

July 15, 1941.

F. H. NICHOLSON

2,249,722

APPROACH CONTROL APPARATUS FOR RAILWAY SIGNALING SYSTEMS

Filed Feb. 9, 1940

4 Sheets-Sheet 1

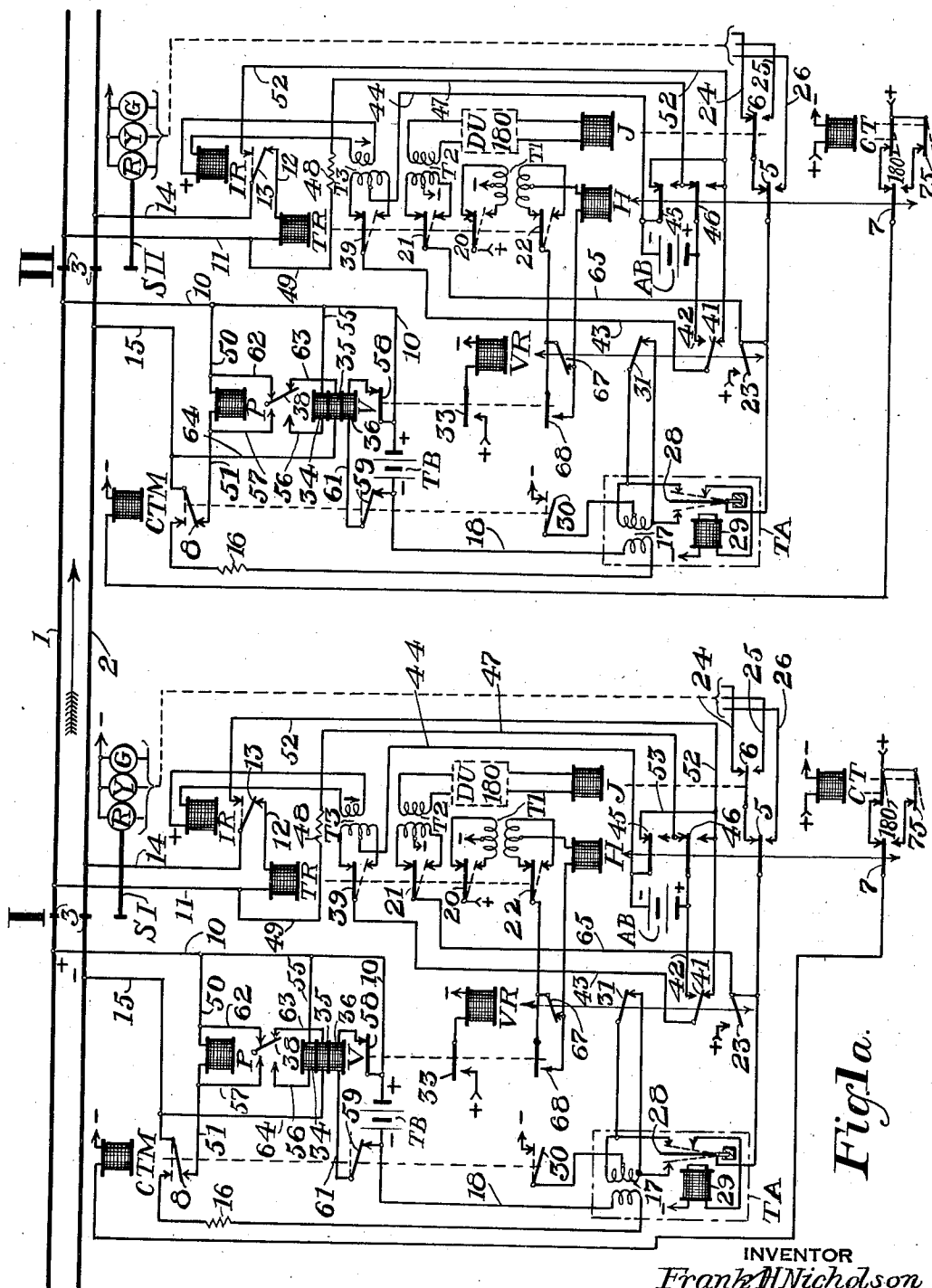


Fig. 1a.

INVENTOR
Frank H. Nicholson
 BY *Kalwood*
 ATTORNEY

July 15, 1941.

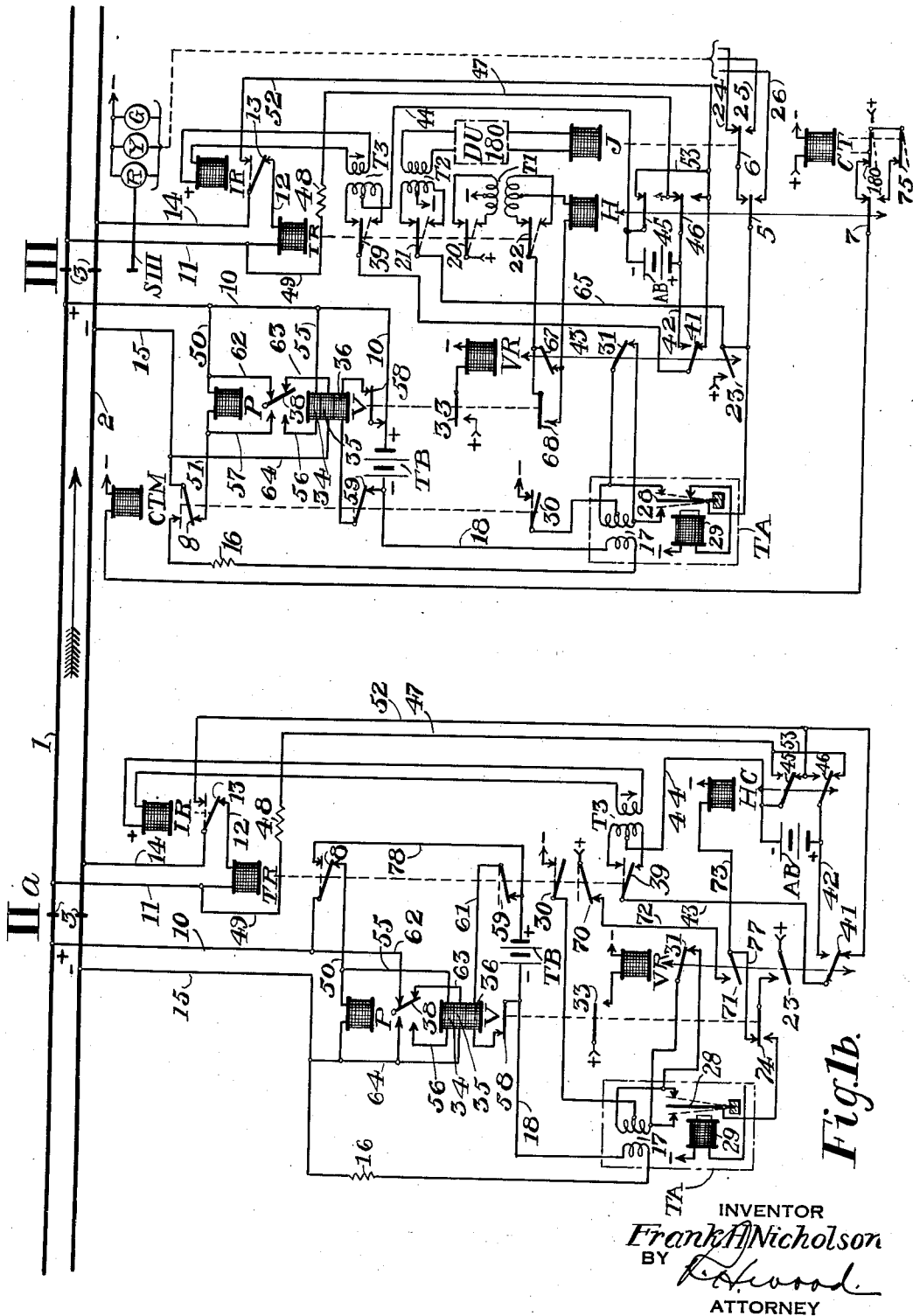
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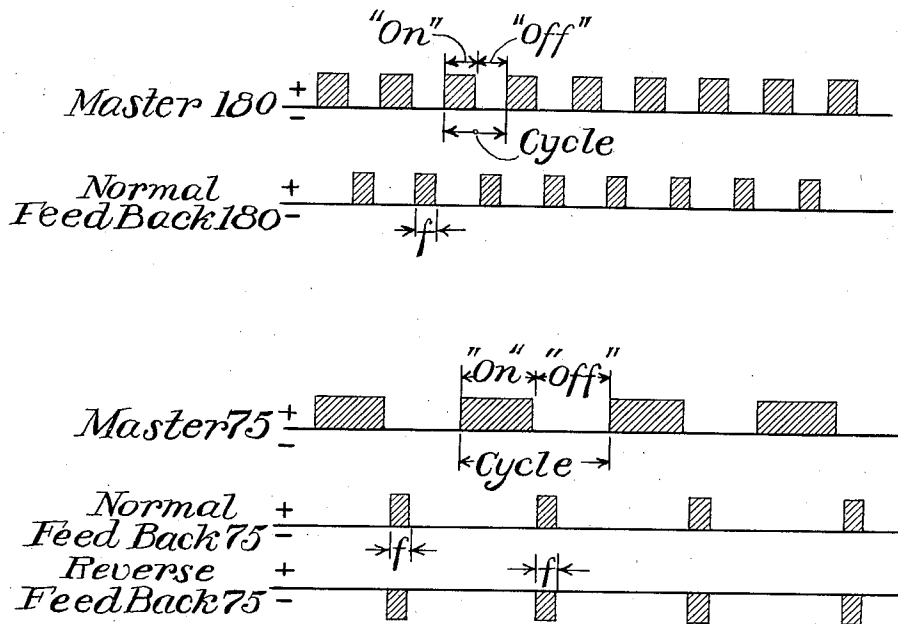


Fig. 2.

