 1CP to apply the next driven code pulse.

In this way, while the train is approaching the signal 1, an inverse code is transmitted in the track section 1T so that the relay 1FAP is maintained steadily picked up although it is only intermittently energized through front contact 41. Front contact 42 of relay 1FAP thus causes steady energization of relay 2TPA which causes steady energy to track section 2T. Thus, the entrance of the train into the track section T results in the transmission of driven and inverse codes in the track section 1T, and the inverse code acts to maintain steady energization in the track section 2T and each of the track sections in advance.

The train in receiving the yellow indication of signal 1 proceeds into the track section 1T. As soon as this train enters the track section 1T and causes the transmission of the inverse code therein to cease because of the shunting of the track rails, then the relay 1AP remains steadily deenergized so that its repeater relay 1FAP drops away closing back contact 42. This deenergizes the relay 2TPA so that steady energy is removed from the track section 2T which allows the relay 2AP to drop away and close back contact 51. This allows the relay 2CP to immediately start operation at the 75 code rate as energized through back contact 52 of relay 3H. The presence of the driven code in track section 2T as the result of the operation of relay 2CP causes an inverse

code to be transmitted in the section 2T since back contact 42 is closed. The driven code in the section 2T causes the relay 2H to be picked up closing front contact 50 so that a 180 code is applied to the track section 1T. Also, the relay 2H closes its front contact 53 so that the signal 2 is caused to give a yellow indication since back contact 58 of relay 1FAP is closed.

The train in track section 1T is proceeding towards the signal 2 and will receive a yellow indication at that signal, but it is assumed that such train also has suitable cab signalling equipment such as illustrated in Fig. 4 and this equipment responds to the alternating current component of each driven code pulse. Since the driven code pulses are occurring at the 180 code rate as the train approaches the signal 2, the relay 180D of Fig. 4 is energized which causes the green indicator of the cab signal to be illuminated. It may be noted here that it is assumed that the train carried apparatus so operates that the relay 180D is energized or picked up only when there is a 180 code in the track section occupied by the train; while the relay 75H is picked up whenever either a 75 or 180 rate is present therein. This train carried apparatus of Fig. 4 is merely typical of such apparatus, and it is to be understood that any suitable train carried apparatus may be employed.

In brief then, the train in track section 1T is proceeding upon a green or clear cab signal but will pass the signal 2 displaying a yellow indication.

When the train enters the track section 2T, the relay 2AP is caused to remain deenergized which in turn allows the relay 2FAP to drop away so that driven and inverse code conditions are established in the track section 3T in a similar manner as previously described for track sections 1T and 2T. This will cause the energization of the relay 3H, so that the yellow indicator of signal 3 will be illuminated by reason of the closed condition of back contact 55 of relay 2FAP and front contact 56 of relay 3H. Also, the closure of front contact 52 of relay 3H causes the relay 2CP to apply a 180 driven code to the track section 2T. Thus, the train is caused to receive a clear or green cab signal as it proceeds through the track section 2T approaching the signal 3 giving a yellow indication.

In brief, each track section (after the first section T) when occupied by a train has a 180 driven code transmitted toward the train as indicated in Fig. 5 by the arrow having the associated 180 for the track section 1T. There is no inverse code in this section as indicated in Fig. 5 by the zero above the track section 1T. When traffic conditions are unrestricted the section in advance of the train will have a driven code of the 75 code rate as well as an inverse code which acts to maintain steady energization in the second and succeeding track sections in advance as indicated by the arrows with the legends "steady" in Fig. 5. Thus, as the train proceeds from section to section, the initiation of the coding in the track section in advance of the train is effected and a clear cab signal is provided on which the train may proceed.

If, however, a preceding train or other obstruction occupies the section in advance of a train, such as the section 2T while the train is proceeding in track section 1T, it will be obvious that the track relay 2TR will be shunted and the relay 2H will remain deenergized causing the signal 2 to display danger. Under such conditions, it will be seen that back contact 50 of the relay 2H is closed so that a 75 driven code is applied to the track section 1T, which driven code through its alternating current component acts on the train carried apparatus of Fig. 4 to cause the energization of the relay 75H only and the illumination of the yellow cab signal so that the train proceeds toward the signal 2 with a caution cab indication prepared to stop at the red signal indication of signal 2. If the train should pass the signal 2, while there is no code in such section, due to the obstruction or the presence of a preceding train as above mentioned, both the relays 75H and 180D of the train carried apparatus would be deenergized to give a continuous red or danger indication. In this way, three indication cab signals are provided in combination with two indication wayside signals.

It might be well to note that as a train proceeds through a stretch of track equipped with the signalling system of this invention as disclosed in Fig. 1, the sections in the rear of the train receive steady energy and are maintained at rest as under normal conditions. For example, while a train is proceeding through the track section 1T, and has wholly vacated the section T, the front contact 40 of relay TR is closed so that the relay 1TPA is picked up. This applies steady energy to the track section 1T so that as soon as such train proceeds past the signal 2, the relay 1AP becomes energized during the first "off" period of the operation of the relay 1CP and is maintained energized holding open back contact 49 so that no further driven code pulses can be applied to the track section 1T. This continuous energization of the relay 1AP is of course repeated by its front contact repeater 1FAP and by the steady closure of front contact 42 prepares for the steady application of energy to the track section 2T. In this way, the steady or normal state of the various track sections is established in the rear of a train passing through the stretch of track.

In the event a train should reverse its movement with respect to the normal direction of traffic, it should be readily apparent that the withdrawal of a train from a track section having driven code applied thereto would of course permit the immediate reestablishment of an inverse code in that track section, and such inverse code would act at the exit end of the section to pick up the front contact repeater relay FAP and thus remove the inverse code from the next section beyond in the normal direction of traffic and apply steady energy thereto. Thus, as the train proceeds in the reverse direction, the steady or normal state would be reestablished section by section as such train successively moved out of the sections of the stretch.

Structure of Fig. 2

With reference to Fig. 2 of the accompanying drawings, a stretch of track has been shown as including track sections 20T, 21T, 22T, 23T and so forth. The track section 20T forms a normally closed circuit type of track circuit energizing the relay 20TR in the usual way. At the entrance to each of these track sections (except the first section 20T) is a signal assumed to be of the color light type for displaying green, yellow and red indications for three aspect signalling. Each track section also has apparatus associated therewith which is designated by suitable letter reference characters made distinctive by preceding numerals characteristic of that track sec-

tion and the signal governing traffic thereover. Considering track section 21T as typical of the sections having coding apparatus, a code transmitting relay 21CP is provided to alternately connect and disconnect the approach relay 21AP during the transmission of a driven code, and when the relay 21CP is picked up, it connects track battery 60 across the track section 21T. The relay 21AP is provided with a slow-acting front contact repeater relay 21FAP normally energized through front contact 62.

At the entrance end of track section 21T is the track relay 21TR and a track battery 63. Normally the repeating relay 21TPA is energized through a front contact 64 of relay 20TR to cause the application of steady potential to the track section 21T, but this relay 21TP may be operated to transmit an inverse code in a manner presently to be described while back contact 64 is closed. To effect this inverse code transmission, a secondary repeater relay 21TPB is provided which is slightly slower acting than the relay 21TPA.

