May 5, 1942. C. E. STAPLES 2,281,890

APPARATUS FOR DETECTING THE APPROACH OF RAILWAY TRAINS

Filed April 11, 1940 4 Sheets-Sheet 1

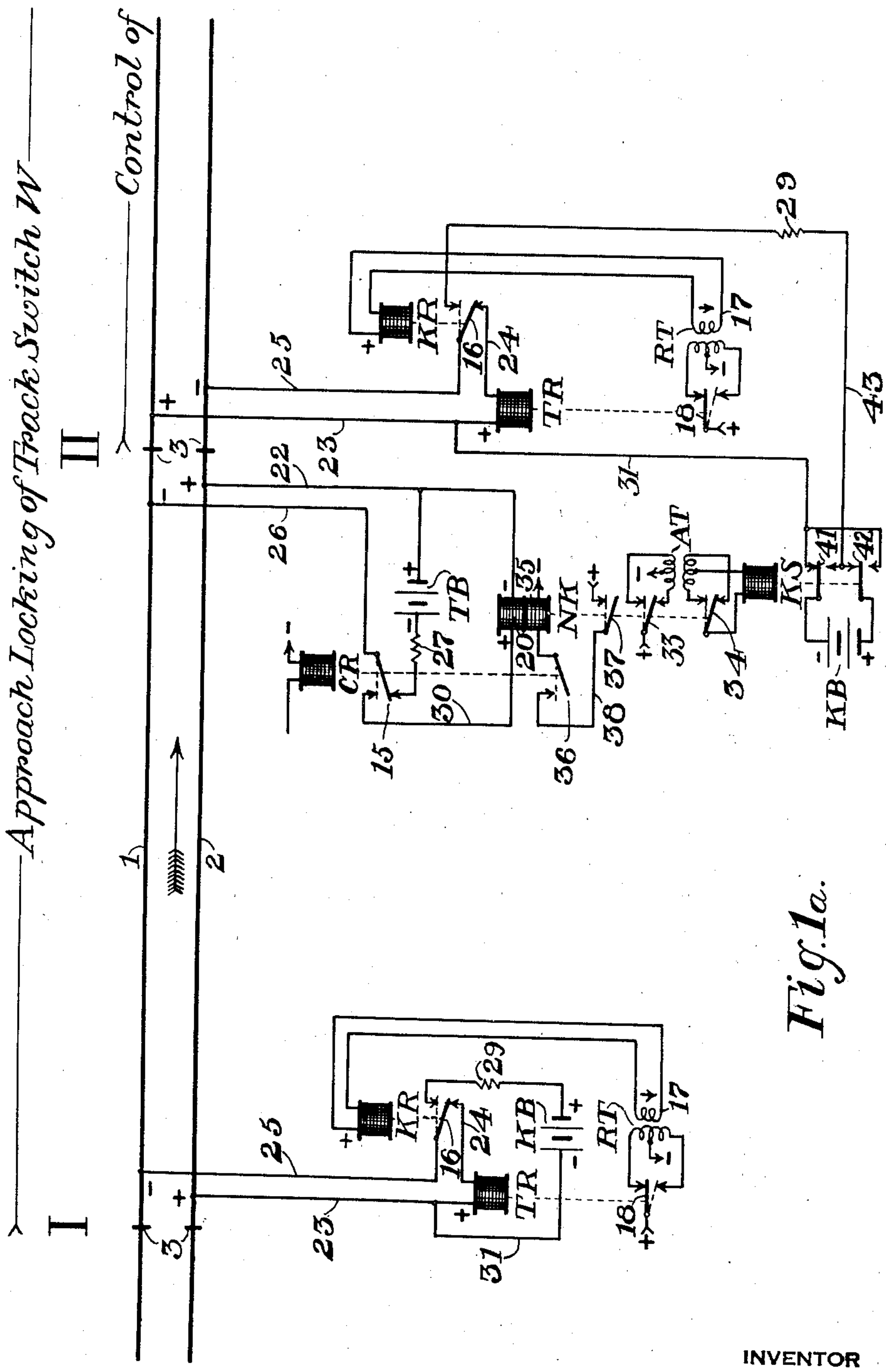

Fig. 1a.

INVENTOR
Crawford E. Staples
BY [signature]
HIS ATTORNEY

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Filed April 11, 1940 4 Sheets-Sheet 2

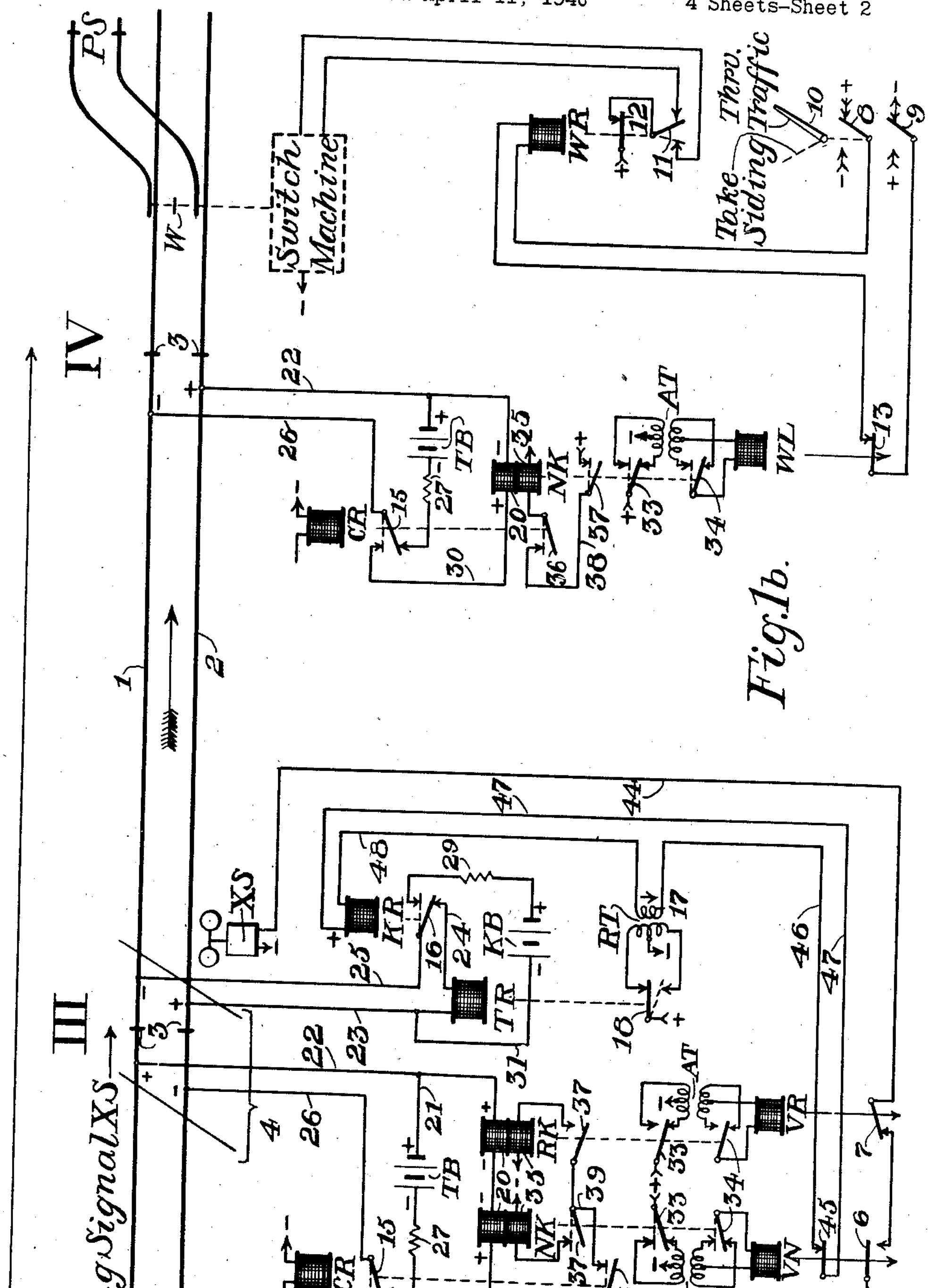

Fig. 1b.