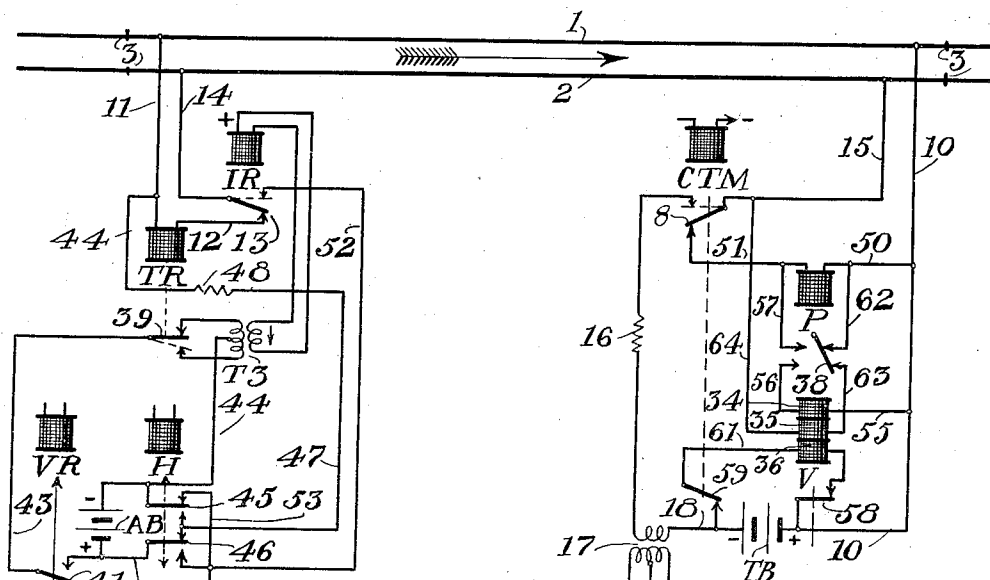


Fig. 3.

INVENTOR
 Frank H. Nicholson
 BY
 K. Wood
 ATTORNEY

July 15, 1941.

F. H. NICHOLSON

2,249,722

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I

II

III

Fig. 4a.

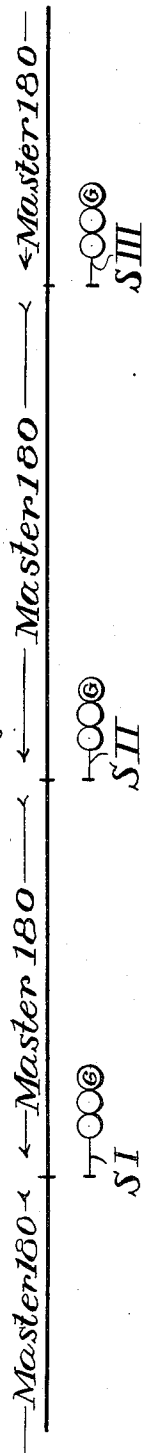


Fig. 4b.

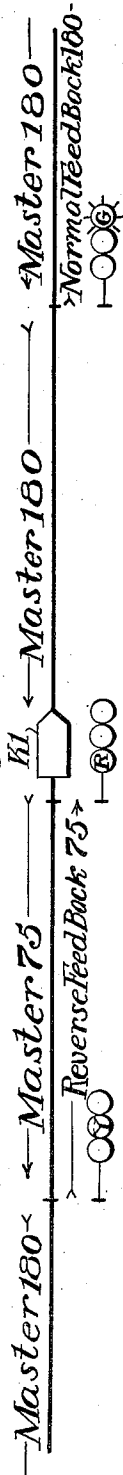
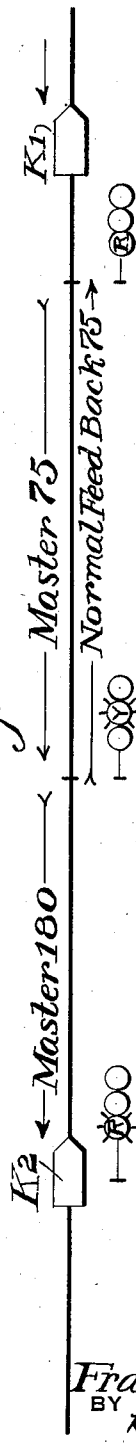


Fig. 4c.



INVENTOR
Frank H. Nicholson
BY *Edward*
ATTORNEY

UNITED STATES PATENT OFFICE

2,249,722

APPROACH CONTROL APPARATUS FOR
RAILWAY SIGNALING SYSTEMS

Frank H. Nicholson, Wilkinsburg, Pa., assignor
to the Union Switch & Signal Company, Swiss-
vale, Pa., a corporation of Pennsylvania

Application February 9, 1940, Serial No. 318,122

19 Claims. (Cl. 246—38)

My invention relates to approach control apparatus for coded track circuit systems of railway signaling and it has special reference to apparatus of this class which requires no line wires between signal locations and which operates on the "coded feed back" principle of Frank H. Nicholson Patent No. 2,021,944 (issued November 26, 1935).

Generally stated, the object of my invention is to apply the above principle in an extended way which further cuts down power consumption and which renders the signaling system more suitable for energization from primary battery sources.

A more specific object is to lower the consumption of "feed back" energy in signaling systems that are approach controlled through the medium of "coded feed back" track circuits.

Another object is to enable all of the "feed back" circuits in the system normally to remain inactive and to cause each of those circuits to come into operation only when a train approaches or leaves the section of track with which the circuit is identified.

An additional object is to lower the power consumption of various other portions of the system apparatus and in other ways to prolong the life of the primary battery sources.

In practicing my invention, I attain the above and other objects and advantages by maintaining all of the signals in the approach governed system normally deenergized; supplying the exit end of each of the track sections in the approach governed stretch with the usual continuously recurring pulses of "master" code energy and using those pulses to determine the indication of the system signals in customary automatic block manner; supplying the entrance end of each track section with "off" period pulses of normal polarity "feed back" energy only when a train approaches that entrance end; using those normal polarity pulses at the section exit to precondition energizing means for the signal which is there located; causing those thus preconditioned means to energize the associated signal when and only when a train occupies some portion of the section to the rear of that signal; supplying reverse polarity "feed back" energy to the section rails for a short time after the train clears the section exit; and using those reverse polarity pulses to return the signal energizing means to their normally inactive state.

I shall describe one form of approach control apparatus embodying my invention and shall then point out the novel features thereof in

claims. This illustrative embodiment is disclosed in the accompanying drawings in which:

Figs. 1a and 1b are diagrammatic views which when placed end to end and in the order named show a stretch of single-direction running track that is equipped with the extended non-line-wire approach control apparatus of my invention;

Fig. 2 is a representation of "master" and "feed back" codes by which the apparatus of Fig. 1 may be controlled;

Fig. 3 is a simplified showing of the "coded feed back" track circuits which are identified with each of the signal blocks of Figs. 1a-b; and

Figs. 4a to 4c are single line representations of the track stretch of Figs. 1a-b showing the trackway codes and wayside signal indications that are effective under various traffic conditions of the stretch.

In the several views of the drawings like reference characters designate corresponding parts. Referring first to the composite diagram of Figs. 1a-b the improvements of my invention are there disclosed in association with a coded track circuit system of automatic block signaling for a stretch of railway track 1-2 over which it will be assumed that traffic moves in the single direction indicated by the arrow or from left to right in the diagram. The protected stretch of this track is divided into the customary successive sections I-II, II-IIa, IIa-III, etc., by insulated rail joints 3 and the rails of each section form a part of a "coded feed back" track circuit combination presently to be described.

In this view of Fig. 1 each of the locations, I, II and III marks the entrance end of a signal block length of the track 1-2 and installed at each of these entrance ends in a wayside signal S which governs the passage of traffic into the block in the usual way. Location IIa, however, defines a cut in one of these signal blocks and for this reason it has no wayside signal associated therewith. Such a cut may, of course, be occasioned by excessive block length or for any other reason which makes it desirable to divide the block into two sections.

System of automatic block signal control

The just named wayside signals S form a part of the coded track circuit system of automatic block signaling that was previously mentioned. Further included in that system are code following track relays TR installed at the entrance ends of the several track sections and operated by energy received from the rails thereof; master track batteries TB installed at the exit ends of

the sections for the purpose of supplying the rails thereof with the relay operating energy just referred to; similarly located coding devices CTM which code this operating energy by periodically interrupting the master rail supply circuits; code transmitters CT which operate each of the exit end devices CTM at one or another of the usual plurality of distinctive code rates; and decoding relays H and J at each signal location which are controlled by the track relay TR that is there installed.

In the illustrative form represented the coded system of automatic block signaling is of the three-indication variety; it is operated by the "master 180" and the "master 75" trackway codes of Fig. 2 that selectively are supplied to the track rails at the exit end of each section; and it requires no line wires between signal locations. In it each set of decoding relays H and J performs the usual functions of: (1) governing the indication of the signal S at the relay location; and (2) selecting the coding of the master track relay operating energy that is supplied to the section to the rear. In the arrangement shown, the first of these functions is effected by means of contacts 5 and 6 while the second is effected through the medium of a contact 7.

The two "master" codes above named respectively are produced by contacts 180 and 75 of each of the transmitters CT and they respectively consist of 180 and 75 energy pulses per minute spaced in the manner represented in Fig. 2. Both result from the circuit making and breaking action of a master coding contact 8 of the repeating device CTM at the supply location; the 180 code rate prevails when contact 7 of the associated relay H is picked up to include transmitter contact 180 in the driving circuit for device CTM; and the 75 pulse per minute rate is effective when contact 7 is released to include transmitter contact 75 in the driving circuit for the code repeating device.