The code transmitting relays for each track section, such as relay 21CP, is controlled in accordance with a 75 code rate or a 180 code rate by suitable coding contacts 75C and 180C, which coding contacts may be operated by any suitable means at their respective rates, such means disclosed in the prior patent No. 2,351,588, granted June 20, 1944, to O. S. Field. Also, each signal location has associated therewith a slow acting control relay, such as relay 21CC, which is governed by the associated approach relay, such as 21AP, and also over a line wire in accordance with the slow acting repeater relay, such as relay 21FAP, of the preceding track section for reasons presently to be described.

The track relay of each signal location, such as track relay 22TR for signal 22, acts through suitable decoding apparatus to energize a relay 22H in response to the reception of driven codes of both the 75 and 180 code rates, while an associated relay, such as relay 22D, is actuated to a picked up condition only upon the reception of the 180 code rate. These relays, such as relays 22H and 22D, act to control the indications of the associated signal, as well as to govern the selection of the code rate to be applied to the section in the rear.

Operation of Fig. 2

Under normal conditions, the energized condition of the track relay 20TR closes a circuit for the control relay 21CC at signal 22 from (+), through a circuit including front contact 66 of relay 20TR, line wire 67, front contact 68 of relay 21AP, and windings of relay 21CC, to (—). It might be noted that a suitable return line wire or a ground connection is employed to complete the circuit for the line relay 21CC. The front contact 68 of relay 21AP is closed because steady energy from battery 63 is applied through front contact 65 of relay 21TPA which is energized by reason of closed front contact 64 of relay 20TR.

The steady energization of relay 21CC maintains its contact 69 closed so that the relay 22TPA maintains its front contact 70 closed to apply steady energy from battery 71 to the track section 22T. Such energization of track section 22T maintains the relay 22AP energized closing front contact 72, so that with the front contact repeater relay 21FAP energized closing front contact 73, the relay 22CC is maintained energized over the line wire 74.

The relay 22CC acts to maintain the relay 23TPA energized so as to apply steady energy to the track section 23T in a similar manner. In this way steady energy is maintained on each of the track sections throughout the stretch of track. This steady energy on each track section acts to prevent operation of the code transmitting apparatus of its section. For example, relay 21AP steadily picked up keeps its back contact 80 open so that relay 21CP cannot be operated by its coding contacts.

Let us assume that an eastbound train enters the approach track section 20T and deenergizes the track relay 20TR. This opens the front contact 64 which deenergizes the relay 21TPA removing steady energy from the track section 21T. The deenergization of the approach relay 21AP closes back contact 80 so that the code transmitting relay 21CP is set into operation at the 75 code rate because back contact 81 of relay 22H is still closed. The transmission of a driven code over the track section 21T by the intermittent closure of front contact 61 of relay 21CP causes the energization of the track relay 21TR.

Each energization of relay 21TR by a driven code pulse opens back contact 82 which deenergizes the relay 21TPB. At the cessation of each driven code pulse, the relay 21TR drops away closing back contact 82 which, through back contact 83 of relay 21TPB and back contact 64 of relay 20TR, causes the energization of the relay 21TPA. This applies an inverse code pulse on the track section 21T which persists only for a short interval of time because the closure of back contact 82 also reenergizes the relay 21TPB after a short interval of time. In other words, the relay 21TPB picks up slightly slower than the relay 21TPA, but as soon as relay 21TPB opens its back contact 83, the relay 21TPA is deenergized causing the cessation of the inverse code pulse. This operation for the transmission of an inverse code pulse follows the termination of each driven code pulse so that an inverse code is applied to the track section 21T.

The reception of the inverse code of track section 21T by the relay 21AP acts through front contact 62 to maintain the contacts of the relay 21FAP in picked up positions which maintains front contact 73 closed so that the control relay 22CC at signal 23 remains picked up; and also, the maintenance of back contact 84 in an open condition prevents the lighting of the signal 22.

At the same time that steady energy is removed from the track section 21T, the opening of front contact 66 of relay 20TR deenergizes the control relay 21CC, which opens its front contact 69 after a short interval of time and deenergizes relay 22TPA to remove steady energy from the track section 22T.

The deenergization of the approach relay 22AP closes back contact 85 so that the code transmitting relay 22CP is controlled through back contact 86 to transmit a driven code of the 75 code rate. The reception of this driven code at the signal 22 results in the transmission of an inverse code over section 22T in a similar manner as explained in connection with the reception of driven code at signal 21. The reception of this inverse code at the signal 23 causes the intermittent operation of front contact 87 of relay 22AP which maintains the relay 22FAP picked up, so that the control relay (23CC not shown) in advance is not deenergized because front contact 88 is maintained closed. However, it should be noted that the intermittent operation of the relay

22AP opens and closes the front contact 72, but the control relay 22CC is slow acting in its release characteristics so that this intermittent energization maintains this relay 22CC picked up.

In other words, the relays, such as relays 21FAP, 22FAP, etc., as well as the relays such as 21CC, 22CC, etc., have such characteristics that, during the coding operation of a track circuit causing their intermittent energization, they will be picked up and remain steadily picked up although they are actually energized only intermittently. This is illustrated by the conditions described above where the relay 21AP is being operated by an inverse code, but such operation causes the continuous picked up condition of the relay 21FAP. Similarly, the operation of the relay 22AP by inverse code pulses causes its associated relay 22FAP to be continuously picked up; and this operation of 22AP intermittently energizes relay 22CC through front contact 72 to cause it to be steadily picked up.

At the signal 22, the reception of the 75 driven code results in the picking up of the relay 22H which opens back contact 81 and closes front contact 81 to change the operation of the code transmitting relay 21CP from the 75 driven code rate to the 180 driven code rate. The reception of such 180 driven code rate at the signal 21 of course results in the picking up of the relay 21D as well as the picking up of the relay 21H. Since back contact 89 of relay 20TR is closed by reason of the presence of the train in section 20T, the green lamp G is energized through front contact 90 of relay 21H and front contact 91 of relay 21D.

Thus, the entrance of a train into the track section 20T causes signalling apparatus to be initiated into operation for two blocks in advance providing such blocks are unoccupied, and codes are transmitted to cause the signal 21 to indicate green or proceed.

Let us assume that the eastbound train passes the signal 21 which is indicating proceed, and in so doing shunts the track relay 21TR and of course causes the cessation of the reception of inverse code by the relay 21AP. This of course holds front contacts 62 and 68 open so that relay 21FAP drops away and the relay 21CC is maintained deenergized although the rear of the train leaves the track section 20T and allows the relay 20TR to pick up and close its front contacts.

The opening of front contact 73 of relay 21FAP causes the deenergization of the relay 22CC, which in turn opens its front contact 93 and causes the removal of steady energy from the track section 23T and the initiation of a 75 driven code therein accompanied by an inverse code. The reception of this 75 driven code at the signal 23 causes the relay 23H to pick up and close front contact 86 which changes the driven code in the track section 22T to the 180 code rate. The reception of this 180 code at the signal 22 energizes the relay 22D so that with the back contact 84 of relay 21FAP closed, the green lamp of signal 22 is energized through front contact 94 of relay 22H and front contact 95 of relay 22D. Also, closure of front contact 81 continues to cause relay 21CP to apply a 180 driven code to the track section 21T in which the train is located. Thus, if an alternating current component is added to the driven code pulses by a suitable transformer as indicated in Fig. 1, a suitable train carried apparatus would be caused to indicate in accordance with such code rate.