INVENTOR
Crawford E. Staples
BY
HIS ATTORNEY

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Filed April 11, 1940 4 Sheets-Sheet 3

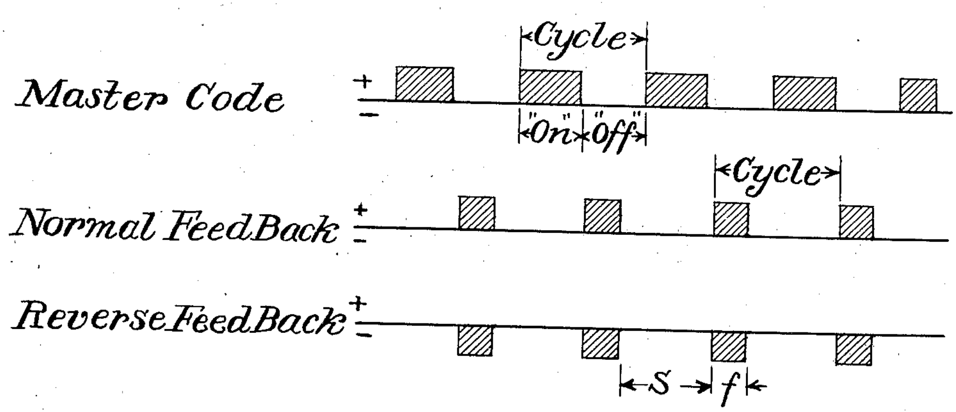


Fig. 2.

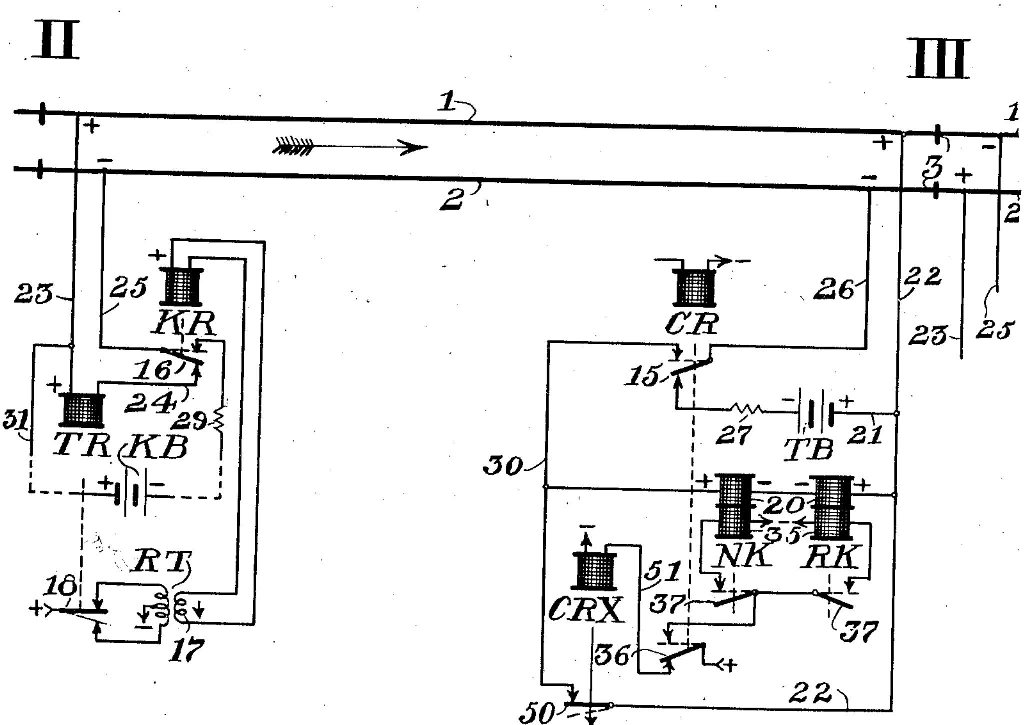


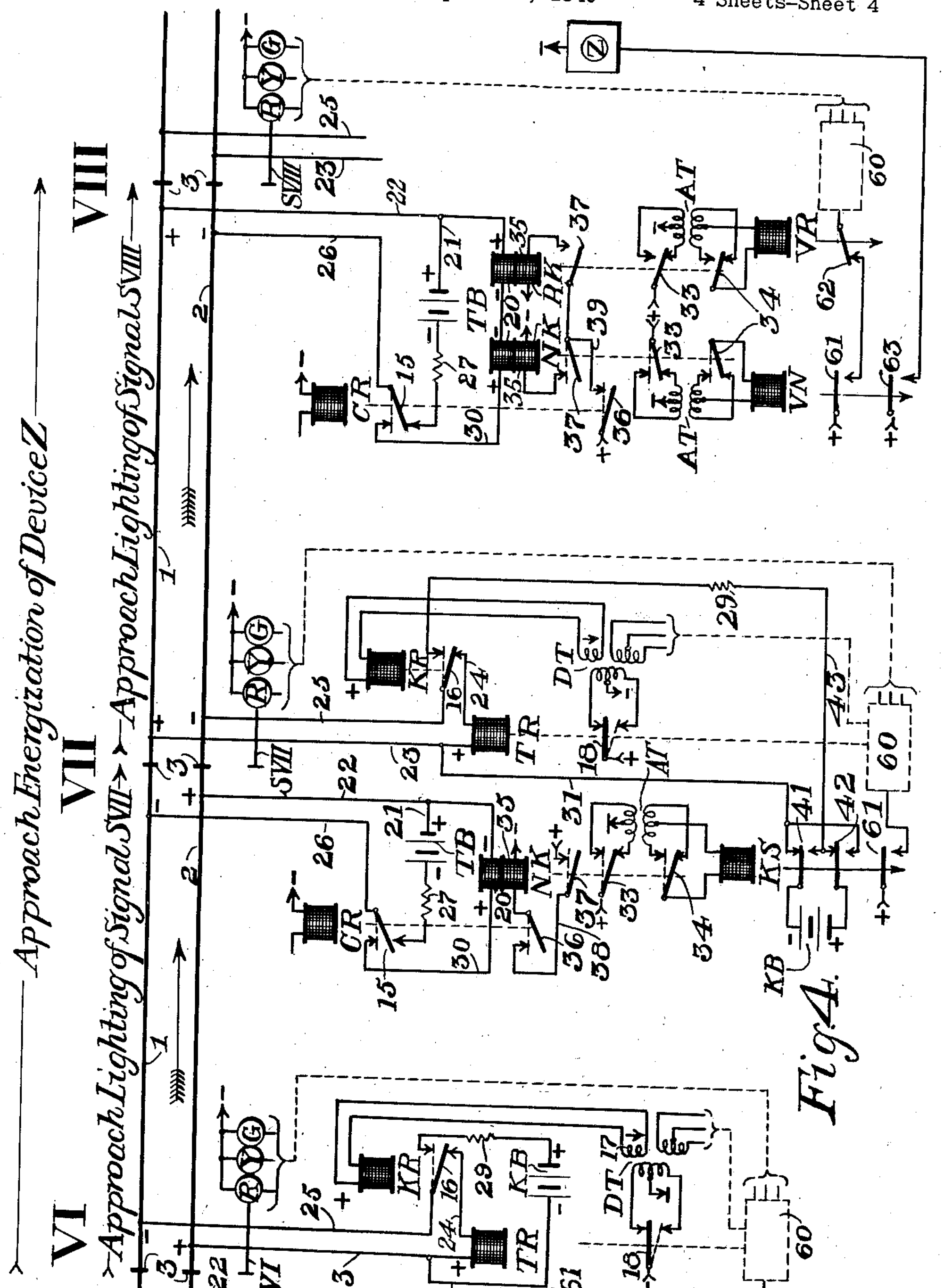
Fig. 3.