In each instance the master track battery TB at the section exit is recurrently connected with the section rails over the front point of contact 8 and under vacant conditions of the section it recurrently picks up the track relay TR at the section entrance. As is most clearly shown in Fig. 3, the circuit over which pick-up current is transmitted to the track relay extends from the positive terminal of battery TB through conductor 10, one of the section rails, conductor 11, the winding of relay TR, conductor 12, back contact 13 of an impulse relay IR (later to be described), conductor 14, the other section rail, conductor 15, front contact 8 of device CTM, a current limiting impedance 16, the secondary of a transformer 17 and conductor 18 back to the negative terminal of battery TB.

In following one or the other of the two "master" codes of Fig. 2, the track relay TR at each of the signal locations controls the decoding relays H and J in customary manner. These two relays respectively are "home" and "distant" devices and they receive pick-up energy from transformers T1 and T2. These two transformers, in turn, are excited from a twelve volt control battery (not shown) or other suitable local source with which the terminals "plus" and "minus" are identified. Included in the exciting circuit for transformed T1 is a pole changing contact 20 of the controlling track relay TR while the exciting circuit for transformer T2

similarly includes a corresponding pole changing contact 21.

The "home" decoding relay H is adapted to pick up when the track relay TR responds to operating energy of either the 75 or the 180 pulse per minute code rate. It is a direct current device having a substantial period of pick-up delay and receives from the secondary of transformer T1 energy that is rectified by a contact 22 of relay TR. This rectifying contact is included in the transformer output circuit in the same manner as that disclosed and claimed by Frank H. Nicholson et al. copending application Serial No. 210,744 filed May 28, 1938, on "Railway traffic controlling apparatus."

The "distant" decoding relay J receives its pick-up energy through a resonant unit DU180 interposed between the relay winding and the output circuit of the winding supply transformer T2. Under the selective action of this unit energy of pick-up intensity is transmitted to the relay only when the code following track device TR responds to operating energy of the 180 pulse per minute code.

At each of the signal locations in the system, therefore, the elements just named cooperate to cause both the "home" relay H and the "distant" relay J to pick up when the track relay TR is following the "master 180" code of Fig. 2; to allow only the "home" relay H to pick up when the track relay responds to the slower "master 75" code; and to cause both of the relays H and J to release when the track relay TR ceases to follow code.

In determining the aspect which is displayed by the controlled wayside signal S, the above described decoding relays make use of the previously named contacts 5 and 6. Further included in the lamp lighting circuits of which these contacts form a part is the previously described local source (12 volt control battery) with which the terminals "plus" and "minus" are identified and a contact 23 of an approach relay VR later to be described. For the purpose of economizing the drain of power on the local supply source, this relay VR must be picked up in order that lighting current may be transmitted to any one of the lamps G, Y and R of the controlled signal S.

When, under that condition, the track relay TR is responding to the "master 180" code and both of the decoding relays H and J are picked up, the "clear" lamp G then is lighted over a circuit which includes front contacts 23, 5 and 6 and a conductor 24; when the track relay is responding to the "master 75" code and relay H only is picked up, the "approach" lamp Y then receives lighting current over front contacts 23 and 5, back contact 6 and a conductor 25; and when the track relay TR is not following code and both of the relays H and J are released, the "stop" lamp R is lighted over a circuit which includes front contact 23, back contact 5 and a conductor 26.

For applications in which train-carried cab signals (not shown) also are to be controlled, the just described coded signaling facilities may still further comprise means at the exit end of each track section for additionally supplying the rails thereof with coded alternating current energy. In the form shown in Fig. 1 such means include a tuned alternator TA which at proper times introduces alternating current energy of 100 cycles per second or other suitable carrier wave frequency into the rail supply circuit which coding

contact 8 of device CTM completes during each "on" period of the direct current "master" code from battery TB.

Each of these tuned alternators TA may derive exciting energy from the previously described local source (twelve volt control battery) with which the terminals "plus" and "minus" are identified. As shown, each alternator includes a reed type of vibrating armature 28 which pole changes the primary energizing circuit over which the transformer 17 is supplied with exciting current and which has a natural rate of vibration corresponding to the 100 cycle per second or other desired frequency of the alternator output voltage. Driving movement is imparted thereto by an electromagnet 29 having an energizing circuit which the armature periodically completes in a manner keeping it in vibration as long as the magnet driving circuit is supplied with operating energy. In this way an electromotive force of the 100 cycle or other cab signal control frequency is generated (as a result of the pole changing action of armature 28 in the primary circuit of transformer 17) in the secondary of transformer 17 whenever the magnet driving circuit is connected with the local supply source.

Before such connection can be completed, in the arrangement of Fig. 1, the approach relay contact 23 not only must be picked up but a contact 30 of the associated coding device CTM also must be picked up. This latter requirement assures that each of the tuned alternators TA will draw energy from its local exciting source only during the "on" periods of the "master" trackway code and will be disconnected from the local source during the "off" periods of that code (when the secondary of the alternator transformer 17 is disconnected from the section rails). The action just named, quite obviously, reduces drain on the local control battery and tends to prolong its life.

For the purpose of reducing the secondary impedance of each of the tuned alternator transformers 17, the approach relay VR at the alternator location is provided with a contact 31 which short circuits the primary of the transformer at all times that the approach relay is released. Under all inactive conditions of the alternator TA, therefore, this primary short circuit (over the back point of contact 31) causes the secondary of transformer 17 to introduce into the rail supply circuit (of which track battery TB forms a part) only a minimum of series reactance and thus assures a minimum degree of contact arcing at front contact 8 of relay CTM.

The apparatus so far described (with the single exception of the approach relays VR) is that which ordinarily is included in a conventional "frequency code" system of automatic block signaling. Under vacant conditions of the protected stretch such a system sets all of the controlled wayside signals S at "clear" and supplies the rails of each section with "master" energy of the 180 pulse per minute rate. Such vacant stretch conditions are represented in Fig. 4a.

Each passage of a train through the thus conditioned stretch of Fig. 1 now is accompanied by the following actions. In entering the stretch from the left and advancing past locations I, II and III thereof, this train successively deenergizes the track relay TR at those locations and thus successively conditions: (1) each of the wayside signals SI, SII and SIII to show "stop"; and (2) each associated coding device CTM and track battery TB to supply the rails of the sec-

tion to the rear with energy of the 75 pulse per minute "master" code. Once established, each of these "stop" aspect conditionings persists until the trailing vehicle of the train clears the next location in advance. When that happens: (1) the rails of the just vacated section transmit this "master 75" code energy to the relay TR at the exit end thereof; (2) the wayside signal S at that entrance end is thereby conditioned to show "approach"; and (3) the track battery TB and coding device CTM at the same location are caused to supply the rails of the section to the rear with energy of the "master 180" code. At the entrance end of that rear section the track relay TR responds in the usual manner and: (1) conditions the wayside signal S which it controls to display "clear"; and (2) causes the track battery TB and coding device CTM to supply "master 180" code energy to the rails of the succeeding section to the rear. At the entrance end of that section (and also at the entrance end of each succeeding section of vacant track still further to the rear) these same actions are repeated.

Approach energization of traffic governing signals

The previously mentioned relays VR form a part of an approach energizing scheme which has the usual purpose of reducing the power consumption of the controlled traffic governing apparatus and of prolonging the term of service of the signal lamps which that apparatus includes. The former function is especially important in installations which depend exclusively upon primary batteries for power supply.

In the arrangement of Fig. 1 the approach energization has been applied to each and every one of the wayside signals S and also to the supply of alternating current cab signaling energy through each of the tuned alternators TA. As a consequence, each of the governed signals remains dark at all times except when the display of an indication is actually needed to advise the engineman of an approaching train of the conditions of the track ahead.

Both of the before named functions (lighting of the control wayside signal and supply of cab signal energy) are approach governed by the relay VR through the medium of the before mentioned contact 23 thereof. As long as this contact occupies the normally released position which is represented at each of the locations in Fig. 1, the lighting circuit for the wayside signal S and the exciting circuit for the alternator TA both are disconnected from the "plus" terminal of the local control source. When, however, relay VR becomes picked up (in response to the approach of a train as will be described presently) the named circuits become connected with the control source and both wayside and cab signal indications then are made available.

Each of these approach relays VR is normally deenergized and hence normally released. Each, moreover, has slow pick-up slow release characteristics and the winding thereof must receive steady or uninterrupted energization in order that the relay contacts may be picked up. At proper times this energization is supplied over the back point of a contact 33 of an associated train detector relay V.

When this contact 33 is continuously released, the controlled approach relay VR is picked up over the then established continuous connection with the local supply source (twelve volt battery) with which the terminals "plus" and "minus" are identified. However, should this contact 33 re-

currently pick up and release in response to a code following action of relay V, the resulting periodic energization of relay VR will neither pick up the contacts of that approach relay nor hold them picked up. Still further, those same contacts remain continuously released when relay V occupies the continuously picked-up position that is shown.

Each of the named train detector relays V is provided with three separate windings 34, 35 and 36 which at proper times respectively are energized recurrently by a "feed back" track battery AB at the opposite end of the section, recurrently by the master track battery TB at the same location, and steadily by the same master track battery. As reference to Fig. 3 will most clearly show, this device V at times functions as a code following track relay, at other times it is continuously picked up, and at still further times it is continuously released.

Aiding to select among these three conditions is a polarized stick relay P installed at the location of each of the detector relays V. At proper times each of these polar relays P receives operating energy from the "feed back" track battery AB at the opposite end of the track section and depending whether the polarity of that feed back energy is "normal" or "reverse" it moves a single contact 38 to the left or to the right.

This contact 38 continuously remains in the position of its last operation until "feed back" energy of the opposing polarity is received by the relay winding. When in the left position, this contact 38 conditions the winding 34 of the associated detector relay V also to receive "feed back" energy from the track battery AB at the opposite end of the section; when in the represented right position the same contact conditions the winding 35 of relay V to receive energy from the master track battery TB at the relay location.

At proper times the just mentioned "feed back" energy is transmitted from the track battery AB at the entrance end of each section to the relays P and V at the section exit over a "feed back" track circuit which will now be described. Like the already described "master" track circuit for the same section, each of these "feed back" track circuits includes the section rails 1 and 2. In addition (as is most clearly shown in Fig. 3), it further includes the beforementioned track battery AB and impulse relay IR at the section entrance and the already described devices CTM, P and V at the section exit.