These conditions described above with respect to the various track sections of the stretch while the train is in the track section 21T, have been indicated in the diagram of Fig. 6. This diagram shows that the coded track circuit apparatus is set into operation for two track sections in advance of the section in which the train is located while the sections further in advance are maintained in their normal-at-rest conditions with steady energy applied thereto. The section in which the train is located and the first section in advance both have 180 driven codes applied, while the second section in advance has a 75 or caution code applied to it. The two sections in advance of the train both have inverse codes, but the section in which the train is located obviously cannot have an inverse code. This diagram also indicates that only the signal at the exit end of the section in which the train is located is illuminated. This is because a signal is illuminated by the deenergization of the approach track relay repeater FAP. This relay is deenergized only during the absence of inverse codes and steady energization such as when the section is shunted by the wheels and axles of a train. The other signals have letters associated therewith indicating what indication would be displayed if they were illuminated.

It will be readily understood that the entrance of the train into the track section 22T will cause the cessation of the inverse code in track section 22T and the release of relay 22FAP. The opening of front contact 88 will initiate the application of driven code to the second track section in advance (section 24T not shown), and close back contact 96 to cause the illumination of the signal 23. Thus, the invention disclosed in Fig. 2 of the accompanying drawings illustrates how a normally-at-rest coded track circuit type of signalling system can be initiated into operation for two track sections in advance of the train as it advances section by section so as to provide what is commonly known as three indication wayside signalling.

This form of the invention has the characteristic that if a train reverses its direction of movement, the inverse codes will be restored section by section as the train recedes, and the restoration of inverse code in both of two adjacent sections acts over a line wire such as 74 to stop the coding operation in the next section in advance and in this way the system is restored to normal as the train recedes against the normal direction of traffic. So long as the train proceeds in the normal direction of traffic it will be apparent that the steady normal state will be restored in the rear of the train by the circuits dependent upon the steady energization of relays 20TR, 21AP, 22AP, etc.

Structure of Figs. 3A and 3B

With reference to Figs. 3A and 3B of the accompanying drawings, a stretch of track has been illustrated as including track sections 30T, 31T, 32T, 33T, 34T and 35T, etc.

At the entrance to each track section or block, a suitable signal is indicated for convenience as being of the color light type with two arms one above the other, of which the signals 31, 32, 33, 34 and 35 have been shown. Each of these signals is capable of displaying green, yellow and red color light indications for each arm; and the indications thus displayed by the two arms of a signal are used in combination to provide for what may be conveniently termed four indication block signal. In this form of the invention, G/G is used for the proceed or clear indication; Y/Y

is used for the next restrictive indication to advise a train to proceed preparing to stop at the second signal; Y/R is used for a still more restrictive indication to advise a train to proceed preparing to stop at the next signal; and R/R is used for danger or stop.

It is of course to be understood that the signals may be employed to give different combinations of indications in accordance with the variation in traffic conditions found in practice, but these indications have merely been selected for the purpose of providing the desired number of indicators for four indication block signalling. It should be also understood that other types of light signals may be employed such as signals of the searchlight type, and such signals may also be suitably controlled to give similar indications for the traffic conditions encountered in a signalling system of this character.

Considering briefly the organization of parts associated with each block or track section of a system embodying this form of the invention, it should be noted that each block has associated therewith similar apparatus to that disclosed in Figs. 1 and 2, but in addition thereto employs certain additional apparatus to accomplish the approach control for three track sections in advance of a train without the use of line wires. For this reason, it may be expedient to consider the apparatus associated with the track section 32T as typical of the other sections throughout a stretch of track having a signalling system of this form of the invention applied thereto.

More specifically, a code transmitting relay 32CP is located at the exit end of the track section 32T and is effective to alternately connect a track battery 106 and two approach track relays 32AP and 32NP across the track rails by operation of its contact 107. These approach approach relays 32AP and 32NP are of the polarized biased type, that is, the armature of each of these relays is normally biased towards a back contact position and is picked up only when that relay is energized by a current flowing in a particular direction as indicated by the arrow within the relay symbol. As noted in the drawings, these arrows point in opposite directions in the relays 32AP and 32NP, so that the relay 32AP may be considered as picked up only upon energization by current of normal or positive polarity in the track rails and the track relay 32NP may be considered as picked up only with the flow of current of negative polarity in the track rails.

In series with the track battery 106 is a suitable series relay 32SR which normally does not respond to the impulses applied to the track rails by the operation of the code transmitting relay 32CP where the section is not occupied by a train, but when a train enters the track section 32T, this series relay 32SR is picked up because of the increased current strength as the train progresses through the track section. This relay 32SR, for example, can be adjusted to pick up as soon as the train enters the track section or at some intermediate point depending upon the adjustment of the relay with respect to the current applied to the track rails.

In series with the track battery 106 and the series relay SR is the secondary winding of a suitable transformer 108 which has a primary winding supplied with 100 cycle alternating current so that each driven code pulse may have an alternating current component to act upon suitable car carried cab signalling apparatus. This control of cab signalling is of course optional and may or may not be provided as desired. In this connection, it should be noted that the series relay 32SR may be of such a design that its inductance does not materially affect the alternating current component of the driven code pulses or a suitable condenser may be shunted around the relay to reduce its effect upon such alternating current component.

The approach track relay 32AP is provided with a back contact repeater 32BAP as well as a front contact repeater 32FAP. Both of these relays 32BAP and 32FAP are of the slow-acting type, so as to be maintained in their energized positions if their control contact 109 of the relay 32AP is intermittently operated at any of the code rates. Also, a slow-acting repeater relay 32ANP is provided to be controlled jointly by front contacts 110 and 111 of relays 32AP and 32NP respectively. This relay 32ANP also has such characteristics as to remain "picked up" if it is intermittently energized at any of the code rates employed.

Each of the signal locations except the first, is provided with suitable coding contacts which are operated at different code rates in order to provide the different codes applied to the track rails. In this form of the present invention, the coding contacts are illustrated as operated by self-oscillating means respectively designated 75C, 120C and 180C for generating code pulses of the 75, 120 and 180 code rates. These self-impulsing code contacts may be of any suitable type, and may be combined in a single motor driven device, if desired; but this form of coding contact has been shown merely for convenience to illustrate how such coding contacts may be normally at rest and then initiated into operation upon the approach of a train. Such self-impulsing coding contacts have been shown for example in the prior Patent No. 2,351,583 granted June 20, 1944 to O. S. Field.

At the entrance end of track section 32T is a track relay 32TR which is normally disconnected from the track rails by the steady energization of an associated relay 32CPP. This relay 32TR is shown as being a neutral relay but in practice this relay would probably be a biased polarized relay that responds to only one polarity of driven code impulses so as to render this relay very quick acting and also to make it immune to impulses of the opposite polarity.