INVENTOR
Crawford E. Staples
BY
[signature]
HIS ATTORNEY

May 5, 1942. C. E. STAPLES 2,281,890

APPARATUS FOR DETECTING THE APPROACH OF RAILWAY TRAINS

Filed April 11, 1940 4 Sheets-Sheet 4



INVENTOR
Crawford E. Staples
BY
[signature]
HIS ATTORNEY

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UNITED STATES PATENT OFFICE

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APPARATUS FOR DETECTING THE APPROACH OF RAILWAY TRAINS

Crawford E. Staples, Wilkinsburg, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application April 11, 1940, Serial No. 329,316

5 Claims. (Cl. 246—34)

My invention relates to apparatus for detecting the approach of trains over multi-section stretches of railway track and it has special reference to the employment of such apparatus for performing various approach detecting functions without the aid of line wires and by means of coded energy that is transmitted through the track rails.

Generally stated the object of my invention is to increase the utility and broaden the range of application of non-line-wire approach detecting systems which operate on the "coded feed back" track circuit principle of Frank H. Nicholson Patent No. 2,021,944.

A more specific object is to extend the distance over which the approach of a train may be detected by the aid of track circuits of the just named "coded feed back" type.

Another object is to extend the number of approach detecting functions which such track circuits are capable of performing.

A further object is to provide a plurality of overlapping channels of approach control over which independent functions may be detected separately and without interfering with one another.

In practicing my invention I attain the above and other objects and advantages by equipping each of the track sections in the approach governed stretch with the previously referred to "coded feed back" track circuit facilities by which the exit end of the section is supplied with recurring pulses of "master" code energy and the entrance end with "off" period pulses of "feed back" energy; providing an approach relay at the exit end of each section and energizing this relay in step with the pulses of "feed back" energy which are there received; employing certain of these approach relays to reverse the polarity of the feed back pulses that are supplied to the next section in advance when the section from which the relay is energized becomes occupied; and providing the exit end of each of these specially supplied sections with approach detecting apparatus which responds in selectively distinctive manners to the normal polarity pulses and to the reverse polarity pulses of the feed back energy which the section rails transmit.

I shall describe a few forms of approach detecting apparatus embodying my invention and shall then point out the novel features thereof in claims. These illustrative embodiments, together with a supplemental showing of certain modified portions thereof, are disclosed in the accompanying drawings in which:

Figs. 1*a* and 1*b* are diagrammatic views which when placed end to end in the order named represent a stretch of single-direction running track that is equipped with non-line-wire apparatus organized in accordance with my invention to perform a first approach detection function over three sections and a second overlapping function over one of those sections;

Fig. 2 is a diagrammatic showing of "master" and "feed back" codes which are suitable for controlling the apparatus of Figs. 1*a*—*b*;

Fig. 3 is a diagram showing exit end facilities supplemented to overcome all objectionable effects of track storage energy; and

Fig. 4 is a diagrammatic view representing a second stretch of railway track that is equipped with non-line-wire apparatus organized in accordance with my invention to perform a first approach detection function over two sections and other overlapping functions over both of those sections.

In the several views of the drawings like reference characters designate corresponding parts.

Referring first to the composite diagram of Figs. 1*a*—*b*, the improvements of my invention are there disclosed as being incorporated in a non-line-wire system of approach detection for a stretch of single track **1**—**2** which includes four locations I, II, III and IV of track section division and over which it will be assumed that traffic moves in the single direction indicated by the arrow, or from left to right in the diagrams. Each of the named locations of track section division includes the customary insulated rail joints **3** which divide the protected stretch of track into the usual electrically separate sections I—II, II—III and III—IV and the rails of each of these sections form a part of a "coded feed back" track circuit combination which will be described presently.

As shown in the composite diagrams of Fig. 1, the location III is occasioned by the intersection of a highway **4** with the track **1**—**2**. Installed at this location in the usual way is a crossing signal XS which may be of any well-known design that is suitable for warning users of the highway whenever a train approaches and that at all other times is maintained inactive. In the particular arrangement represented, the operation of this crossing signal XS is controlled by a pair of relays VN and VR.

These relays VN and VR carry contacts **6** and **7** that serially are included in a circuit over which the signal is at times supplied with operating current from a suitable source designated by the terminals "plus" and "minus." As long as either one of these contacts is picked up the operating circuit is broken and the signal then is kept inactive. When, however, both of the contacts are released, the circuit is completed and the signal then is brought into operation.

Identified with and positioned slightly beyond the succeeding location IV of Fig. 1b, I have shown the rails of a branch track or passing siding PS onto which traffic from the main track 1—2 may be diverted when the customary track switch W is thrown from the represented "through" traffic position to the opposite or "take siding" position. Operation of the switch from one position to the other is effected by the usual switch machine under the control of a relay WR. That relay, in turn, responds distinctively to normal polarity and to reverse polarity energy which is selectively transmitted thereto over contacts 8 and 9 that are carried by the customary manually operable control lever 10.

With this lever in the represented right position, the energy supplied from the source terminals "plus" and "minus" to the switch control relay WR causes that relay to hold its polar contact 11 also to the right. When, however, the lever is shifted to the opposite or left position, contacts 8 and 9 reverse the polarity of the transmitted energy and cause relay WR to shift contact 11 to the left. In the former instance there is completed over a neutral contact 12 of the relay a circuit which causes the track switch W to be operated to its "through traffic" position while in the latter there is completed a corresponding circuit under the action of which the switch is operated to its "take siding" position.

For the purpose of at times locking the switch W into the position of its last operation the represented installation includes means for introducing a break into the energizing circuit of the relay WR. The effect of such a break, of course, is to deenergize the relay and cause it to release its neutral contact 12. That release, in turn, disconnects the switch machine from its source of operating energy and thus makes further functioning of the machine impossible until contact 12 is again picked up.

As shown in Fig. 1 the just mentioned switch locking means take the form of a relay WL having a contact 13 which is included in the supply circuit for the switch control relay WR. As long as this contact 13 is picked up, relay WR responds to shifts in the position of control lever 10 and causes the control machine to effect corresponding shifts in the position of the track switch W. When, however, the contact 13 is released, it keeps relay WR continuously deenergized and thereby renders it totally unresponsive to movements of the switch control lever 10.

When applied to the multi-section stretch of single-direction running track of Fig. 1, the improved organization of apparatus and circuits of my invention enables each train that advances through the stretch to release the switch locking relay WL at location IV as soon as it passes location I at the extreme opposite end of the stretch and to release both of the signal control relays VN and VR at location III when it enters section II—III. In this Fig. 1 scheme of my invention, moreover, both of the two just named overlapping functions of approach detection are effected without the aid of line wires and by means of coded energy which is transmitted through the track rails.

This novel and advantageous form of approach detection is made possible by operating two coded track circuits simultaneously on each of the sections I—II, II—III and III—IV into which the track 1—2 of Fig. 1 is divided. One of these track circuits transmits recurring pulses of "master code" energy over the section rails in the direction of from the exit to the entrance end and it will be referred to as the first or "master" track circuit; the other transmits "off" period pulses of "feed back" energy over the section rails in the opposite direction and it will be referred to as the second or "feed back" track circuit. To designate both of these simultaneously operating track circuits use will be made of the expression "coded feed back" track circuit combination.

One elementary form of such a combination is disclosed and claimed in the before referred to Nicholson Patent No. 2,021,944. In the "coded feed back" track circuit combination of that patent the character of the "feed back" pulses is always the same and never is it altered in a selectively distinctive way. As utilized, however, by the approach detecting apparatus of my invention, the "coded feed back" track circuits now about to be described possess a number of added refinements and certain of them are, moreover, novelly arranged to have the polarity of the "feed back" energy variously change in response to the passage of traffic through the circuited sections of the single-direction running track.

In the case of each of the three track sections I—II, II—III and III—IV of Fig. 1, both of the above-named "master" and "feed back" track circuits therefor include the section rails 1 and 2; the "master" circuit further includes an energy source TB and a code repeating relay CR installed at the traffic exit end of the section and a code following track relay TR installed at the opposite or traffic entrance end thereof; and the "feed back" circuit further includes an energy source KB and an impulse relay KR installed at the entrance end of the section and a "normal" polarity responsive track relay NK installed at the section exit end.