During the "off" periods of whichever one of the two "master" codes (of Fig. 2) it is producing, contact 8 of device CTM connects the "feed back" track circuit relays P and V (winding 34) in energy receiving relation with the section rails and thus conditions them for reception of energy from the "feed back" track battery AB at the section entrance. At proper times the there located impulse relay IR shifts the track rail connection from the master track relay TR to the feed back battery AB during each master code "off" period and at those times this action causes the rails further to receive momentary pulses of "feed back" energy such as are represented at f in Fig. 2.

When so operating simultaneously, the herein disclosed "master" and "feed back" track circuits interact in the same basic manner as is disclosed and claimed in the before referred to Nicholson Patent No. 2,021,944. That is, each

master circuit transmits recurring pulses of "master" code energy over the rails of the identified section in the direction of from the exit to the entrance end while each associated feed back circuit transmits "off" period pulses of "feed back" energy over the section rails in the opposite direction. To designate both of these track circuits under the simultaneously operating condition just stated use will be made of the expression "coded feed back" track circuit combination.

As utilized by the apparatus of my invention, these "coded feed back" track circuits are further similar to those disclosed and claimed in Herman G. Blosser Patent No. 2,174,255 (issued September 26, 1939), and in the case of the impulse relays IR the named similarly is particularly close.

Each of these relays IR is of the polar type and contact 13 thereof occupies the released position as long as the relay remains deenergized or receives current of "reverse" polarity. In that position the contact connects the operating winding of the master track relay TR directly across the section rails 1 and 2. When, however, relay IR receives a pulse of "normal" polarity energy, it picks up contact 13 and thereby disconnects the relay TR from the track rails and connects the feed back battery AB in energy supplying relation therewith.

Pick-up energy for each relay IR is at proper times supplied from the secondary of a transformer T3. Each of these transformers is provided with a direct current exciting circuit which is pole changed by a contact 39 of the master track relay TR at the same location. Each time that the track relay releases the pole changing action of this contact 39 causes to be induced in the transformer secondary a pulse of voltage having the polarity designated by the small arrow and which for convenient will be referred to as "normal"; each time that the track relay picks up, the reverse action of the named contact causes to be induced in the transformer secondary a pulse of voltage having the opposite or "reverse" polarity. Each of these "normal" polarity pulses picks up the impulse relay IR; each "reverse" polarity pulse continues it in the released position represented.

In this manner each release of the track relay TR generates in transformer T3 a pulse of relay pick-up voltage which at proper times causes the impulse relay IR momentarily to transfer the track rail connection from the winding of the track relay to the output circuit of battery AB. As already stated, each of these 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; each feed back pulse constitutes an "on" period in one or another of the "feed back" codes of Fig. 2; and each of those feed back "on" periods has a fixed length designated by "f" and coincides with an "off" period of the "master" code which is represented immediately thereabove.

In the arrangement of each of the before referred to Nicholson and Blosser Patents 2,021,944 and 2,174,255, the polarity of the feed back pulses is always the same and under vacant track conditions those pulses are continuously received at the exit end of each section where they cause the there located traffic governing apparatus to be maintained continuously deenergized. While this earlier form of arrangement is very satis-

factory from the standpoint of lowering the power drain on the sources of energization for the approach controlled signals yet it has the disadvantage of requiring a continuous consumption of "feed back" energy. When the sources AB of this feed back energy are of the primary battery type, such a continuous consumption requires their replacement at more frequent intervals than is economically desirable.

Approach energization of "feed back" track circuits

In order to lower the consumption of "feed back" energy and thereby render the signaling system more suitable for energization from primary battery sources, I have provided an extended approach control arrangement which enables all of the "feed back" circuits in the system normally to remain inactive and which causes each of those circuits to come into operation only when a train approaches or leaves the section of track with which the circuit is identified.

To this end the approach relay VR at each location is provided with a contact 41 which when released at a time that the associated decoding relay H is picked up disconnects the primary energizing circuit for the impulse relay transformer T3 from the transformer exciting source (here shown as feed back battery AB) and thereby causes the associated impulse relay to remain continuously released even though the controlling track relay TR may be following code. Under that condition the "feed back" battery AB at the same location is kept continuously disconnected from the rails of the associated section and the "feed back" track circuit for that section is thereby maintained inactive.

When, however, contact 41 of relay VR is (1) picked up or (2) released at a time that the associated relay H is released it connects the primary energizing circuit for transformer T3 across the terminals of the exciting source AB and allows the associated impulse relay IR then to respond to code following operation of track relay TR. Under either of the two just stated conditions of such response the impulse relay IR picks up during each "off" period of the master code which relay TR follows and thereby causes the "coded feed back" track circuit combination for the associated section to operate in conventional manner.

Under the impulse relay responding condition first stated above the exciting current for transformer T3 flows over a circuit extending from the positive terminal of battery AB through conductor 42, front contact 41 of device VR, conductor 43, pole changing contact 39 of relay TR, the primary of transformer T3 and conductor 44 back to the negative terminal of source AB; under the relay responding condition last stated the transformer exciting circuit extends from the positive terminal of battery AB through back contact 46 of decoding relay H, back contact 41 of device VR, conductor 43, pole changing contact 39 of device TR, the primary of transformer T3 and conductor 44 back to the negative terminal of source AB.

During the operating conditions of each impulse relay IR that have just been described, the "feed back" pulses which are supplied from the associated battery AB are of "normal" polarity at times while at other times they are of "reverse" polarity. Selection between these two polarities is controlled by the decoding relay H

at the feed back battery location. When contacts 45 and 46 of this relay are picked up, there is set up the "normal" polarity connection wherein rail 1 (see Fig. 3) of the supplied track section is rendered positive with respect to rail 2; however, when contacts 45 and 46 are released, there is similarly set up the "reverse" polarity connection wherein each supplied pulse of feed back energy makes rail 2 positive with respect to rail 1.

At the exit end of the track section the received pulses of feed back energy which have the "normal" polarity are circulated through the winding of the polar relay P by way of a circuit which extends from the positive terminal of the entrance end battery AB through front contact 46 of device H, conductor 47, current limiting resistance 48, conductors 49 and 11, one of the section rails, conductors 10 and 50, winding of relay P, conductor 51, back contact 8 of device CTM, conductor 15, the other section rail, conductor 14, front contact 13 of device IR, conductors 52 and 53, front contact 45 of device H and conductor 44 back to the negative terminal of entrance end battery AB.

These "normal" polarity pulses cause the feed back energized relay P to move its contact 38 to the left position and there continuously hold it until such time as the relay receives "reverse" polarity pulses of feed back energy. When in this left position the contact connects the winding 34 of the associated detector relay V in parallel circuit relation with the winding of relay P. In consequence that winding 34 now also receives the "normal" polarity feed back pulses over a circuit which in part includes conductors 10 and 55, the winding 34, conductor 56, left biased contact 38, conductors 57 and 51 and the back point of coding contact 8.

Each of these normal polarity feed back pulses received by winding 34 operates the detector relay V to its picked-up position. That relay, being a code following device, releases between feed back pulses in the usual code following manner. Accordingly, relay V follows code whenever "normal" polarity pulses of feed back energy are received from the track rails.

For the purpose of equalizing the periods of relay pick-up and release which are effective during this operation, the "stick" winding 36 of the relay V is energized from the instant of each pick-up of the relay until the end of the master code "off" period during which that pick-up occurs. This energization is over a circuit which includes front and back contacts 58 and 59 of devices V and CTM and an energizing source shown in the form of the master track battery TB at the relay location.

During the operation now under consideration this "stick" circuit functions in a manner comparable to that disclosed and claimed in Edward U. Thomas Patent No. 1,172,893 (issued September 12, 1939). Prior to the reception of each "normal" polarity feed back pulse the coding device CTM releases both of its contacts 8 and 59 so that when the detector relay V responds, contact 58 thereof completes for the stick winding 36 an energizing circuit that extends from the positive terminal of battery TB through front contact 58, relay winding 36, conductor 61 and back contact 59 of device CTM back to the negative terminal of battery TB.

Once completed this "stick" circuit holds the relay V picked up until the end of the master code "off" period. At that time contact 59 of

device CTM picks up and breaks the circuit. That break, in turn, allows relay V to release in customary manner.

The operating results of "normal" feed back energy now having been examined attention will next be directed to the effects produced when "reverse" polarity pulses of feed back energy are supplied to the section rails from the entrance end battery AB. Such "reverse" polarity pulses are, as has been seen, supplied when decoding relay H at the feed back battery location is released.

Under this condition each "off" period release of the master track relay TR causes the polar relay P at the section exit to receive a pulse of "reverse" polarity feed back energy over a circuit which extends from the positive terminal of the entrance end battery AB through back contact 46 of device H, conductor 52, front contact 13 of device IR, conductor 14, one of the section rails, conductor 15, back contact 8 of device CTM, conductor 51, the winding of relay P, conductors 50 and 10, the other section rail, conductors 11 and 49, resistance 48, conductor 47, back contact 45 of device H and conductor 44 back to the negative terminal of battery AB.

Under the influence of this reverse polarity energization, relay P moves its contact 38 to the illustrated right position and there continuously holds it until the relay receives "normal" polarity pulses of feed back energy. In that right position contact 38 sets up a circuit over which winding 35 of the associated detector relay V receives from battery TB at the same location energizing current during each "on" period of the there supplied "master" code.

This energizing circuit for winding 35 extends from the positive terminal of battery TB through conductors 10, 50 and 62, right biased contact 38, conductor 63, the winding 35, conductor 64, front contact 8 of device CTM, resistance 16, transformer 17 and conductor 18 back to the negative terminal of battery TB. Each of these energizations of winding 35 picks up the contacts of relay V and thus sets up (at contact 58) the previously traced energizing circuit for stick winding 36.