The slow-acting repeater relay 31ANP associated with the track section 31T acts normally to close front contact 112 to apply positive potential on the track rails of section 32T with front contact 113 of relay 32CPP closed; but under certain conditions, as will be later explained, the contact 112 will be dropped away by relay 31ANP so as to shift the energization of the track rails 32T from the normal positive polarity of track battery 114 to the negative polarity supplied by track battery 115. It will of course be appreciated that two batteries 114 and 115 have been shown so as to provide for the reversal of polarity in connection with the transmission of inverse codes, but a single battery may be employed and pole changing contacts provided if desired.

The operation of the track relay 32TR, for example, acts through its contact 116 to energize the primary windings of a decoding transformer 117 in opposite directions alternately which acts through its secondary windings and rectifying contact 118 to energize the home relay 32H whenever the track relay 32TR is being operated by a

75, 120 or 180 driven code. The decoding transformer 117 also has a secondary winding 119 which supplies at proper times impulses to the relay 32CPP for applying inverse code pulses to the track section 32T in a manner as will be presently described. This relay 32CPP is of the biased polar type, that is, its contacts are biased to one position and are operated to an opposite position only when the relay is energized with a current of particular polarity.

Another secondary winding 124 acts through suitable tuning and rectifying means to control relays 32BH and 32D in accordance with the code rate received. In other words, the relay 32BH is picked up only when a 120 code is being received and the relay 32D is picked up only when a 180 driven code is being received.

Although only four track sections (and part of a fifth) have been shown in the drawings as having coded track circuit apparatus as provided in accordance with this form of the invention, it is to be understood that the stretch of track may be of any desired length and that as many such track sections may be provided as may be required in accordance with the length of the stretch, and that each of such track sections is equipped as typically described above for track section 32T.

Operation of Figs. 3A and 3B

Under normal conditions, the track relay 30TR of the approach section 30T is normally energized so that a circuit is closed from (+), through a circuit including front contact 125 of relay 30TR, and windings of relay 31TPA, to (—). This energization of the relay 31TPA closes its front contact 126 which connects the track battery 127 across the track section 31T to apply steady potential of normal polarity to this track section, which of course steadily energizes the approach relay 31AP at the exit end.

The closed condition of front contact 128 of relay 31AP normally energizes the relay 31ANP through an obvious circuit, so that its front contact 112 conditions the energy applying circuit for the track section 32T to apply the normal polarity from track battery 114. Also, the closure of front contact 129 of relay 31AP energizes the relay 31FAP through an obvious circuit. This relay 31FAP closes its front contact 130 to apply steady potential to the relay 32CPP so that it closes its front contact 113 causing steady potential of normal polarity to be applied to the track section 32T.

The energy of normal polarity applied to the track section 32T energizes the approach relay 32AP and the closure of its front contacts 109 and 110 cause the energization of the relays 32FAP and 32ANP in an obvious manner. These relays act to cause the application of a steady potential of normal polarity to the track section 33T in a similar manner as described for the relays 31FAP and 31ANP respectively. In a similar way, the reception of the steady potential of normal polarity across the track section 33T acts at the signal location 34 to apply steady potential to the track section 34T. In this way, the application of steady potential of normal polarity is maintained on each of the track sections throughout the stretch of track having the present invention (as disclosed in these figures) applied thereto.

Under these normal conditions, it can be seen that the front contacts of the relays BAP at the various signal locations are open so that the coders at such locations are normally at rest. More specifically, it can be seen that front contact 131 of relay 31BAP is open.

Also, since the relays ANP at the respective signal locations are normally energized, their back contacts are open so that the signal lamps are normally deenergized. More specifically, back contact 132 of relay 31ANP is normally open.

Let us assume that a train enters the starting track section 30T causing the deenergization of the track relay 30TR. The initial closure of back contact 125 of relay 30TR of course causes the illumination of the signal lamps which will indicate R/R until the code apparatus for certain track sections in advance has been intiated into operation. The deenergization of relay 31TPA by the opening of front contact 125, causes the removal of the steady potential from the track section 31T as supplied from battery 127, and back contact 126 connects the track relay 31TR across the track rails in readiness to receive a driven code.

At the other end of the track section 31T, the deenergization of the approach relay 31AP, causes the relays 31FAP and 31ANP to release after a short time, and also the closure of back contact 129 causes the energization of relay 31BAP. Although the relay 31BAP is indicated as being slow releasing in its characteristics, it is relatively quick in picking up, so that it closes front contact 131 to immediately initiate the operation of the coders 75C, 120C and 180C at that location. Since back contact 133 of relay 31AP is now closed, the relay 31CP is set into operation to transmit a driven code of the 75 code rate because back contact 134 of relay 32H is still closed. This driven code in the track section 31T of course causes the energization of the relay 31H at the signal 31 so that the closure of front contact 135 and the closure of front contact 136 of relay 31H causes the signal 31 to display a Y/R indication.

As soon as the relay 31FAP at signal location 32 drops away and opens its front contact 130, the relay 32CPP is deenergized removing steady potential from the track section 32T. This causes the deenergization of the approach relay 32AP at the signal location 33 so that back contact 109 is closed to energize the relay 32BAP which in turn closes its front contact 137 to initiate the operation of the coding apparatus at that location. The code transmitting relay 32CP can now be energized through a circuit closed from (+), including coding contacts 138 of coder 75C at that location, back contact 139 of relay 33H, back contact 140 of relay 32AP, back contact 141 of relay 32NP, and windings of relay 32CP, to (—).

This circuit for relay 32CP causes its intermittent operation to effect the application of a 75 driven code to the track section 32T which results in the operation of the relay 32TR at signal 32 and causes the picking up of the contacts of relay 32H. This shifts the control of the driven code transmitting relay 31CP through front contact 134 of relay 32H and back contact 142 of relay 32BH so that the relay 31CP acts through its contact 143 to apply a driven code of the 120 rate. This driven code is received at the signal 31 which results in the picking up of the relay 31BH as well as the maintained picking up of the relay 31H. Since front contact 144 is now closed, the signal 31 is caused to display a Y/Y indication.

The reception of the driven code at the signal location 32 acts through the decoding trans-

former 117 and its secondary winding 119 to momentarily energize the relay 32CPP at the end of each driven code pulse because back contact 130 of relay 31FAP and back contact 145 of relay 31SRP are closed. In this connection it should be noted that both the closure of front contact 116 and the closure of back contact 116 of the track relay 32TR creates an impulse in the secondary winding 119 of the transformer 117. These two impulses are of course in opposite directions, since the contact 116 in movement from front to back or from back to front reverses the direction of energization of the primary winding of transformer 117. Since relay 32CPP is of the biased polarized type of relay, it will respond to only one of these pulses, and the circuit connections are so made that the pulse in the secondary winding 119 created when the track relay 32TR releases, is the particular pulse which operates this relay. It will thus be seen that the deenergization of the track relay 32TR at the end of each driven code pulse causes the momentary energization of relay 32CPP, while the picking up of relay 32TR does not effect any operation of relay 32CPP. This momentary energization of the relay 32CPP acts to apply through its front contact 113 an inverse code pulse following each driven code pulse. Since the relay 31AP is steadily deenergized, its repeater 31ANP is also deenergized so that these inverse code pulses are of reverse polarity as supplied through back contact 112 from track battery 115.