In the case of the central section II—III of Fig. 1, the "feed back" track circuit still further includes an entrance end selector relay KS which at times reverses the polarity of the energy that is supplied to the section rails and a second exit end track relay RK which responds only to "reverse" polarity pulses of feed back energy that are received at the relay location. As already indicated, the companion track relay NK at location III (or at locations II and IV) responds only to received pulses of feed back energy which are of "normal" polarity.

The mentioned energy sources TB and KB preferably are direct current track batteries and may be of any suitable type such as primary, storage, or the like. Alternatively, of course, these direct current sources also may take the form of rectifier units (not shown) which convert alternating current energy from a commercial supply source (again not shown) into the required direct current.

The code repeating relay CR for each of the "master" track circuits of Fig. 1 has a contact 15 which functions: (1) periodically to connect the master track battery TB in energy supplying relation with the section rails for the purpose of producing the "master" code which is represented in Fig. 2; and (2) to connect the "feed back" circuit track relay NK (and also device RK in the case of section II—III) in energy receiving relation with those rails during each "off" period of the there supplied master code.

Current for operating each of the relays CR is supplied to the winding thereof by way of the usual driving circuit (not shown). Each of these driving circuits includes a contact (again not shown) of the usual code transmitter or other circuit making and breaking device and functions continuously to supply the repeating relay CR with pulses of pick-up energy which recur at any suitable rate of coding such as 180 times per minute. In this manner each of the devices CR is caused repeatedly to pick up and release its contact 15 at a corresponding frequency and in this way the "master" code of Fig. 2 is produced.

Each of the master circuit track relays TR is a code following device which responds to each pulse of master code energy that is received from the rails of the identified section and transmitted to the track relay over the back point of a contact 16 of the before named impulse relay KR.

Coding of the energy which each of the "feed back" track batteries KB supplies to the rails of the identified section is performed by the front point of the just named contact 16 of the impulse relay KR at the battery location. This contact functions to transfer the connection of the track rails 1 and 2 from the track relay TR to battery KB during each "off" period of the received master code. Current for picking up the contact at proper times is supplied to the winding of the impulse relay KR from the secondary 17 of a relay transformer RT.

Each of these transformers RT is provided with a direct current exciting circuit which is controlled by a contact 18 of the master track relay TR at the same location. Each time that the track relay releases, the pole changing action of this contact causes to be induced in the secondary 17 a pulse of transformer voltage having a polarity designated by the small arrow and which for convenience will be referred to as "normal"; each time that the track relay picks up the reverse action of the contact 18 causes to be induced in the transformer secondary a pulse of voltage of the opposite or "reverse" polarity.

Each of the named impulse relays KR is of the polar type and contact 16 thereof occupies the released position (shown in full lines) as long as the relay remains deenergized or receives current of the "reverse" polarity just described. In that position the contact connects the operating winding of the track relay directly across the section rails 1 and 2.

When, however, relay KR receives from winding 17 a pulse of "normal" polarity energy it picks up contact 16 and thereby disconnects relay TR from the track rails and connects the "feed back" battery KB thereacross. In this manner (which is the same as that disclosed and claimed in Herman G. Blosser Reissue Patent No. 21,783 granted April 29, 1941) each release of the track relay TR causes the impulse relay KR momentarily to transfer the track rail connection from the winding of track relay TR to the output circuit of battery KB.

Each of the just named transfer actions takes place during an "off" period of the master trackway code and causes the section rails then further to be supplied with a pulse of "feed back" energy which constitutes an "on" period *f* in one or the other of the two "feed back" codes of Fig. 2. From an inspection of that figure it will be seen that the "on" periods of each of the there shown "feed back" codes coincide with the "off" periods of the "master" code which is represented immediately thereabove and vice versa.

Each of the "feed back" circuit track relays NK also is a code following device which responds only to positive or "normal" polarity energy and which has a control winding 20 that during the "off" periods of the before described "master" trackway code is connected in energy receiving relation with the section rails over the back point of contact 15 of the before described code repeating relay CR. Serially included in the connection represented at location III is the beforementioned companion feed back track relay RK which responds only to negative or "reverse" polarity energy and which performs a function later to be described.

As already indicated, each of the exit end "feed back" circuit track relays NK and RK is disconnected from the section rails (under the action of contact 15 of device CR) during the "on" periods of the there supplied "master" code. This disconnection prevents the master track circuit energy from reaching those relays and thus renders them responsive only to energy that is supplied to the section rails from the feed back battery KB at the entrance end thereof.

As has already been pointed out, likewise, each of the entrance end "master" circuit track relays TR is similarly disconnected from the section rails (under the action of contact 16 of impulse relay KR) during the "on" periods of the there supplied "feed back" code, and in that manner those relays are rendered responsive only to energy that is supplied to the rails from the master track battery TB at the section exit.

In operation of the master and feed back track circuits for each of the three track sections that are shown in Fig. 1, the code repeating relay CR at the section exit acts as a "master" device in that it sets the rate at which the pulses of both the "master" and the "feed back" trackway codes recur. This rate may be the same for all three of the sections and will be assumed to be of the previously mentioned order of 180 pulses per minute. At that rate the coding contact 15 of each of the devices CR periodically moves between an upper and a lower position.

When in the lower position, the just named coding contact 15 produces an "on" period of the "master" code of Fig. 2 and causes the track battery TB (at the section exit end) to energize the master circuit track relay TR (at the section entrance end) over a circuit which extends from the positive terminal of battery TB through conductors 21 and 22, one of the section rails, conductor 23, the winding of relay TR, conductor 24, back contact 16 of device KR, conductor 25, the other section rail, conductor 26, back contact 15 of device CR, and a current limiting impedance 27 back to the negative terminal of battery TB.

In receiving each of the just supplied energizing pulses, the master track relay TR picks up and marks an "on" period of the received master code and an "off" period of the interfitting "feed back" code. Both are accompanied by a continuously released condition of the impulse relay KR.

In going to the upper position at the end of the master code "on" period the contact 15 of each of the code repeating devices CR disconnects the master track battery TB from the section rails and thereby marks the beginning of a master code "off" period. During each of those "off" periods the just named contact 15 connects the feed back circuit track relay NK (and also the companion device RK where used) in energy receiving relation with the section rails.

At the same time (that is, during each master code "off" period) the master circuit track relay TR at the section entrance end becomes deenergized and releases in the usual manner. That release, in turn, marks the beginning of an "on" period of one of the "feed back" codes. Under the releasing action of contact 18 transformer RT now supplies a pulse of "normal" polarity pick-up energy to the impulse relay KR.

In response to that pulse, relay KR picks up and completes (at contact 16) a circuit over which battery KB at the section entrance end supplies energizing current to the "feed back" circuit track relay NK (and also device RK where used) at the section exit end. This circuit may be traced from the positive terminal of feed back battery KB through a current limiting impedance 29, the front point of contact 16 of device KR, conductor 25, one of the section rails, conductor 26, front contact 15 of device CR, conductor 30, the pick-up winding of relay NK, conductor 22, the other section rail, and conductors 23 and 31 back to the negative terminal of battery KB.

Each of the above transmitted pulses of "feed back" energy is effective for picking up one or the other of the feed back track relays NK and RK at the section exit. In the case of each of the track sections I—II and III—IV these feed back pulses are always of "normal" polarity and the single feed back track relay NK at the section exit always responds to each of them. In the case of the central section II—III the feed back pulses are at times (when the selector relay KS at location II is picked up) of "normal" polarity and at other times (when the selector relay KS is released) of "reverse" polarity. In the former instance relay NK at location III responds while in the latter relay RK is similarly caused to follow code.

The duration of each of these pulses of "feed back" energy is determined by the pick-up time of contact 16 of impulse relay KR and in practice it is of the comparatively short order designated at *f* in Fig. 2. In all cases this feed back pulse length thus is slightly less than the shortest "off" period of any of the "master" codes which the system employs. Prior to the end of each master "off" code period, therefore, contact 16 of device KR releases and interrupts the above traced feed back energy supply circuit. This release terminates the "feed back" pulse somewhat before device CR at the section exit again releases its contact 15.