While relay V is a code following device yet it is designed to have a slight period of release delay that is sufficient to hold contact 58 picked up during the time required for device CTM to move its contacts 8 and 59 from the uppermost to the lowermost position. Such a delay may, quite obviously, be produced by employing means (not shown) of any one of a number of well-known types. At the end of each master code "on" period, accordingly, the detector relay V does not release but instead stays picked up until contact 59 completes the supply circuit for stick winding 35. Once energized this winding holds relay V picked up for the full duration of the master code "off" period.

At the end of that period, likewise, relay V still stays picked up while device CTM moves its contacts from the lowermost to the uppermost position and once more restores the energizing circuit for winding 35. Under the operating conditions now being considered, therefore, relay V continuously holds its contacts in the picked-up position where they remain until such time as the section either becomes occupied or "normal" polarity pulses of feed back energy are again transmitted over the rails thereof.

With the section vacant, the just described response by relay V is still effective even after

the transmission of "reverse" polarity feed back pulses has been discontinued. This is for the reason that the polar relay P holds contact 38 in the illustrated right position until "normal" polarity pulses of feed back energy are again received from the track rails. Until such a reception, therefore, the detector relay V is kept continuously picked up unless the section rails in the meantime become shunted by a train.

The continuously picked-up condition of each relay V which has just been described persists only as long as the section of track to the immediate rear thereof remains vacant. With contact 38 of relay P in the illustrated right position, it will be seen that winding 35 of relay V is bridged directly across the section rails 1 and 2 and hence is energized only by the portion of potential from track battery TB that appears between those rails. Under vacant section conditions this potential is sufficient to hold the relay picked up as just described.

When, however, a train comes into the section and by-passes the rails thereof, a large portion of the master track battery potential is absorbed in resistance 16 and the comparatively small portion impressed upon the rails and winding 35 during the master code "on" periods is insufficient to maintain relay V picked up. Accordingly, each entry of a train into the associated track section releases that relay in spite of the "off" period hold-up action of the stick winding 36, because "stick" contact 58 is open when contact 18 on device CTM is closed.

From the foregoing, therefore, it will be seen that each of the train detector relays V: (1) follows code when its winding 34 receives "given" polarity feed back pulses over left biased contact 38 of relay P; (2) is held continuously picked up when contact 38 of relay P is in its right position and the associated track section is vacant; and (3) becomes continuously released upon each entry of a train into the associated track section.

From the earlier description of each controlled approach relay VR it will be seen that during each of the two forms of response first named in the preceding paragraph relay VR is continuously released and that only during the last named response of relay V is the controlled approach relay VR caused to pick up its contacts.

At each of the signal locations I, II and III such a pick-up of the approach relay VR: (1) connects (at contact 23) the wayside signal S with its source of lamp lighting current; (2) connects (also over contact 23) the tuned alternator TA with its source of exciting current; (3) connects (over contact 41) the impulse relay transformer TE with its source of exciting current; and (4) performs certain further functions which will now be described.

These further functions involve the two decoding relays H and J. Relay J normally is de-energized by virtue of contact 23 of the approach relay VR introducing a break in the connection of the primary of transformer T2 with its exciting source. When, however, contact 23 is picked up, there is then completed for transformer T2 the usual exciting circuit which may be traced from the positive terminal of the local supply source through front contact 23, conductor 65, pole changing contact 21 of device TR and the primary of transformer T2 back to the negative terminal of the exciting source. Under this condition the decoding relay J responds to code following operation of relay TR in the usual manner.

Regarding the companion decoding relay H, the energization of this device also is specially controlled by the approach relay VR through a contact 67 thereof which acts in conjunction with a companion contact 68 of the associated train detector relay V. As long as either of these two contacts is released, decoding relay H is connected in energy receiving relation with its supply transformer T1 in the usual manner which enables the coding relay to respond to code following operation on the part of the master track relay TR. During those times, however, that both of the contacts 67 and 68 may be picked up, then the just named connection is interrupted and relay H is allowed to release even though the controlling relay TR may be following code.

Under the conditions stated, this release takes place fairly quickly. It is produced each time that relay V picks up following a period of continuous release thereof, such as results when the associated track section becomes occupied. Following such a pick-up of contact 68, contact 67 of relay VR also stays picked up until the end of the release delay period of that relay. It is during this period that relay H becomes released as a result of its disconnection from transformer T1. That release, in turn, occurs before contact 41 of device VR disconnects transformer T3 from its exciting source and thereby discontinues operation on the part of the "feed back" track circuit for the section immediately in advance.

When released as a result of the master track relay TR ceasing to follow code, the decoding relay H has a much slower action and due to the snubbing effect of the portion of the secondary winding of transformer T1 which contact 22 of device TR bridges across its winding. Moreover, in picking up after a release produced by either of the two causes just described the decoding relay H is comparably slow and requires at least two cycles of code following operation on the part of the controlling track relay TR.

A later portion of the specification will make clear the respective utilities of the several special characteristics which have just been described. For the present it will suffice to say that the reason for arranging that each decoding relay J be normally deenergized is to conserve the drain on supply sources such as the primary battery type; and the reason for keeping each relay IR normally deenergized is to maintain the "feed back" track circuit which it controls normally inactive.

Operation of complete system of Figs. 1a-1b

The apparatus and circuits which are comprised by the extended non-line-wire scheme of approach control of my invention now having been described, attention will next be directed to the manner in which this system operates to provide all of the usual functions of approach control while at the same time enabling all of the "feed back" track circuits in the system normally to remain inactive. As an aid to this explanation further reference will be had to the simplified track circuit diagram of Fig. 3 and to the code and signal indication diagrams of Figs. 4a-c.

Moreover, to simplify the original analysis of the system operation it will be assumed that the signal block II-III does not include the cut represented at IIA, Fig. 1b but that instead each of the section rails 1 and 2 is electrically continuous from location II to location III and that the "coded feed back" track circuit combination for this block thus is the same as that shown in Fig. 3. As will become evident from a later por-

tion of the specification, the cut section apparatus that actually is installed at location IIA operates in a manner which is in full line with the assumption just expressed and for this reason a temporary disregard of the details is justified in the interest of description simplicity.

Under the vacant track stretch condition which Figs. 1a-b and Fig. 4a represent, "master 180" code is supplied to the exit end of each of the sections in the stretch and transmitted over the rails thereof to the track relay TR at the section entrance; all of the "feed back" track circuits in the stretch are inactive as a result of the impulse relays IR being kept deenergized; all of the exit end polar relays P hold their contacts 38 to the right; all of the detector relays V are kept picked up under the joint action of windings 35 and 36; all of the approach relays VR are released; all of the decoding relays H are picked up; all of the decoding relays J are deenergized; all of the wayside signals S are disconnected from their lighting sources; and all of the tuned alternators TA are disconnected from their exciting sources.

Starting with the signaling and approach control apparatus conditioned as just described (and shown in Fig. 4a), a representative train move will now be traced through the approach governed stretch of Figs. 1a-b.

As the train enters the section to the immediate rear of location I, the shunting action of its wheels and axles releases the detector relay V at that location and thereby picks up the associated approach relay VR. That action: (1) connects (at contact 23) the tuned alternator TA with its exciting source and thus supplies energy for the control of cab signals which may be carried by the approaching train; (2) connects (also at contact 23) transformer T2 with its exciting source and thus causes decoding relay J to respond to the code following action of the master track relay TR; and (3) connects (likewise at contact 23) the lighting circuits of wayside signal SI with their lighting source and thereby causes that signal to display the "clear" indication (which results from both of the decoding relays H and J being picked up).

At the same time the above-named pick-up of relay VR connects (at contact 41) transformer T3 at location I with its exciting source and thereby conditions the associated impulse relay IR for the customary response to the code following action of contact 39 of the master track relay TR. This brings into action the "feed back" track circuit for section I-II and causes battery AB at location I to supply the polar relay P at location II with pulses of "normal" polarity feed back energy that have the character represented at "normal feed back 180" in Fig. 2.

At location II relay P now shifts contact 33 to the left position and thereby causes winding 34 of the associated detector relay V also to receive the normal polarity feed back pulses. In response thereto relay V follows code but does not pick up the approach relay VR at location II.

As the leading vehicle of the train passes location I and shunts the rails of section I-II the following actions at location I take place. Relay TR releases and thereby causes all three of the associated relays H, J and IR also to drop out. This puts (at contact 5) the wayside signal SI at "stop" and discontinues the application of feed back energy to the rails of section I-II. In addition, it shifts (at contact 7) the control of coding device CTM to contact 15 of transmitter

CT and thereby causes the rails to the rear of location I to be supplied with the slower "master 75" code. Still further, it sets up at back contact 46 an exciting circuit (which includes back contact 41 of device VR) for the impulse relay transformer T3 and thereby conditions relay IR for the customary response to the code following action of relay TR.

At location II the same shunting of section I—II causes the following actions to take place. All reception of feed back energy from location I is discontinued and contact 38 of relay P remains to the left. No energy now is supplied to either of windings 34 and 35 of detector relay V and in consequence this relay V releases and picks up approach relay VR over back contact 33.

That pick-up of relay VR at location II: (1) connects transformer T2 with its exciting source and thereby allows code following relay TR to pick up decoding relay J; (2) connects wayside signal SII with its lighting source and thereby causes the signal to show "clear"; (3) connects alternator TA with its exciting source and thereby starts the supply of cab signal control energy to section I—II; and (4) connects transformer T3 with its exciting source—all in the same way as was explained in connection with location I.

The last named action causes impulse relay IR at location II to respond to the code following operation of the master track relay TR and thereby brings into action the "feed back" track circuit for signal block II—III. For the moment, it will be assumed that the cut IIa is not present and that the rails of the named block are continuous from location II to location III.

Under that condition feed back energy of "normal" polarity is transmitted from battery AB (and by way of front contacts 45 and 46) at location II over the rails to location III. In being received at location II by polar relay P this feed back energy shifts contact 38 to the left and causes winding 34 of detector relay V also to receive the same feed back pulses. While relay V now follows code it still does not pick up approach relay VR.