These inverse code pulses of reverse polarity in the track section 32T are received by the relay 32NP which intermittently operates its front contact 111 so that the repeater relay 32ANP is maintained energized.

The steady deenergization of the relay 32AP of course releases relay 32FAP which opens its front contact 146 and deenergizes relay 33CPP to remove steady energy from the track section 33T. This of course causes the deenergization of the relay 33AP. The closure of back contact 147 of relay 33AP, causes the picking up of relay 33BAP which in turn closes front contact 148 to initiate the associated coders. This immediately causes the code transmitting relay 33CP to apply a driven code of the 75 code rate since back contact 149 of relay 34H as well as back contacts 150 and 151 of relays 33AP and 33NP are closed. This 75 driven code is received at the signal location 33 which acts to pick up the relay 33H to change the driven code applied to the track section 32T from the 75 code rate to the 120 code rate, which in turn is received at the signal 32 where the picking up of the relay 32BH closes front contact 142 and causes a driven code of the 180 rate to be applied to the track section 31T. The reception of this driven code of the 180 rate causes the picking up of the relay 31D at the signal location 31 so that front contacts 152 and 153 are closed to cause the signal 31 to display a G/G indication. It should be appreciated that these successive and progressive indications of the signal 31 occur in rather rapid sequence as the coding apparatus is initiated into operation so that the signal 31 gives its G/G indication before the train is ready to actually act upon such signal indication.

The reception of the 75 driven code at the signal location 33 of course causes an inverse code to be applied to the track section 33T since back contact 146 of relay 32FAP is closed as well as back contact 154 of relay 32SRP. This inverse code, however, is of the normal polarity because the intermittent operation of the relay 32NP in response to the inverse code in the track section 32T causes the continued picked up condition of the relay 32ANP. Thus, its front contact 155 is closed so that the normal polarity of inverse code can be applied from the track battery 156 upon the operation of the contact 157 of relay 33CPP.

The reception of an inverse code of the normal polarity at the exit end of the track section 33T, causes the operation of the approach relay 33AP which through its front contact 147 intermittently energizes the relay 33FAP so that this relay continually remains picked up and causes the steady deenergization of the relay 34CPP through front contact 158. This relay 34CPP applies steady energy to the track section 34T, and thus the tumble-down effect or approach control is limited to the first three track sections having coding apparatus upon the entrance of the train into the starting track stretch 30T.

It should be noted that the intermittent operation of the relay 33AP acts through contact 159 to intermittently energize the relay 33ANP so that it remains picked up and through its front contact 160 causes the steady energization of the track section 34T to be of the normal polarity. Also, the intermittent operation of the contact 147 closes the circuit for relay 33BAP each time the relay 33AP is released so that the relay 33BAP having slow-release characteristics, is caused to be picked up and remain picked up so that through its front contact 148 the coders 75C, 120C and 180C are continued in their operation.

Thus, it can be seen that as the train approaches the signal 31, the section in advance, namely, section 31T has no inverse code while the second and third sections in advance have inverse codes of reverse and normal polarities respectively. This condition of the track sections in advance of an eastbound train is progressively maintained in advance of the train as it proceeds from section to section in a manner as will be presently explained, to thereby cause the control of the signals in such a way as to provide that the train may proceed upon a signal indication of G/G. Since this is true, the track section 31T is not organized identically with the remaining track sections of the stretch as represented by the apparatus and organization thereof associated with the track section 32T for example. This is mainly because an inverse code is not needed in this section 31T. But it is believed that the differences between the apparatus and operation thereof in connection with track section 31T will be better appreciated as the description progresses.

Let us assume that the train accepts the G/G indication of signal 31 and passes into the track section 31T. This of course causes the deenergization of the track relay 31TR so that the relays 31H, 31BH and 31D are released and the signal 31 is caused to display an indication of R/R. Since this track section 31T does not have an inverse code at any time, no particular action occurs with respect to the relay 31AP except that it remains deenergized as previously explained with the train approaching the signal 31.

As the train enters and proceeds through the track section 31T, the series relay 31SR is caused to pick up at an appropriate point in the track section in accordance with the characteristics of the track circuit as previously explained.

This picking up of the relay 31SR is of course intermittent, since a driven code is being applied to the track section 31T by the operation of the relay 31CP at the 180 code rate. But the intermittent operation of the contact 161 of relay 31SR causes the intermittent energization of the relay 31SRP which effects its picking up and maintains it steadily picked up. This opens back contact 145 so that the inverse code of reverse polarity is removed from the track section 32T which acts to cause the relay 32NP to remain steadily deenergized. It is of course appreciated that the absence of inverse codes in the section 32T causes both the relays 32AP and 32NP to remain steadily deenergized. Thus, the entrance of the train into the track section 31T results in the deenergization of the relay 32ANP and the continued energization of the relay 32BAP.

The shifting of contact 155 of relay 32ANP from a front to a back position closes a circuit for track battery 162 so that the inverse code pulses applied to the track section 33T are now of reverse polarity and thus act upon the relay 33NP at signal location 34. The operation of front contact 163 of relay 33NP continues the picked up condition of the relay 33ANP, but the continued release of the relay 33AP causes the relay 33FAP to be released. The continued closure of back contact 147 of relay 33AP of course maintains relay 33BAP picked up, it having been picked up by the intermittent operation of relay 33AP by the inverse code of normal polarity.

The opening of front contact 158 of relay 33FAP removes steady potential from the track section 34T which releases the relay 34AP and causes the picking up of relay 34BAP to close front contact 164 to initiate the operation of the coders 75C, 120C and 180C at the signal location 35. Since back contact 165 of relay 35H is closed, the closure of back contact 166 of relay 34AP, causes the code transmitting relay 34CP to be set into operation at the 75 code rate. The resulting application of the 75 driven code to the track section 34T, of course causes the operation of the track relay 34TR and the picking up of the relay 34H. It may be pointed out that this causes a 120 code to be applied to the track section 33T which of course is received at signal 33 causing a 180 code to be applied to the track section 32T. But it should be noted that as soon as the 75 driven code is received at the signal 34, the back contact 158 of relay 33FAP being closed as well as the back contact 167 of relay 33SRP, an inverse code of the normal polarity is applied to the track section 34T so that the relay 34AP is intermittently operated. The intermittent operation of front contact 168 acts to maintain the relay 34ANP picked up and to act through contact 169 to maintain the relay 34FAP picked up to thus cause steady potential of the normal polarity to be applied to the track section 35T.

The reception of the 180 driven code at the signal location 32 of course causes a 180 driven code to be applied to the track section 31, which driven code of course includes an alternating current component as provided from the alternating current source of 100 cycle. This is for the purpose of providing that suitable train controlled apparatus, not shown in detail but which may be similar to that shown in Fig. 4, may be employed upon the train and be responsive to the code impulses to give a cab signal or train control operation.