When that happens, the just described cycle of "coded feed back" track circuit operation repeats itself. In the manner just outlined, therefore, the "master" and "feed back" track circuits operate over the main section rails concurrently and without interfering with each other.

In the complete approach detecting system of the composite diagram of Fig. 1 each of the "feed back" track relays NK and RK performs a special function which will now be described. Through the medium of an interposed transformer AT each of these devices NK and RK governs a direct current repeater relay which is associated with the transformer and the controlling device in a manner similar to that disclosed and claimed in Frank H. Nicholson et al. Patent No. 2,237,788 granted April 8, 1941. At location II the thus governed repeater device takes the form of the before mentioned polarity selector relay KS; at location III the repeaters for devices NK and RK are designated as VN and VR; and at location IV the repeater takes the form of the before mentioned switch locking relay WL.

Pick-up energy for each is transmitted thereto through the associated transformer AT. Exciting current for that transformer is derived from the direct current source terminals "plus" and "minus" and is impressed upon the transformer primary over a pole changing contact 33 of the controlling track relay NK or RK. The secondary of the transformer is connected with the direct current repeating relay over a circuit that includes a second or rectifying contact 34 of the controlling track relay.

As long as the contacts 33 and 34 of that relay occupy one position continuously there is no transfer of energy through the transformer to the repeater relay (KS, VN, VR or WL) and the contacts of that repeater device are then continuously released. When, however, the controlling track relay (device NK or RK) is recurrently picking up and releasing in response to received pulses of feed back energy, the joint action of contacts 33 and 34 thereof causes the associated repeater to receive direct current energization in recurring pulse form.

Each of these repeaters is provided with a period of release delay which is sufficient to span the spacing between these recurrent energizing pulses and in consequence the contacts of the repeater are held continuously picked up as long as the controlling track relay continues to follow code.

For the purpose of reducing the minimum release delay period of the repeater relays KS, VN, VR and WL and thereby quickening the response of each of these devices to the approach of a train, each of the "feed back" energized track relays NK and RK in the system of Fig. 1 is provided with a second or "stick" winding 35 and a supplemental energizing circuit therefor. In the illustrative form shown, each of these "stick" circuits: (1) includes the back point of a second contact 36 of the coding device CR at the relay location and the front point of a contact 37 of the winding carrying relay NK or RK itself; and (2) functions in a manner comparable to that disclosed and claimed in Patent No. 2,172,893 which issued September 12, 1939 to Edward U. Thomas on "Approach control apparatus for railway signaling systems."

In the case of each of the so equipped track relays NK and RK it will be seen that when that relay is picked up (by "feed back" energy received over the front point of contact 15 of coding device CR) the back contact 36 of device CR completes for the picked up relay the before referred to "stick" circuit. As is illustratively represented at each of locations II and IV, that circuit extends from the positive terminal of a local supply source through front contact 37 of relay NK, conductor 38, front contact 36 of device CR and the stick winding 35 of the track relay NK back to the negative terminal of the supply source; as shown at location III the corresponding circuit for each of the track relays NK and RK extends from the positive supply terminal through front contact 36 of device CR, conductor 39, front contact 37 of the track relay NK or RK, and the "stick" winding 35 of that relay back to the negative supply terminal.

Once completed, each of the just traced stick circuits holds the track relay with which it is identified picked up until contact 26 of the coding device CR is again moved to the lowermost position. That movement takes place at the end of the particular master code "off" period during which the relay (NK or RK) receives its original pick-up current from the section rails. This pick-up current, of course, was in the form of a pulse of one of the "feed back" codes of Fig. 2 and hence was of the comparatively short duration indicated at *f*.

Because of that fixed shortness the spacing (indicated at *s* in Fig. 2) between recurrent pulses of the track relay exciting "feed back" energy is prolonged. In the absence of the supplemental hold-up provision now being described the period of release delay for the controlled repeater relay (device KS, VN, VR or WL) would have to be made objectionably long. Because, however, of the just explained "stick" action this release delay period can be substantially shortened without allowing the repeater relay to drop out between the recurring pulses of "feed back" energy by which the feed back track relay NK or RK is operated.

Before analyzing the operation of the complete approach detecting system of Fig. 1, it will be helpful to examine in somewhat greater detail the function which each of the repeater devices KS, VN, VR and WL performs. Relay KS at location II determines, as already pointed out, the polarity of the "feed back" energy which battery KB supplies to the rails of section II—III and in effecting this determination it makes use of contacts **41** and **42**.

As long as those contacts are picked up the positive terminal of battery KB is connected with conductor **43** and the negative battery terminal with conductor **31**. Under this condition the supplied pulses of feed back energy have the "normal" or positive polarity. When, however, contacts **41** and **42** of relay KS are released, the connections just stated are reversed and under that condition the pulses of feed back energy which battery KB supplies to the rails of section II—III are of the "reverse" or negative polarity.

Looking at repeater devices VN and VR at location III, it has already been seen that through the medium of contacts **6** and **7** thereof these devices control the operation of the highway crossing signal XS. As long as either of the named contacts is picked up that signal is maintained inactive. When, however, both of the contacts are released, the signal XS is brought into operation as a result of the completion therefor of an operating circuit which extends from the positive supply terminal through back contact **6** of device VN, back contact **7** of device VR, conductor **44**, and the operating mechanism of the signal back to the negative supply terminal.

Also performed by the repeater relay VN at location III is a second function in which a contact **45** takes part. That contact controls the connection of the impulse relay KR at the named location with the secondary **17** of the relay transformer RT. As long as contact **45** remains picked up, the named connection is completed and each pulse of "normal" polarity energy generated in the transformer winding **17** picks up the impulse relay in the manner already explained and over a circuit extending from the lower terminal of winding **17** through conductor **46**, front contact **45** of device VN, conductor **47**, the winding of relay KR, and conductor **48** back to the upper terminal of winding **17**.

When, however, contact **45** of the repeater device VN is released, the circuit just traced is interrupted and the impulse relay KR then remains continuously released even though the associated track relay TR at location III responds to recurring pulses of "master" code energy that are transmitted thereto from location IV. As a result of this continuous release the supply of "off" period pulses of "feed back" energy from battery KB to the rails of section III—IV is discontinued.

Looking finally at repeater relay WL at location IV, it has already been seen that this device performs the single function of controlling the locking of the track switch W at the same location. As long as contact **13** of relay WS is picked up movements of the switch control lever **10** are effective to shift the position of the track switch W; however, when contact **13** is released, the switch control relay WR is continuously deenergized and movements of the control lever **10** then become ineffective to operate the switch W from its last operated position.

The apparatus and circuits which the improved non-line-wire system of approach detection utilizes now having been described, the manner in which this complete system operates will next be explained. As an aid to this explanation, reference will first be had to the "control limit" notations which appear on the upper portion of the composite diagram of Fig. 1.

From these notations it will be seen that the represented organization of the apparatus and circuits performs two independent and overlapping functions of approach control. The first is the locking of the track switch W at location IV and it begins with the time that a train (moving from left to right) passes location I and continues uninterruptedly until that train has cleared location IV; the second consists in placing the highway crossing signal XS at location III in operation and it takes place from the time that the forward portion of the train first passes location II until the rear truck of the train clears location III.

Under the vacant track stretch conditions which are represented in Fig. 1, "master" code of 180 or other given number of pulses per minute is transmitted from the exit to the entrance end of each of the sections in the stretch while "normal feed back" code is returned in the opposite direction over the rails of each section during the master code "off" periods. Each of the feed back track relays NK now responds to this "normal" polarity feed back energy; polarity selector KS at location II is accordingly picked up; repeater relay VN at location III is likewise picked up to maintain the highway crossing signal XS inactive; and the switch locking relay WL at location IV likewise is picked up to keep the track switch W responsive to control movements of lever **10**.

Continuing the operation explanation, it will now be assumed that a train moving in the direction of from left to right enters the stretch at the end location I, progresses through the several sections therein ,and finally clear the stretch at the opposite end location IV.