As the trailing vehicle of the train clears location I, the there supplied "master 75" code energy is now transmitted rearwardly to the next signal location therebehind. There relay TR (not shown) follows this 75 pulse per minute code and through the medium of decoding relays H and J sets up the wayside signal S for a display of its "approach" indication. At location I the approach relay VR is now released (in the manner more completely to be explained in connection with location II after the train has passed that point) and it deenergizes signal SI, alternator TA, decoding relay J and impulse relay IR.

As the leading vehicle of the train passes location II and shunts the rails of block II—III the following actions take place at location II. Master track relay TR stops following code and releases all three of the associated relays H, J and IR. These releases: (1) cause signal SII to show "stop"; (2) transfer the control of code repeating device CTM from contact 180 to contact 75 of transmitter CT; (3) discontinue the supply of feed back pulses to the rails of block II—III; and (4) set up at back contact 46 an exciting circuit (which includes back contact 41 of device VR) for the impulse relay transformer T3.

At location III the same shunting of block II—III introduces the following actions. Polar relay P becomes de-energized but holds contact 38 to the left. Detector relay V also no longer

receives feed back energy and allows its contacts to occupy the released position continuously. This action picks up (at contact 33) the approach relay VR and that pick-up: (1) connects transformer T2 with its exciting source and causes decoding relay J to respond to the code following action of master track relay TR; (2) connects wayside signal SIII with its lighting source and causes a display of the "clear" indication; (3) connects alternator TA with its exciting source; and (4) connects transformer T3 with its exciting source.

The action last named brings the impulse relay IR into action and starts the supply of "feed back" energy to the section in advance of location III. At the succeeding signal location in advance this feed back energy acts upon relays P and V in the same manner as already explained in connection with each of locations II and III.

As the trailing vehicle of the train clears location II the conditions become as shown in Fig. 4b wherein the train is designated as K1. The following actions now take place at location I. Relay TR follows the "master 75" code now received from location II. After a period of two or more cycles decoding relay H picks up. During this period, however, contact 46 of relay H and back contact 41 of relay VR keep transformer T3 connected with its exciting source (battery AB). With the first release of relay TR, the impulse relay IR accordingly picks up and supplies the rails of section I—II with "reverse" feed back energy from battery AB. The same action is repeated during each succeeding master "off" period which precedes the pick-up of relay H so that in character this feed back energy is as represented at "reverse feed back 75" in Fig. 2. It persists for two or more cycles of the "master 75" code (that originates at location II).

When relay H at location I does pick up, contact 5 conditions the wayside signal SI to show "approach"; contact 7 returns the control of code repeating device CTM to contact 180 of transmitter CT; and contact 46 disconnects transformer T3 from its exciting source and thereby stops all responses on the part of impulse relay IR. This action, in turn, restores the "feed back" track circuit for section I—II to its normally inactive state.

Preceding the last named action at location I the following effects are produced at location II. The there received "reverse feed back 75" energy is impressed upon relay P and the first pulse thereof shifts contact 38 from the left into the right. Here the contact stays continuously and connects winding 35 of detector relay V in energy receiving relation with the track battery TB. Under the joint action of windings 35 and 36 relay V now is held continuously picked up as long as section I—II remains vacant.

This pick-up of relay V deenergizes the approach relay VR and releases the contacts of the latter. That release, in turn: (1) disconnects wayside signal SII from its lighting source; (2) disconnects alternator TA from its exciting source; (3) deenergizes transformer T2 which supplies decoding relay J; and (4) deenergizes transformer T3 which supplies impulse relay IR. The latter action discontinues the supply of "feed back" energy to the rails of block II—III.

As the leading vehicle of the train passes location III the following actions there take place. Relay TR ceases to follow code and releases all three of the associated relays H, J and IR. Those

releases, in turn: (1) cause the wayside signal SIII to show "stop"; (2) transfer the control of coding device CTM from contact 180 to contact 75 of transmitter CT; and (3) set up at back contact 46 an exciting circuit (which includes back contact 41 of device VR) for the impulse relay transformer T3.

As the trailing vehicle of the train clears location III the following actions take place at location II. The master track relay TR now responds to the "master 75" code energy that now is received from location III. During the period of pick-up delay for relay H, the impulse relay IR responds to the code following action of relay TR as a result of transformer T3 receiving exciting current over back contact 46 of device H and back contact 41 of device VR. This causes the rails of block II—III to be supplied with "reverse feed back 75" energy. This feed back energy supply continues for the two or three code cycles which precede the pick-up of relay H.

At the expiration of that time relay H at location II: (1) conditions signal SII for the display of the "approach" indication; (2) restores the control of repeating device CTM to contact 180 of transmitter CT; and (3) disconnects (at contact 46) transformer T3 from its exciting source and thereby causes relay IR to remain continuously released. Under this condition the "feed back" track circuit for block II—III is restored to its normally inactive state.

Meanwhile, at location III several recurring pulses of "reverse feed back 75" energy are received from location II and impressed upon polar relay P. That relay responds by shifting contact 38 from the left to the right position. As a result of that shift the detector relay V now is kept continuously picked up due to the joint action of windings 35 and 36. That continuous pick-up, in turn, deenergizes and releases approach relay VR and thereby: (1) disconnects signal SIII from its lighting source; (2) disconnects alternator TA from its exciting source; (3) deenergizes decoding relay J by disconnecting transformer T2 from its exciting source; and (4) sets up for transformer T3 an exciting circuit which includes back contacts 41 and 46.

With the original train K1 still in the section just ahead of location III as shown in Fig. 4c, it will be seen that upon the entry of a following train K2 into section I—II there is instituted a series of operations which cause the rails of block II—III to receive feed back energy having the character designated as "normal feed back 75" in Fig. 2. The steps in this series by which relay VR at location II is picked up and relay IR thereby is caused to respond to the code following operation of track relay TR are the same as previously described. Hence the feed back pulses that now are supplied to the rails ahead of location II again are of "normal" polarity.

Since, however, the location II track relay TR is now responding to "master 75" code (received from location III), the above named feed back pulses recur at the rate of 75 times per minute instead of at the higher 180 code rate. Consequently they now are of the "normal feed back 75" instead of the "normal feed back 180" character. Notwithstanding, however, their slower rate of recurrence they perform at location III the same function as did the "normal feed back 180" pulses that were there received in the manner previously described.

From the foregoing it will be seen that in the complete system of Figs. 1a-b all of the "feed

back" track circuits normally remain inactive and each comes into operation only when a train approaches the section of track with which that circuit is identified. Moreover, upon the departure of the train from that section the "feed back" track circuit therefor is restored to its normally inactive state. In other words, the approach control feature is in itself approach controlled thereby achieving considerable economy in power and rendering the system as a whole more suitable for energization from primary battery sources.

Cut section facilities

All of the description so far given has assumed that the rails of each of the main signal blocks (I—II, II—III, etc.) of track in the system are electrically continuous and thus constitute the conductors of but a single track section. In the composite diagram of Figs. 1a-b such a condition is, in fact, shown for section I—II.

My extended scheme of non-line-wire approach control is, however, not restricted to applications of this type alone but may also be applied to stretches of track wherein one or more of the main signal blocks is, because of excessive length or other reasons, divided into two or more track circuit sections. In such situations I propose to equip each one of the signal block subdivisions with cut section facilities of the character shown at location IIa in Fig. 1b.

The subdividing location which is there represented is shown as being produced by interposing insulated rail joints 3 between the entrance and the exit ends of the signal block II—III. Obviously, of course, the same facilities may be used in a comparable manner in any of the remaining signal blocks in the system. When installed as at location IIa, the cut section facilities perform functions which are comparable to those performed by the equipment at each of the signal locations I, II and III. At the cut location IIa, however, these functions differ in that no wayside signal is there controlled and also in that no codes are there independently generated.

Looking at location IIa it will be seen that the equipment there utilized includes track circuit apparatus comprising elements TR, IR, T3 and AB arranged as at the main signal locations; other track circuit apparatus comprising elements TB, TA, P, V and VR which also correspond to similarly identified devices at the main signal locations; and a relay HC which selects the polarity of the there supplied feed back energy in a manner similar to that performed by relay H at each signal location.

Instead, however, of forming a part of the coding relay CTM the contact 8 by which the track battery TB and tuned alternator TA at the cut section are periodically connected with the rearwardly extending rails is carried by the forward section track relay TR. This same relay also operates contact 30 which breaks the exciting circuit of the alternator TA during the "off" periods of the master code and it further carries contact 59 over which the "stick" winding 36 of the detector relay V at proper times is connected with battery TB.

The effect of cut section apparatus such as I have shown at location IIa is to divide the main signal block into two "coded feed back" track circuit combinations. The exit end portion of the rear combination includes elements TB, TA, P and V while the entrance end portion of the forward combination includes elements VR, IR,

AB and the selector relay HC. Despite the certain minor differences in circuit arrangement which the transfer of contacts 8, 59 and 30 from the signal location device CTM to the cut location track relay TR occasions, the response characteristics of the named cut location devices remain the same as the corresponding signal location elements.

This similarity extends even to the approach relay VR which at the cut location is controlled over contact 33 of the detector relay V in the same manner as at the signal locations. This cut location device VR is normally released and picks up only when contact 33 releases and there stays continuously.

Controlled jointly by this relay VR and by the cut location track relay TR (over contacts 71 and 70 thereof) is the previously mentioned polarity selector relay HC. This selector relay HC is normally deenergized and released and it is similar to relay VR in that it requires steady energization in order to pick up or hold up its contacts. When relay TR is continuously released at a time that relay VR is picked up such steady energization is supplied to relay HC over a circuit that extends from the positive terminal of the local control source through back contact 70 of relay TR, conductor 72, front contact 71 of relay VR, conductor 73 and the winding of relay HC back to the negative terminal of the local supply source.