Assuming that the train proceeds toward the signal 32 and accepts its G/G indication entering into the track section 32T, the entrance of the train into such track 32T acts to effect the intermittent picking up of the series relay 32SR in a manner previously described for the relay 31SR. Since there has been no inverse code in the track section 32T just prior to the entrance of the train, the relay 32ANP has been dropped away so that the signal 33 has been illuminated by reason of the closed condition of back contact 170. The intermittent picking up of the relay 32SR causes the intermittent closure of an energizing circuit for the relay 32SRP at front contact 181 of relay 32SR. This effects the picking up of the relay 32SRP and causes it to be maintained energized as the train approaches the signal 33. The opening of back contact 154 of relay 32SRP causes the inverse code of reverse polarity to be removed from the track section 33T which acts to release the relay 33ANP at the signal location 34. This changes the polarity of the inverse code of track section 34T from a normal polarity to a reverse polarity, which of course causes the initiation of the coding in the track section 35T with an accompanying inverse code of normal polarity which limits the coding in the stretch to the section 35T. The initiation of the 75 driven code in the track section 35T of course causes the relay 35H to be picked up, which in turn causes a 120 code to be transmitted in the track section 34T. This changes the driven code in the section 33T to the 180 code rate so that the signal 33 indicates G/G.

The conditions of the various track sections of a stretch of track thus provided with coded track circuit apparatus, with the train in the track section 32T, has been indicated in the diagram of Figs. 7A and 7B, which are assumed to be placed end to end. From this diagram, it can be seen that there is a steady potential applied to the track section 31T in the rear of the train and that there is no coding in that track section. Similarly, there is no inverse code in the track section 32T or in the track section 33T and both of such sections have the 180 code applied thereto. But the second and third track sections in advance of the train have 120 and 75 driven codes respectively with inverse codes of reverse and normal polarities respectively. It will be noted that only the signals 33 and 34 are illuminated. This is because the signals are illuminated only upon the cessation of inverse codes or during the absence of a steady potential. Thus, if a train in passing signal 32 for example can see the signal 33, then the next signal indication can be anticipated and as the train enters the stretch the trainman can see that the signal advances to the next less restrictive indication in accordance with his approach. On the other hand, if the signal does not advance to the next indication then the engineer recognizes that he must decrease his speed and prepare to stop at the second signal in advance. Although only two signals in advance of a train are illuminated, the signal control relays for the remaining signals assume particular conditions, and these conditions have been indicated in Figs. 7A and 7B by the various letters adjacent those signals, such as G/G, Y/Y, Y/R and R/R representing the different controls previously explained.

In view of the above description, it will be appreciated that each time a train enters the next track section, it effects the picking up of the series relay at the exit end of that track section which

removes the inverse code of reverse polarity in the next track section. This results in the change of the polarity of the inverse code in the second track section in advance from a normal polarity to a reverse polarity, which in turn results in the removal of the steady energy across the succeeding track section in advance to thereby initiate the coding operation in that track section accompanied by an inverse code of normal polarity. Whenever an inverse code of normal polarity is present, it causes a steady potential to be applied to the next track section in advance and the same is true of the application of a steady potential. Thus, as a train proceeds, it advances section by section the initiation of the coded track circuit apparatus for the successive sections but that advance is limited to one track section at a time because the leading track section always has inverse code of normal polarity which causes steady potential to be applied to the next track section in advance. In this way, the coded track circuit organization of Figs. 3A and 3B provides for the approach initiation and approach lighting of the signalling apparatus of a normally-at-rest coded type signalling system.

In the event that a train should reverse its direction of traffic, it is apparent that as it moves out of each section it would release the series repeating relay of that section and thus cause the return of the inverse code to the track section next in advance, and this would in turn change the inverse code of the second section to a normal polarity which would act to apply steady potential to the next track section beyond, and thus restore such track section to its normal inactive condition. In this way, a train receding against the normal direction of traffic would act to restore the track apparatus to a normal condition. Similarly, if a train should leave the stretch of track by way of a turnout, then the system would be restored to its normally-at-rest conditions.

Summary

In each of the different forms of the present invention disclosed in this application, it is apparent that inverse codes are employed in connection with driven codes for limiting the extent to which a tumble-down organization may extend for the initiation of coded track circuit apparatus in advance of a train. One characteristic common between the different forms of the invention is that the back contact of the approach relay such as contact **51** of relay **2AP** in Fig. 1, contact **85** of relay **22AP** in Fig. 2, and contact **140** of relay **32AP** in Fig. 3A, act to stop the driven code transmission whenever steady potential is applied to the associated track section, but such contacts are ineffective to stop driven code transmission during the reception of inverse codes. In the form of the invention shown in Figs. 3A and 3B, the contacts of the relays such as **32NP**, have back contacts included in the driven code transmitting relays such as back contact **141**, but although these contacts do not under usual functioning of the system act to stop the driven code, they may be considered as check contacts which would become effective if a steady potential of reverse polarity were accidentally and undesirably applied to the associated track section. The present invention has many advantages over a normally operating system, and yet provides all the facility necessary in a signalling system. For example, assume that a train might enter the section **32T** from an outlying switch, the entrance of such train would shunt the steady potential placed across the track rails and result in the initiation of the coding at the exit end of that section and for the proper number of track sections in advance, so that the train could proceed in accordance with the signal indications in the direction of traffic governed by the signals.

Having thus shown three different forms of a coded track circuit signalling system of the normally-at-rest type initiated into operation for a limited number of sections in advance of a train as embodying the principles of the present invention, it is to be understood that these forms are selected to facilitate in the disclosure of the invention rather than to limit the number of forms which the invention may assume; and it is to be further understood that various modifications, adaptations and alterations may be applied to the specific form shown to meet the requirements of practice without in any manner departing from the spirit or scope of the present invention except as limited by the appended claims.

What I claim is:

1. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, an approach control relay at the exit end of each track section normally maintained steadily energized over the rails of its section but deenergized by the presence of a train in such section, code transmitting means at the exit end of each section caused to be inactive by steady energization of its associated approach control relay but set into operation to transmit a selected distinctive code whenever said approach control relay is steadily or intermittently deenergized, and means at the exit end of each track section controlled by the steady deenergization of its approach control relay due to the presence of a train in its section to act over the rails of the next adjoining section in advance to intermittently deenergize the approach control relay at the exit end of such advance section to thereby render its code transmitting means active but not to affect the normal condition of energization of any track section that is farther in advance of said advance section.

2. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, code transmitting means at the exit end of each section capable of transmitting selected distinctive codes over the rails of that section to the entrance end when such transmitting means is rendered effective, an approach control relay at the exit end of each track section connected across the track rails during the off periods between the pulses of said codes and acting when intermittently energized to render said code transmitting means effective but acting whenever it is steadily energized to render said code transmitting means ineffective, and means at the entrance end of each track section for normally applying steady potential to the rails of that section when the approach control relay of the adjoining section is steadily or intermittently energized but acting to apply intermittent energy to the track rails when such adjoining approach control relay is steadily deenergized, whereby the presence of a train in any given track section maintains the operation of the code transmitting means at the exit end of that track section and initiates the operation of the code transmitting means at the exit end of the next adjoining track section in advance.

3. In a coded track circuit signalling system for a stretch of track having a plurality of track

sections, apparatus associated with each track section operable to transmit an inverse code from the entrance end of that section through the track rails toward the exit end during the off intervals of a driven code transmitted in the opposite direction, apparatus including an off-code track relay and a transmitter at the exit end of each track section operable intermittently to transmit driven code pulses through the track rails and to connect said off-code track relay across the rails during each off interval between the driven code pulses, means for preventing the operation of said transmitter while said off-code track relay is energized, and means at the entrance end of each track section for steadily energizing the track rails only when the off-code track relay of the next adjoining track section in the rear is steadily energized or is intermittently energized in response to an inverse code, whereby the presence of a train in one track section maintains the operation of the code transmitting means at the exit end of its track section and initiates operation of the code transmitting means at the exit end of the next adjoining track section in advance.

4. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance end of each track section, a transmitter at the exit end of each track section for alternately connecting a source of current and an off-code track relay across the rails of said section at any selected one of a plurality of code rates, decoding means associated with each signal at the entrance end of a track section for governing its indications in accordance with the rate of driven code transmitted over that track section, inverse code transmitting means at the entrance end of each track section for applying across the track rails at that end an off-code current pulse during each of the off periods of the driven codes for energizing said off-code track relay, means at the exit end of each track section for automatically stopping operation of the associated transmitter when said off-code track relay is maintained energized by sustained current on the track rails, and means at the entrance end of each track section for preventing operation of the associated inverse code transmitting means and applying a sustained current on the track rails when the off-code track relay of the next adjoining track section in the rear is steadily or intermittently energized.

5. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance end of each track section, a transmitter at the exit end of each track section for alternately connecting a source of current and an off-code track relay across the track rails at that end at any selected one of a plurality of code rates, decoding means associated with each of said signals for governing its indications in accordance with the rate of driven code transmitted toward that signal, inverse code transmitting means at the entrance end of each track section for applying an inverse code pulse across the track rails at that end during each of the off periods of the driven code for energizing said off-code track relay at the exit end of that track section, means including a back contact of said off-code track relay for preventing operation of said transmitter whenever said off-code track relay is maintained energized by a sustained current on the track rails of its section, a slow-acting relay associated with each off-code track relay so as to be maintained picked up whenever such relay is steadily energized or is intermittently energized by inverse code pulses, but is dropped away when such off-code relay is steadily deenergized, and means at the entrance end of each track section including contacts of the slow-acting repeater relay associated with the off-code track relay of the next adjoining track section in the rear for preventing operation of the inverse code transmitting means and causing a steady potential to be placed across the track rails when such slow-acting relay is maintained picked up.

6. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, driven code transmitting means at the exit end of each track section capable of transmitting selected distinctive driven codes over the track rails of that section, driven code receiving means at the entrance end of each track section for governing the indications of the associated signal, inverse code receiving means at the exit end of each track section energizable between the impulses of any driven code applied to the track rails by said code transmitting means, and inverse code transmitting means at the entrance end of each track section effective to transmit through the track rails an inverse code pulse between successive driven code pulses when the inverse code receiving means of the next adjoining track section in the rear is steadily deenergized, but acting to apply steady potential to the rails of its track section when such inverse code receiving means for the next adjoining track section to the rear is steadily energized or is intermittently energized by inverse code pulses in its track section, and means at the exit end of each track section for rendering the associated driven code transmitting means ineffective whenever the associated inverse code receiving means is steadily energized.

7. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance end of each track section, an approach track relay at the exit end of each track section, a code transmitter relay capable of being intermittently energized to transmit a driven code through the track rails for governing the signal at the entrance end and also acting to connect its associated approach track relay across the track rails during each off period of the driven code, an energizing circuit for said transmitter relay including a back contact of said approach track relay, approach control means at the entrance end of each track section for normally applying a steady potential across the rails of its track section to energize said approach track relay at the exit end to thereby stop operation of the transmitter relay at such exit end, and means associated with each signal for acting on said approach control means for the section in advance of that signal to remove said steady potential upon the approach of a train to such signal within certain limits.

8. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance end of each track section, an off-code track relay at the exit end of each track section, a transmitter relay at the exit end of each track section capable of being intermittently energized to transmit a driven code through the track rails for governing the signal at the entrance end of its section and also acting to connect its associated off-code track relay across the track rails during each off period of the driven code, a normally-at-rest code pulse

generating device, an energizing circuit for said transmitter relay including a back contact of said off-code track relay and contacts of said code pulse generating device, approach means at the entrance end of each section for normally applying a steady potential across the rails of its track section to energize said off-code track relay at the exit end, means associated with the signal at the entrance end of each track section for acting on said approach control means for the section in advance of such signal to remove said steady potential upon the approach of a train within a predetermined distance and effect the transmission of an off-code when a driven code is received, and means responsive to the deenergization of said off-code track relay upon the removal of said steady potential and during the reception of an off-code for initiating said code pulse generating device into operation and maintaining such operation until said steady potential is reapplied.

9. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance end of each track section, an off-code track relay at the exit end of each track section, a transmitter relay at the exit end of each track section capable of being intermittently energized to transmit a driven code through the track rails for governing the signal at the entrance end of its section and also acting to connect its associated off-code track relay across the track rails during each off period of the driven code, said transmitter relay being rendered ineffective whenever said off-code track relay is energized, approach control means associated with each signal for normally applying a steady potential across the rails of the track section in advance of that signal to energize said off-code track relay at the exit end of that section to thereby render the corresponding transmitter relay ineffective to transmit a driven code, said approach control means for such signal acting when governed to remove said steady potential from the track rails of said advance track section and apply an inverse code during the reception of a driven code, and means including a line circuit extending between the entrance and exit ends of each section for governing said approach control means associated with the signal at the entrance to the section in advance to remove said steady potential and apply said inverse code to such advance section whenever either the first or second track sections in the rear of that signal is occupied by a train.

10. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance end of each track section, an approach track relay at the exit end of each track section, a code transmitter relay at the exit end of each track section, an energizing circuit for each transmitter relay including a back contact of the associated approach track relay and intermittently energized for causing said transmitter relay to transmit a driven code through the track rails for governing the signal at the entrance end of its section and also for connecting its associated approach track relay across the track rails during each deenergization of said transmitter relay, normally energized approach control means at the entrance end of each track section for normally causing the application of a steady potential across the rails of its track section to energize said approach track relay at the exit end to thereby stop the operation of the transmitter relay at such exit end, said normally energized approach control means acting when deenergized to effect the transmission of an inverse code through the track rails during the reception of a driven code to intermittently energize said approach track relay at the exit end of its track section, a slow-acting repeater relay associated with each approach track relay so as to be picked up whenever its associated approach track relay is steadily or intermittently energized, but so as to be dropped away whenever said approach track relay is steadily deenergized, and line circuit means for said approach control means for each signal acting to deenergize such approach control means when the approach control track relay for the next section in the rear is steadily deenergized and when the repeater relay for the approach track relay for the second section in the rear is dropped away.

11. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance end of each track section, coded track circuit apparatus associated with each track section for transmitting selected distinctive driven codes over the rails of that section to the entrance end in accordance with traffic conditions and for transmitting inverse codes of either selected polarity from the entrance to the exit end of such track section, means at the exit end of each track section for preventing the transmission of a driven code when the track rails of that section are steadily energized, and approach control means associated with the exit end of each track section for causing the track section in advance to be steadily energized with a particular polarity whenever the track section in the rear is steadily energized with said particular polarity or is intermittently energized by an inverse code of said particular polarity, said approach control means acting to cause the transmission of an inverse code of a polarity opposite to said particular polarity whenever said track section in the rear is steadily deenergized, but acting to cause the transmission of an inverse code of said particular polarity whenever said track section in the rear is receiving an inverse code of said opposite polarity.

12. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance end of each track section, an inverse code receiving means at the exit end of each track section, a driven code transmitter relay at the exit end of each track section for connecting a source of current across the track rails when energized and for connecting said inverse code receiving means across the track rails when deenergized, normally-at-rest coding contacts associated with said transmitter relay, an energizing circuit for said transmitter relay including contacts closed only when said inverse code receiving means is deenergized and including said coding contacts, decoding means associated with each of said signals for governing its indications in accordance with driven code transmitted to that signal, inverse code transmitting means at the entrance end of each track section for applying inverse code pulses of either selected polarity across the track rails of the section at that end during the reception of a driven code, approach control means associated with each signal location for normally causing the application of a steady potential across the rails of the section in advance of that signal in response to the steady energization of the track rails of the next track section in the rear with

a particular polarity, but acting upon the steady deenergization or the reception of an inverse code of the opposite polarity in the track section in the rear to cause the transmission of an inverse code in the section in advance of the signal, said means causing the inverse code in advance of said signal to be of a particular polarity if an inverse code is being received in said rear section but to be of the opposite polarity in the absence of the reception of an inverse code in the rear section, and means causing the operation of said coder contacts whenever said inverse code receiving means associated with the same track section is steadily deenergized or is intermittently energized with inverse code pulses of either polarity.

13. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, coded track circuit apparatus associated with each section organized to be operable to transmit driven codes through the track rails towards the entrance end of said section and to transmit inverse codes through the track rails in the opposite direction, during the off periods between respective driven code pulses, means associated with the exit end of each section for preventing the transmission of driven codes while steady energy is applied to that track section, means associated with the entrance end of each section for stopping the transmission of inverse code in that section and applying steady energy to the rails thereof dependent upon the presence of steady potential across the rails of the next preceding track section, whereby the coded track circuit apparatus for each section throughout the stretch is normally maintained inactive dependent upon the presence of steady energy across the rails of the next preceding track section of the stretch, and whereby the presence of a train in any track section causes the removal of steady energy from the next track section in advance and the application of an inverse code in such advance section, and means associated with the entrance end of each section for causing the application of steady potential during the presence of an inverse code in the next preceding section, whereby the tumble-down effect upon the entrance of a train into a section is of limited extent.

14. In a coded track circuit signalling system for a stretch of track having a plurality of track sections, a signal at the entrance to each track section, coded track circuit apparatus associated with each track section and operable to transmit driven codes over the track rails in one direction and inverse codes through the track rails of that track section in the opposite direction by applying code pulses to the track rails during the off periods between pulses of the driven codes, said driven codes for any given track section being effective to govern the signal at the entrance to its track section and the characteristics of the driven codes in the preceding track sections, holding means associated with each track section for steadily energizing the track rails of that track section at the entrance end to normally maintain its coded track circuit apparatus inactive, and means associated with each track section controlled over the rails of the preceding track sections through the medium of the inverse codes in such preceding track sections for rendering its associated holding means ineffective when a train approaches within a predetermined number of track sections to thereby initiate its coded track circuit apparatus into operation for the control of the signal governing the entrance of traffic into its track section as well as the governing of the driven codes of the preceding track sections.

15. In a coded track circuit signalling system of the character described for a particular direction of traffic over a stretch of railway track divided into several track sections and having a signal for governing entrance to each track section, a coded track circuit for the control of each of the signals extending through the track rails of the track section in advance of that signal and comprising a normally inactive driven code transmitter at the exit end of the track section and a normally inactive inverse code transmitter at the entrance end of that track section, an approach control relay at the exit end of each of said track sections normally connected across the track rails but disconnected from the track rails during each driven code pulse by said driven code transmitter for that track section, means at the entrance end of each of said track sections for steadily energizing the track rails of that track section when said approach control relay for the track section in the rear is steadily or intermittently energized, means responsive to the steady or intermittent deenergization of said approach control relay for rendering said driven code transmitter for that track section active, and means responsive to the steady deenergization of said approach control relay for rendering said inverse code transmitter active for the next track section in advance.

16. In a coded track circuit signalling system for a particular direction of traffic over a stretch of track divided into a plurality of track sections and having a signal for governing entrance to each track section, a track circuit for the control of each of said signals extending through the track rails of the track section in advance of that signal and comprising a normally inactive driven code transmitter for applying driven codes at the exit end of that track section and a normally inactive inverse code transmitter for applying inverse codes to the track rails at the entrance end of that track section, a series relay at the exit end of said track section connected in series with said track circuit but rendered active only in response to abnormal energization of the track circuit as provided upon the shunting of the track rails, an approach control relay at the exit end of each of said track sections normally connected across the track rails but disconnected from the track rails during each driven code pulse transmitted by said driven code transmitter for that track section, means at the entrance end of each of said track sections for steadily energizing the track rails of that track section when said approach control relay for the track section in the rear is steadily or intermittently energized, means responsive to the steady or intermittent deenergization of said approach control relay for rendering said driven code transmitter for that track section active, and means for rendering said inverse code transmitter active for each track section only when said approach control relay for the track section in the rear is deenergized and only when said series relay for the next track section in the rear is inactive.

17. An automatic block signal system for railroads having normally inactive coded track circuits automatically set into operation and restored to normal by train movement comprising in combination, a plurality of coded track circuit sections each having at the exit end a driven code transmitter and inverse code responsive means,

each of said track circuit sections having at its entrance end a driven code following track relay and inverse code transmitting means, said coded track circuit sections being operable at times to transmit driven code pulses from the exit end to the entrance end of the track section and inverse code pulses of selected porality in the opposite direction during the off intervals of said driven code pulses, means for each track section responsive to the energization of the inverse code responsive means at the exit end of that track section by one polarity either steadily or intermittently for causing steady energization of the exit end of the track section next in advance, said means acting when the corresponding track section is occupied by a train or is energized by inverse code of the other polarity to remove the steady energy from a track section next in advance after a time interval and also rendering the inverse code transmitting means for said track section in advance effective to transmit inverse code pulses of said one polarity unless the next track section in the rear is occupied by a train, whereby control of the inverse code in the several track sections by a train automatically initiates coding operation in a plurality of track sections in advance of that train and the coded track circuits in the rear of a train are automatically restored to their normal inactive condition.

18. A coded track circuit automatic block signal system for railroads automatically set into coding operation and restored to a normal steadily energized condition by train movement, comprising in combination, a plurality of coded track circuits

each operable at times to transmit driven code pulses from the exit end of a track section toward the entrance end of that track section through the track rails, and each operable at times to transmit inverse code pulses in the opposite direction during the off intervals of said driven code pulses, each of said track circuits including an inverse code transmitter relay at the entrance and acting when energized to apply energy to the track rails, relay means for the exit end of each track section acting when energized either steadily or intermittently by inverse code pulses for maintaining energized the transmitter relay for the next track section in advance, whereby a normal steadily energized condition of each track section is maintained so long as the next track section in the rear is unoccupied and energized from its entrance end steadily or intermittently by inverse code pulses.

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