As the leading vehicle of the train passes location I and shunts the rails of section I—II, it cuts off the transmission of feed back energy to the polar track relay NK at location II and causes the there associated polarity selector relay KS to release. Contacts **41** and **42** of that selector relay now reverse the connections of battery KB with the rails of section II—III and thereby cause the recurring pulses of feed back energy received by those rails to have the negative or "reverse" polarity.

At location III this "reverse feed back" energy is ineffective for operating the positive polar relay NK and instead produces a response on the part of the negative polar device RK. That device now picks up the repeater relay VR and causes contact 7 thereof to introduce an additional break into the energizing circuit for the crossing signal XS. This additional break further assures that the signal will be continued inactive.

At the same time the now inactive positive polar device NK at location III allows the repeater relay VN which it controls to release and thereby disconnect (at contact 25) the impulse relay KR from its source of pick-up energy. This action prevents relay KR at location III from further responding to the code following operation of the master track relay TR and completely discontinues the previous supply of "feed back" energy to the rails of section III—IV.

At location IV the feed back track relay NK now is continuously released as a result of the just named feed back energy cut-off and the associated switch locking relay WL accordingly drops out. That action disconnects (at contact 13) the switch control relay WR from its supply source and thereby sets up the desired locking of the track switch W.

Once set up in the manner stated this switch locking is continued as long as any part of the train remains in the track stretch between locations I and IV. This continuance results, as will be seen, from the fact that each advance of the train into the succeeding track section does not alter the previously effected cut-off of feed back energy from the rails of section III—IV. Thus, as the train passes location II it merely prevents all feed back energy from reaching location III and it does not restore the supply of feed back energy to section III—IV. Likewise, as the train passes location III the previous cut-off of feed back energy for section III—IV is not interfered with.

Tracing in greater detail the further train moves that have just been stated, it will be seen that as the leading vehicle of the train passes location II and shunts the rails of section II—III, the supply of all feed back energy to those rails is discontinued. At location III, in consequence, both of the feed back track relays NK and RK are continuously deenergized and the associated repeater devices VN and VR both release.

As a result of that release contacts 6 and 7 now complete for the highway crossing signal XS the before traced operating circuit and thereby cause that signal to warn the users of highway 4 that a train is approaching the intersection. Once started, this warning continues until the rear of the train has cleared location III. Prior to that time, however, certain further actions take place and these will now be described.

The first of these occurs when the rear of the train clears location II. This clearance causes the "coded feed back" track circuits of section I—II to resume their normal vacant section operation wherein pulses of master code energy are transmitted over the rails of location II to location I and "off" period pulses of "normal" polarity feed back energy are transmitted over the same rails in the opposite direction or from location I to location II. The now restored code following action of relay NK at location II picks up the polarity selector relay KS and there restores the "normal" polarity connection of the track battery KB with the rails of section II—III.

As the leading vehicle of the train passes location III and shunts the rails of section III—IV, the transmission of master code pulses to relay TR at location III is discontinued. Relays VN and VR still remain released and the operation of crossing signal XS accordingly continues.

As the trailing vehicle of the train clears location III the "coded feed back" track circuits for section II—III resume their normal vacant section operation wherein recurring pulses of master code energy are transmitted in the direction of from location III to location II and "off" period pulses of feed back energy are returned over the section rails in the opposite direction. Relay KS at location II now being picked up causes these feed back pulses to have "normal" polarity and their effect is to operate the positive polar track relay NK at location III.

This code following operation by relay NK picks up the repeater device VN and thereby interrupts (at contact 6) the energizing circuit for the crossing signal XS. That interruption restores the signal to its normally inactive state. At the same time contact 45 of relay VN restores the connection of the impulse relay KR (at location III) with its pick-up transformer RT and thereby conditions it for response to subsequent code following operation of the master track relay TR.

Until the trailing vehicle of the train clears location IV the just stated conditions of the system apparatus continue unaltered. When, however, the named clearance of location IV does take place, the "coded feed back" track circuits for section III—IV resume their normal vacant track operation wherein recurring pulses of master code energy are transmitted in the direction of from location IV to location III and "off" period pulses of feed back energy are returned over the section rails in the opposite direction. These pulses are of "normal" polarity and they are effective to cause the feed back track relay NK at location IV again to follow code. That action picks up the switch locking relay WL and causes (at contact 13) the previously set up locking of switch W to be discontinued.

From the foregoing, accordingly, it will be seen that when the improved non-line-wire apparatus of my invention is organized in the manner shown in Figs. 1*a*—*b*, it performs a first approach detection function (locking of track switch W) over three sections (I—II, II—III and III—IV) of the approach governed track and a second overlapping function (control of crossing signal XS) of approach detection over one (II—III) of those same three sections. As has also become evident, moreover, these two functions are non-dependent on each other and they are detected separately and without interfering with one another.

Figs. 1*a*—*b* now having been described, attention will next be directed to Fig. 3. In that figure I have reproduced certain of the exit end track circuit apparatus for section II—III of Fig. 1 for the purpose of showing how an auxiliary relay CRX may be combined therewith in installations where the effects of track storage energy may be found objectionable.

As is known, such energy tends to accumulate in the rails and ballast of each of the system track circuits as a result of the repeated application thereto of direct current code pulses from the master track battery TB. In the absence of some counteracting influence difficulty in operating the code following track relays may sometimes be encountered due to a build-up between the rails **1** and **2** of track storage voltage which over a period of time may become sufficient to prevent the intended release of the track relays during the "off" code periods.

For the purpose of overcoming this track storage effect in each of the sections I—II, II—III and III—IV of Fig. 1, I have so connected the auxiliary battery KB with the section rails that the "normal feed back" energy pulses that are supplied thereto are of opposite polarity to the "master" code energy pulses which the rails receive from battery TB. In this manner the usual tendency for the track circuit to accumulate the storage energy just described is directly neutralized in each of the three named sections as long as the track stretch of Fig. 1 is vacant.

In the case of each of sections I—II and III—IV, this neutralization is effective under all operating conditions of the track circuits since the "feed back" pulses supplied thereto are always of "normal" polarity and under no circumstances is this polarity reversed. No supplemental storage reducing means are, therefore, required for either of sections I—II and III—IV.

In the case of section II—III, however, some slight difficulty may be introduced by the track storage energy under those conditions of track circuit operation when the rails are receiving "reverse feed back" pulses the polarity of which is the same as that of the master code pulses. When the track storage properties of the section are extreme, this condition of "reverse" polarity feed back energy supply may produce objectionable distortion in the operation of the various code following track relays that receive energy from the section rails.

To guard against this possibility, the before named auxiliary relay CRX may be used in the manner represented in Fig. 3. This auxiliary device has code repreating characteristics and is supplied with pick-up current over the back point of contact **36** of the code repeating relay CR at the section exit. It also has a period of release delay which is about the same as is that of each of the section track relays TR, NK and RK.

Controlled by this auxiliary relay CRX is a contact **50** which when picked up connects conductor **22** with conductor **30** and thereby puts a short circuit directly across the control windings **20** of the feed back track delays NK and RK and also across the section rails **1** and **2** under certain conditions. This short circuit occurs during a portion of each of the track circuit code cycles and its effect is to dissipate any track storage voltage which may have accumulated between the rails **1** and **2** during the earlier portions of that cycle.

When installed at the exit end of section II—III as shown in Fig. 3, this energy dissipating device CRX operates in the following manner. Pick-up current is supplied to the winding thereof during each "on" period of the "master" code with which the section rails are supplied (from track battery TB over the back point of contact **15** of repeating device CR). The then completed pick-up circuit may be traced from the positive supply terminal through back contact **36**, conductor **51** and the winding of relay CRX back to the negative supply terminal.

As code repeating device CR moves contacts **15** and **36** upwardly to mark the end of the master code "on" period and the beginning of a master code "off" period, the just traced energizing circuit is interrupted. Due, however, to the sluggish releasing characaeristics of device CRX, contact **50** remains picked up for a short time; preferably this is about the same as that required for the master track relay TR (at the section entrance II) to release and the associated impulse relay KR to pick up and connect feed back battery KB with the section rails. During this time contact **15** of device CR (at location III) stays picked up so that there is completed a storage energy discharge circuit which extends from rail **1** through conductor **22**, front contact **50** of device CRX, conductor **30**, front contact **15** of device CR and conductor **26** back to rail **2**.