Under that condition only relay HC picks up. At all other times it is released, as represented. For a purpose later to be made evident, moreover, it has slow releasing characteristics. Still further, it connects the associated "feed back" battery AB in "normal" polarity relation with the forward section rails when contacts 45 and 46 thereof are released and in "reverse" polarity relation with those rails when the same contacts are picked up.

The operation of the cut section facilities for location IIa will now be described. Under the vacant track conditions which are represented in Fig. 1, the apparatus at this cut location IIa repeats into the rails of the rear section II—IIa each pulse of "master" code energy which is received from the rails of the forward section IIa—III. This repeating is performed by contact 8 of relay TR which connects the track battery TB in energy supplying relation with the rear section rails when picked up and which when released interrupts this connection and connects the same rails in energy supplying relation with the feed back responsive relays P and V.

Incident to the just named repeating action relay TR picks up during each "on" period of the forward section master code which is received and releases during each "off" period of that code. The rear section supply circuit then thus periodically established extends from the positive terminal of track battery TB through conductor 78, front contact 8 of relay TR, conductor 10, track rails 1 and 2, conductor 15, resistance 16, the secondary of transformer 17 and conductor 18 back to the negative terminal of battery TB.

In the event that a train enters the signal block I—I and releases approach relay VR at location II, the "feed back" track circuit for the rear section II—IIa then is brought into action and relay P at location IIa now receives "off" period pulses of "normal" polarity feed back

energy. These shift the contact 38 from its right to its left position and connect winding 34 of relay V in parallel with the winding of relay P. Relay V now follows code but does not pick up relay VR so that the "feed back" track circuit for the forward section IIa—III continues inactive.

As the forward vehicle of the train passes location II and shunts the rails of section II—IIa the detector relay V at location IIa continuously releases and picks up approach relay VR. That pick-up brings the cut section alternator TA into action and causes the rear section pulses of "master" code energy to have superimposed thereon waves of alternating current which are suitable for the control of cab signals.

As soon as relay VR picks up, contact 41 thereof connects the impulse relay transformer T3 with its exciting source and thereby conditions the impulse relay IR for response to the code following action of forward section track relay TR. In consequence, the rails of section IIa—III now are supplied with "off" period pulses of feed back energy which have "normal" polarity by virtue of contacts 45 and 46 of relay HC remaining released. As already stated, the periodic energization of relay HC over the back point of contact 70 of relay TR is ineffective either for picking up or for holding up those contacts.

As the leading vehicle of the train passes the cut location IIa and shunts the rails of the forward section IIa—III the cut section relay TR ceases to follow code and causes the associated impulse relay IR also to become inactive. Relay HC now is picked up over back contact 70 of relay TR and front contact 71 of device VR. At location III detector relay V now becomes continuously released and picks up approach relay VR thereby producing at that location the several approach governing actions which already have been explained.

As the trailing vehicle of the train clears cut location IIa the rails of the rear section II—IIa still fail to receive "master" code energy because of the fact that contact 8 of the cut location relay TR continues to stay released. At location IIa, consequently, relay V remains deenergized and released and holds relay VR picked up. That action, in turn, maintains (at contact 71) intact the hold-up circuit for relay HC.

As the trailing vehicle of the train clears the exit end of the forward section IIa—III, recurring pulses of "master 75" code energy now are transmitted from location III to location IIa where they operate track relay TR and, by contact 8 of it, are repeated into the rails of rear section II—IIa. At the entrance end II of that rear section relay TR responds and causes impulse relay IR to supply the same rails with several recurring pulses of "reverse" polarity feed back energy. This happens before decoding relay H is picked up. When that action takes place, relay IR becomes continuously deenergized and the "feed back" track circuit for the rear section is restored to its normally inactive state.

At the cut location IIa, the just mentioned pulses of reverse polarity feed back energy cause relay P to shift its contact 38 from the left to the right position where winding 35 of the detector relay V is conditioned for energization from the track battery TB. Under the joint action of windings 35 and 36 relay V is restored to its normally picked-up condition. This restoration deenergizes and releases the approach

relay VR and thereby also effects the release of relay HC. In consequence, tuned alternator TA is now deenergized and the impulse relay transformer T3 is disconnected from its exciting source.

Prior to the actions just stated, however, and during the initial responses of the cut section track relay TR, the cut section relay IR also responded to the master code energy received from the forward section rails and caused those rails further to be supplied with "off" period pulses of feed back energy. Relay HC being slow releasing stays picked up for the first two or three cycles of track relay response and thus causes the just mentioned pulses of "feed back" energy to be transmitted over front contacts 45 and 46 and hence to have the "reverse" polarity. In a manner previously explained these reverse pulses energize relay P at location III and shift contact 38 thereof from the left to the right position.

Meanwhile, at the cut location IIa the before stated release of approach relay VR: (1) breaks (at contact 71) the energizing circuit of relay HC and thus causes that relay to release its contacts 45 and 46; and (2) disconnects (at contact 41) the impulse relay transformer T3 from its source of exciting current. The latter action restores the "feed back" track circuit for the forward section IIa—III to its normally inactive state.

It will therefore be seen that the facilities at the cut section IIa of Fig. 1b: (1) repeat around the insulated joints 3 and into the rails of the rearwardly extending section each of the "master" codes which is received from the forwardly extending rails; (2) supplement each pulse of repeated direct current master code energy by superimposed waves of alternating current which are suitable for cab signal control whenever the rear section becomes occupied; (3) bring into action the "feed back" track circuit for the forward section each time that a train comes into the rear section; (4) reverse the polarity of the forward section feed back pulses for a short time interval following the movement of each train out of the forward section; and (5) restore the forward section "feed back" track circuit to its normally inactive state immediately thereafter.

Accordingly, each of the signal blocks (such as II—III of Fig. 1) to which the cut section apparatus is applied operates in the same manner as were that apparatus not present therein and performs all of the non-line-wire approach control functions of my invention with the same effectiveness as were the block rails to be in the form of electrically continuous conductors.

It will further be seen that should any one of the track sections in the complete system of Figs. 1a-b have a passing siding or the like associated therewith, the entry of a train into the section from such a siding will still actuate the approach control apparatus at the exit end thereof in desired manner. This is for the reason that the exit end detector relay V will release regardless of whether the train which by-passes the section rails has entered by way of the normal entrance end of the section or at some intermediate point.

In the former case the winding 34 of relay V is receiving "normal" polarity "feed back" energy at the instant of the train entry and it releases due to the resulting discontinuance of this energy supply. In the latter case the relay P is holding its contact 38 to the right and the associated

relay V is held continuously picked up under the joint action of windings 35 and 36. By-passing of the track section rails now so reduces the voltage which battery TB impresses across winding 35 that the detector relay V again releases.

In my new organization of apparatus and circuits, moreover, the movement of a train through the approach governed stretch in the reverse direction has no adverse effects upon the approach control facilities. Considering the track stretch shown in Figs. 1a-b, an examination of the circuits associated therewith will show that a reverse move of a train from location III through the intervening sections and past location I will leave the coded approach track circuit equipment in its normal non-operating condition in each and every one of the track sections except II—IIa. There the "feed back" track circuit will be left operating. In each of the remaining sections, however, the reverse movement will leave the "feed back" track circuits in their normal non-operating condition.

Summary

While the improvements of my invention have been disclosed in connection with automatic block signaling systems which provide for only three indications ("clear," "approach" and "stop") on the part of the controlled signals, it will be apparent that these same improvements may also be applied to coded track circuit systems wherein the signals identified with the approach governed stretch are controlled to either more or less than three indications. Likewise while the several "coded feed back" track circuit combinations in the system have been shown as receiving operating energy from the direct current batteries TB and AB, it will further be apparent that these same track circuits (see the simplified showing of Fig. 3) may readily be modified to operate on energy derived from other equivalent sources.

From the foregoing, therefore, it will be seen that I have made highly practical improvements in non-line-wire apparatus which approach controls coded track circuit systems of railway signaling by utilizing the "coded feed back" principle of Frank H. Nicholson Patent No. 2,021,944.

In particular I have applied the above principle in an extended way which further cuts down power consumption and which renders the signaling system more suitable for energization from primary battery sources; I have lowered the consumption of "feed back" energy in signaling systems that are approach controlled through the medium of "coded feed back" track circuits; I have enabled all of the "feed back" circuits in the system normally to remain inactive and respectively to come into operation only when a train approaches and leaves the section of track with which the circuit is identified; and I have lowered the power consumption of various other portions of the system apparatus and in other ways have lessened the power drain on the primary battery sources.

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

Although I have herein shown and described only one representative form of extended approach control apparatus embodying my inven-

tion, 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, adjoining first and second sections of railway track, 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, means at the junction of said first and second sections which distinguish between vacant and occupied conditions of said first section, normally inactive means at said junction which are controlled by said distinguishing means and rendered active thereby when said first section is occupied and which when so rendered active further supply the second section rails with pulses of feed back energy that are timed by said master code pulses to recur in step with the master code "off" periods, and traffic governing apparatus controlled by the said pulses of feed back energy which are transmitted over the second section rails.

2. In combination, a stretch of railway track that is arranged into adjoining first and second track sections, 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 relay at the junction end of said first section which distinguishes between vacant and occupied conditions of that first section, normally inactive means at the junction end of said second section which are controlled by said relay and rendered active thereby when said first section is occupied and which then further supply the second section rails with pulses of feed back energy that are timed by said master code pulses to recur in step with the master code "off" periods, and traffic governing apparatus controlled by the pulses of said feed back energy which are transmitted to said second section exit.

3. In combination, a stretch of railway track that is arranged into a plurality of consecutive track sections, means at the exit end of each of said sections for supplying the rails thereof with master code energy in the form of recurring pulses that are separated by "off" period intervals, a relay also at the exit end of each section which distinguishes between vacant and occupied conditions of that section, normally inactive means at the entrance end of each of said sections which are rendered active by the said relay for the section to the immediate rear when that rear section is occupied and which then further supply the forward section rails with pulses of feed back energy that are timed by the said master code pulses received therefrom to recur in step with the master code "off" periods, and traffic governing apparatus controlled by the pulses of said feed back energy which are transmitted over the rails of each of said sections.