Just prior to the pick-up of contact **16** of relay KR at location II, the auxiliary relay CRX at location III releases and contact **50** now interrupts the just traced storage discharge circuit. In so doing it removes the short circuit form across the control windings **20** of the feed back track relays NK and RK and thereby conditions those relays for reception and response to a succeeding pulse of feed back energy.

In the manner just stated, therefore, the supplemental means of Fig. 3 are effective to reduce the objectionable effects of track circuit storage energy in situations where such reduction may be found desirable. When applied as shown in Fig. 3 this reduction results from the placing of a momentary short circuit on the section rails during a part of each code cycle. Even under the most adverse conditions this assures the satisfactory operation of "coded feed back" track circuits wherein at times, as in section II—III, the polarity of the feed back energy pulses augments that of the master code energy pulses.

Referring finally to Fig. 4, I have there shown my improved non-line-wire scheme of approach control organized to perform a first detection function over each of two sections VI—VII and VII—VIII of signaled track and other overlapping functions over both of those sections. These two sections are included in a coded track circuit system of automatic block signaling for a stretch of track over which traffic moves in the single direction indicated by the arrow. Of this protected stretch, only the two just mentioned sections, VI—VII and VII—VIII, are shown in Fig. 4.

As in the organization of apparatus that is represented in Figs. 1*a*—*b*, character TR designates a code following track relay which is installed at the entrance end of each of the sections and operated by "master" code energy received from the rails thereof; character TB a source of master code energy provided at the section exit for the purpose of supplying these rails with the relay operating current just referred to; and character CR a coding device having a contact **15** which codes this energy by periodically interrupting the rail supply circuit. In addition there is further installed at the entrance of each of the track sections of Fig. 4 the usual wayside signal S which governs the entry of traffic into that section and which is controlled by the associated track relay TR through the medium of decoding apparatus **60**.

An automatic block signaling system of the referred to coded track circuit type operates without the aid of line wires and in representative form it includes all of the elements above named. Such a system further comprises the customary facilities (not shown in Fig. 4) for continuously operating each of the exit end relays CR at one or another of the usual plurality of distinctive code rates. Selection among these rates (which in a typical three-indication system may consist of 75 and 180 energy pulses per minute) is made in accordance with advance traffic conditions by the decoding apparatus and functioning in customary manner.

This decoding apparatus (details not shown in Fig. 4) is controlled in the usual fashion by the associated track relay TR and it performs the further function of selectively setting up a lighting circuit for one or another of the lamps (G, Y and R in the typical three-indication system above referred to) of the wayside signal S at the same location. In the arrangement represented, these signal lamps derive energizing current from a power source which is designated by the terminals "plus" and "minus."

In order that each of the wayside signals S may be rendered active only upon the approach of a train, the apparatus installed at each of the signal locations VI, VII and VIII is supplemented by detection apparatus which maintains the lighting circuits for the signal deenergized at all times except when the section of track to the rear of this location becomes occupied. This approach lighting function is governed: (1) at location VI by a relay designated as VN; (2) at location VII by a contact 61 of a relay KS; and (3) at location VIII by contacts 61 and 62 of relays VN and VR.

In addition, the apparatus of Fig. 4 is organized to effect the approach energization of a device Z at location VIII whenever a train passes location VI. This device Z represents means of any one of a number of well-known forms for indicating that a train has passed location VI and is occupying some portion of the track stretch between that location and location VIII. It is controlled by a contact 63 of relay VN at the same location and receives energizing current only when that contact is released. From the notations at the top of Fig. 4 it will be seen that the channel of approach control for device Z at location VIII is coextensive with and overlaps both of the approach energizing channels for wayside signals SVII and SVIII.

As in the comparable system of Figs. 1*a*—*b* each of the two represented sections VI—VII and VII—VIII is provided with track circuit facilities of the "coded feed back" type. In the case of section VI—VII these facilities are practically identical with those already described in connection with section I—II of Fig. 1*a*. At the entrance end of the section they differ therefrom in that the winding 17 from which the impulse relay KR is energized forms a part of a decoding transformer DT instead of the special relay transformer RT of Fig. 1. In both instances, however, the response of relay KR to the code following action of the master track relay TR is the same. At the exit end of section VI—VII the named identity is even closer. Comparing Fig. 4 with Fig. 1*a* it will be seen that both arrangements make use of the polarity selector relay KS. In Fig. 4, however, this relay is provided with a third contact 61 already mentioned as effecting the approach energization of wayside signal SVIII.

In the case of the second track section VII—VIII of Fig. 4 the entrance end portion of the "coded feed back" track circuit facilities is a duplicate of the corresponding equipment for section II—III of Fig. 1 with the single exception that the relay energizing winding 17 forms a part of a decoding transformer DT instead of the special relay transformer RT. Likewise, the exit end portion of the track circuit facilities for section VII—VIII is the same as the corresponding apparatus for section II—III of Fig. 1 with the exception that relays VN and VR control (over contacts 61 and 62) the approach lighting of the wayside signal SVIII while relay VN is provided with a contact 63 which controls the approach energization of the special indicating device Z.

It will thus be evident that the "coded feed back" track circuits of the two sections VI—VII and VII—VIII of Fig. 4 have the same operating characteristics as those that have already been explained for the corresponding track circuits of sections I—II and II—III of Figs. 1*a*—*b*. That is, as long as a stretch of track I—II of Fig. 4 is vacant throughout its entire length, each of the two represented track sections thereof transmits recurring pulses of "master" code energy in the direction of from its exit to its entrance end and "off" period pulses of "normal feed back" energy in the opposite direction.

As a result of these actions all of the wayside signals S are maintained inactive and the special indicating device Z at location VIII is kept deenergized. As, now, a train moving in the direction of from left to right enters and passes through the track stretch of Fig. 4 the following functions of approach detection are performed by the apparatus of that figure.

When the forward vehicle of the train passes location VI and shunts the rails of section VI—VII, the transmission of feed back energy to location VII is discontinued and the feed back track relay NK at that location now becomes inactive. This releases the polarity selector relay KS and by closing contact 61 completes the lighting circuit for the wayside signal SVII. As a result that wayside signal now lights the particular lamp which is selected by the decoding equipment 60.

At the same time contacts 41 and 42 of relay KS reverse the connections of the feed back battery KB with the rails of section VII—VIII and thereby cause those rails now to be supplied with energy of the "reverse feed back" code. In being received at location VIII this reverse polarity energy operates the reverse polar track relay RK and allows the normal polar relay NK to become inactive. These two effects cause repeater relay VR to pick up contact 62 and allow repeater relay VN to release its contacts 61 and 63. The first action continues the wayside signal SVIII inactive while the second completes the energizing circuit for the special indicating device Z.

This device Z now shows that a train has entered a portion of track between locations VI and VIII and is proceeding therethrough. Once set up, moreover, the indication is maintained uninterrupted until the trailing vehicle of the train has cleared location VIII.

Thus, as the forward vehicle of the train passes location VII and shunts the rails of section VII—VIII both of the feed back track relays NK and RK at location VIII become continuously deenergized and both of the repeater devices VN and VR are now released. Contact 63 continues the energizing circuit for device Z intact while contacts 61 and 62 serially complete the lighting circuit for the wayside signal SVIII. As a result that signal now lights the particular lamp which is selected by the decoding equipment 60 at the signal location.

As the trailing vehicle of the train clears location VII the "coded feed back" track circuits for section VI—VII again resume their vacant track operation wherein recurring pulses of "master" code energy are transmitted in the direction of from the exit to the entrance end and "off" period pulses of "normal" polarity feed back energy are returned over the section rails in the opposite direction. These feed back pulses recurrently pick up normal polar relay NK at location VII and thereby restore the polarity selector relay KS to its normally picked-up condition wherein contacts 41 and 42 restore the "normal" polarity connection of the feed back battery KB with the rails of section VII—VIII. This same pick-up interrupts (at contact 61) the lighting circuit for the wayside signal SVII.

Until the trailing vehicle of the train clears location VIII the conditions described in the immediately preceding paragraphs remain unchanged. When, however, the named clearance is effected, the "coded feed back" track circuits for section VII—VIII again resume their normal vacant track operation wherein recurring pulses of master code energy are transmitted in the direction of from the exit to the entrance end while "off" period pulses of normal polarity feed back energy are transmitted over the section rails in the opposite direction.

At location VIII these feed back pulses now operate the positive polar relay NK and thereby cause repeater relay VN to pick up. Contact 61 now interrupts the lighting circuit of the wayside signal SVIII while contact 63 similarly interrupts the energizing circuit for the special indicating device Z.

In this manner both of the devices SVIII and Z are once more restored to their normally inactive condition and the "coded feed back" track circuits for both of the sections VI—VII and VII—VIII now function in the same vacant track manner as before the above mentioned train entered the stretch at location VI.

In situations wherein the effects of the track storage energy may tend to interfere with the desired response of the track relays, the exit end apparatus for section VII—VIII may be supplemented as in the manner indicated at location III in Fig. 3. When so supplemented the rails of the track section will receive a momentary short circuit during a portion of each of the code cycles and in that manner storage voltage in the track rails and ballast will be prevented from building up to an objectionable value.

While in the embodiment of Figs. 1*a*—*b* I have explained my invention in an application wherein a switch locking relay WL and a highway crossing signal XS are approach controlled and while in the embodiment of Fig. 4 I have explained my invention in an application wherein the lamps of the wayside signals S and a special indicating device Z are approach energized, it will be understood that any of these functions may be performed separately or in still further combinations with each other and that still further comparable functions may also be provided for in my new system.

From the foregoing therefore, it will be seen that I have made important improvements in apparatus for performing various approach detecting functions without the aid of line wires and by means of coded energy that is transmitted through the track rails.

In particular, I have increased the utility and broadened the range of application of non-line-wire approach detecting systems which operate on the "coded feed back" track circuit principle of Frank H. Nicholson Patent No. 2,021,944; I have extended the distance over which the approach of a train may be detected by the aid of track circuits of the just named "coded feed back" type; I have extended the number of approach detecting functions which such track circuits are capable of performing; I have provided a plurality of overlapping channels of approach control over which independent functions may be detected separately and without interfering with one another; and I have effected the above through the use of apparatus of comparatively simple character and without dispensing with any of the desirable features of coded track circuit control.

As all of these improvements are entirely a function of the track circuits and apparatus which is directly associated therewith, they are independent of the coding or decoding facilities of the coded signaling systems which they may supplement and hence are usable with a wide variety of different types and forms of such facilities.

Although I have herein shown and described only a few forms of approach detecting apparatus embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a section of railway track, means including a coding device at the section exit for supplying the rails of said section with master code energy in the form of recurring pulses that are separated by "off" period intervals, means effective under vacant conditions of said section for further supplying said rails with feed back energy in the form of momentary pulses that recur in step with said master code "off" periods and that are of normal polarity at times and of reverse polarity at other times, a pair of code following track relays at said section exit which respectively are operable by normal polarity energy and by reverse polarity energy and each of which is provided with a pick-up winding and with a stick circuit, means controlled by said coding device for connecting the pick-up windings of said track relays in energy receiving relation with said rails during said master code "off" periods whereby as long as said track section remains vacant both of said pick-up windings receive said pulses of feed back energy and one or the other of said track relays is recurrently picked up by those received pulses, means controlled by said coding device and by each of said track relays for completing the said stick circuit of that track relay from the time of each pick-up of the relay until the end of the "off" code period within which that pick-up occurs whereby to prolong the relay hold-up time for the full duration of each of those "off" code periods, slow release relay means energized in step with the said recurrent pick-ups of each of

said track relays, and traffic governing apparatus controlled by said slow release relay means.

2. In combination, a section of railway track, means including a coding device at the section exit for supplying the rails of said section with master code energy in the form of recurring pulses that are separated by "off" period intervals, means effective under vacant conditions of said section for further supplying said rails with feed back energy in the form of momentary pulses that recur in step with said master code "off" periods and that are of normal polarity at times and of reverse polarity at other times, a pair of code following track relays at said section exit which respectively are operable by normal polarity energy and by reverse polarity energy and each of which is provided with a pick-up winding and with a stick circuit, means controlled by said coding device for connecting the pick-up windings of said track relays in energy receiving relation with said rails during said master code "off" periods whereby as long as said track section remains vacant both of said pick-up windings receive said pulses of feed back energy and one or the other of said track relays is recurrently picked up by those received pulses, means controlled by said coding device and by each of said track relays for completing the said stick circuit of that track relay from the time of each pick-up of the relay until the end of the "off" code period within which that pick-up occurs whereby to prolong the relay hold-up time for the full duration of each of those "off" code periods, a first slow release relay which is energized in step with the said recurrent pick-ups of said normal polarity track relay and which releases only when that track relay ceases to follow code, a second slow release relay which is energized in step with the said recurrent pick-ups of said reverse polarity track relay and which releases only when that track relay ceases to follow code, and traffic governing apparatus controlled by said two repeater relays and distinctively responsive to different picked-up and released conditions thereof.

3. In combination, a stretch of railway track which includes adjoining first and second sections and through which traffic passes in the direction of from said first to said second section, means at the remote end of said second section for supplying the rails thereof with master code energy in the form of recurring pulses that are separated by "off" period intervals, a code following track relay at the junction end of said second section connected with said second section rails and responsive to the said pulses of master code energy which are received from those rails, a similarly located source of feed back energy, an impulse relay which when picked up transfers the said connection of the second section rails from said track relay to said feed back source and thereby causes those rails then to receive a pulse of feed back energy and which when released restores said connection to said track relay, a circuit which is controlled by said track relay and over which said impulse relay is picked up during each "off" period of the said master code to which the said track relay responds, means located at the junction of said two sections and responsive to traffic conditions in and beyond said first section for at times maintaining said impulse relay pick-up circuit intact and for at other times interrupting it whereby at those other times to discontinue said there supplied pulses of said second section feed back energy, and traffic governing apparatus controlled by the pulses of said second section feed back energy which are transmitted over the second section rails.

4. In combination, a section of railway track, means including a coding device at a given end of said section for supplying the section rails with master code energy in the form of recurring "on" period pulses that are separated by "off" period intervals, means effective under vacant conditions of said section and operated by said master code energy for further supplying said rails with feed back energy in the form of momentary pulses that recur in step with said master code "off" periods and that at times have the same polarity as do the "on" period pulses of said master code energy, a code following track relay at said given end of said section which is operable by said feed back energy, means controlled by said coding device for connecting said track relay in energy receiving relation with said section rails during said master code "off" periods whereby that relay receives and responds to the said pulses of feed back energy with which those rails are supplied, and means also controlled by said coding device for placing a momentary short circuit across said rails immediately following each of said master code "on" periods whereby to prevent said rails from accumulating a track storage potential of objectionable magnitude.

5. In combination, a section of railway track, means including a coding device at a given end of said section for supplying the section rails with master code energy in the form of recurring "on" period pulses that are separated by "off" period intervals, means effective under vacant conditions of said section and operated by said master code energy for further supplying said rails with feed back energy in the form of momentary pulses that recur in step with said master code "off" periods and that at times have the same polarity as do the "on" period pulses of said master code energy, a code following track relay at said section's given end which is operable by said feed back energy, means controlled by said coding device for connecting said track relay in energy receiving relation with said section rails during said master code "off" periods whereby that relay receives and responds to the said pulses of feed back energy with which those rails are supplied, a rail by-passing relay installed at said section's given end and provided with a short period of release delay, a pick-up circuit for said by-passing relay which is completed by said coding device during and only during each of said master code "on" periods and which causes the relay to pick up upon the occasion of each of those "on" periods and to release shortly after the beginning of each succeeding master code "off" period, and means including contacts of said by-passing relay and of said coding device for placing a low resistance shunt across said rails from the beginning of each of said master code "off" periods until the time therein that said by-passing relay releases whereby to prevent said rails from accumulating a track storage potential of objectionable magnitude.

CRAWFORD E. STAPLES.