4. In combination, a stretch of railway track which includes a track section, continuously active means at the exit end of said section for supplying the rails thereof with master code energy in the form of recurring pulses that are separated by "off" period intervals, normally inactive means at the entrance end of said section which when placed in operation further supply the section rails with feed back energy in the form of pulses that recur in step with the master code "off" periods and that are of normal polarity

at times and of reverse polarity at other times, means responsive to predetermined conditions of traffic in said stretch for bringing said feed back supply means into operation at preselected times and for selecting the polarity of the said energy pulses which those means impress upon the section rails; and traffic governing apparatus controlled by the rail transmitted pulses of said feed back energy and selectively responsive according as those pulses have said normal polarity or said reverse polarity.

5. In combination, a stretch of railway track that includes adjoining first and second track 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, normally inactive means at the junction of said two sections which when placed in operation further supply the second section rails with feed back energy in the form of 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, means responsive to traffic conditions in said two sections for bringing said feed back supply means into operation when said first section is occupied and also for a short time following each passage of a train out of said second section and for causing the then supplied feed back pulses to have normal polarity under the operating condition first named and to have reverse polarity under the operating condition last named, and traffic governing apparatus at the remote end of said second section controlled by the pulses of said feed back energy which are there received and selectively responsive according as those pulses have said normal polarity or said reverse polarity.

6. In combination, a stretch of railway track that includes adjoining first and second track 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 slow responding decoding relay installed at the junction of said two sections and so controlled by the there received pulses of said master code energy as to distinguish between vacant and occupied conditions of said second section, an approach relay also at said junction which distinguishes between vacant and occupied conditions of said first section, normally inactive means likewise at said junction which when placed in operation further supply the second section rails with pulses of feed back energy that recur in step with the "off" periods of said received master code, means including said approach and decoding relays which bring said feed back supply means into operation when said first section is occupied and also for a short time following each passage of a train out of said second section and which cause the then supplied pulses of said feed back energy to have normal polarity under the operating condition first named and reverse polarity under the operating condition last named, and traffic governing apparatus at the remote end of said second section controlled by the pulses of said feed back energy which are there received and selectively responsive according as those pulses have said normal polarity or said reverse polarity.

7. In combination, adjoining first and second

sections of railway track, means at the exit 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 entrance end of said second section connected with said rails and responsive to the said pulses of master code energy that are received from those rails, a similarly located source of feed back energy, a normally released impulse relay which when picked up transfers the said connection of said rails from said track relay to said feed back source, a circuit controlled by said track relay for momentarily picking up said impulse relay during each "off" period of said received master code and thereby causing the second section rails further to receive pulses of feed back energy which recur in step with said master code "off" periods, a delayed responding decoding relay which is controlled by said track relay and which distinguishes between vacant and occupied conditions of said second section, an approach relay at the exit end of said first section which distinguishes between vacant and occupied conditions of that first section, means jointly controlled by said decoding and approach relays for maintaining said impulse relay and its said pick-up circuit normally inactive and for bringing those elements into operation when said first section is occupied and also for a short time following each passage of a train out of said second section, and traffic governing apparatus controlled by the pulses of said feed back energy which are supplied to the rails of said second section under the just named conditions of impulse relay operation.

8. In combination, adjoining first and second sections of railway track, means at the exit 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 entrance end of said second section connected with said rails and responsive to the said pulses of master code energy that are received from those rails, a similarly located source of feed back energy, a normally released impulse relay which when picked up transfers the said connection of said rails from said track relay to said feed back source, a circuit controlled by said track relay for momentarily picking up said impulse relay during each "off" period of said received master code and thereby causing the second section rails further to receive pulses of feed back energy which recur in step with said master code "off" periods, a delayed responding decoding relay which is controlled by said track relay and which distinguishes between vacant and occupied conditions of said second section, an approach relay at the exit end of said first section which distinguishes between vacant and occupied conditions of that first section, means jointly controlled by said decoding and approach relays for maintaining said impulse relay and its said pick-up circuit normally inactive and for bringing those elements into operation when said first section is occupied and also for a short time following each passage of a train out of said second section, means controlled by said decoding relay for connecting said feed back source in normal polarity relation with said second section rails under the first named condition of impulse relay operation and in reverse polarity relation with those rails under the last named condition of impulse relay operation, and traffic governing

apparatus at the remote end of said second section controlled by the pulses of said feed back energy which are there received and selectively responsive according as those pulses have said normal polarity or said reverse polarity.

9. In combination, a section of railway track, means at the exit end of said section for supplying the rails thereof with master code energy in the form of recurring pulses that are separated by "off" period intervals, a source of feed back energy at the entrance end of said section, a normally inactive impulse relay also at said section entrance which at times is controlled by the pulses of said master code energy that are there received and which at those times connects said source with said rails during each master code "off" period and thereby causes those rails further to be supplied with pulses of feed back energy that recur in step with said "off" periods, a decoding relay at said section entrance which is governed by the there received pulses of said master code energy and which goes to a first position whenever said section becomes occupied and a short time following each passage of a train out of the section goes to a second position and there stays as long as the section remains vacant, contacts of said decoding relay which cause the said pulses of feed back energy to have normal polarity if supplied when the relay is in its said second position and to have reverse polarity if supplied when the relay is in its said first position, and traffic governing apparatus controlled by the rail transmitted pulses of said feed back energy and selectively responsive according as those pulses have said normal polarity or said reverse polarity.

10. In combination, a section of railway track, means at the exit end of said section for supplying the rails thereof with master code energy in the form of recurring pulses that are separated by "off" period intervals, means operable by the rail transmitted pulses of said master code energy and effective under certain vacant conditions of said section for then further supplying said rails with feed back energy in the form of 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, relay means at said section exit energized by all of said feed back pulses which are there received and having a contact that moves to a first position when those received pulses have said normal polarity and to a second position when those received pulses have said reverse polarity, and traffic governing apparatus controlled by said contact and selectively responsive according as it occupies its said first or its said second position.

11. 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 operable by the rail transmitted pulses of said master code energy and effective under certain vacant conditions of said section for then further supplying said rails with feed back energy in the form of 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 polar relay installed at said section exit and provided with a contact which moves to a first position when normal polarity energy is supplied to the relay

and to a second position when the relay is supplied with reverse polarity energy, means controlled by said coding device for connecting said polar relay with the section rails during each of said master code "off" periods whereby that relay receives all of the rail transmitted pulses of said feed back energy and positions its said contact according to the polarity of those received pulses, and traffic governing apparatus controlled by said contact and selectively responsive according as that contact occupies its said first or its said second position.

12. In combination, a stretch of railway track that includes a track section, means at the exit end of said section for supplying the rails thereof with master code energy in the form of recurring pulses that are separated by "off" period intervals, means at the entrance end of said section which respond to the there received pulses of said master code energy and which for a short time before and after each passage of a train through said section are effective further to supply the section rails with pulses of feed back energy that recur in step with said master code "off" periods and that are of normal polarity when the train is approaching the section entrance and of reverse polarity after the train clears the section exit, a polar relay at said section exit which is energized by all of the said feed back pulses that are there received, a contact carried by said polar relay which is operated to a first position when said received pulses have said normal polarity and to a second position when those received pulses have said reverse polarity, and traffic governing apparatus controlled by said contact and selectively responsive according as that contact occupies its said first or its said second position.

13. In combination, a stretch of railway track that includes a track section, means at the exit end of said section for supplying the rails thereof with master code energy in the form of recurring pulses that are separated by "off" period intervals, means at the entrance end of said section which respond to the there received pulses of said master code energy and which for a short time before and after each passage of a train through said section are effective further to supply the section rails with pulses of feed back energy that recur in step with said master code "off" periods and that are of normal polarity when the train is approaching the section entrance and of reverse polarity after the train clears the section exit, a polar relay installed at said section exit and provided with a contact which moves to a first position when normal polarity energy is supplied to the relay and to a second position when the relay is supplied with reverse polarity energy, means for connecting said polar relay with the section rails during each of said master code "off" periods whereby that relay receives all of the rail transmitted pulses of said feed back energy and thereby is caused to shift its said contact from said first to said second position following each movement of a train out of the section and from said second to said first position upon each approach of a train to the section entrance, and traffic governing apparatus controlled by said contact and selectively responsive according as that contact occupies its said first or its said second position.

14. 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 "on" period pulses that are separated by "off" period intervals, means effective under certain vacant conditions of said section for then further supplying said rails with feed back energy in the form of 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 polar relay at said section exit which is energized by all of said feed back pulses that are there received and which has a contact that moves to a first position when those received pulses have said normal polarity and to a second position when those received pulses have said reverse polarity, a detector relay also installed at said section exit, means controlled by said coding device and said polar relay for energizing said detector relay by the said "off" period pulses of feed back energy that are received at the section exit when said polar relay contact is in its first position and by said there supplied "on" period pulses of master code energy together with "off" period pulses of other energy when the polar relay contact is in its second position whereby to cause said detector relay respectively to follow code and to stay continuously picked up under vacant conditions of said section and continuously to release whenever the section becomes occupied, and traffic governing apparatus controlled by said detector relay and selectively responsive according as that relay is or is not continuously released.

15. In combination, a section of railway track, means at the exit end of said section for supplying the rails thereof with master code energy in the form of recurring "on" period pulses that are separated by "off" period intervals, means effective under certain vacant conditions of said section for further supplying said rails with feed back energy in the form of 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, relay means at said section exit energized by all of said feed back pulses which are there received and having a contact that moves to a first position when those received pulses have said normal polarity and to a second position when those received pulses have said reverse polarity, a detector relay at said section exit which has three windings and which continuously releases only when said section is occupied, means controlled by said two-position contact and effective when that contact is in its first position for impressing upon the first of said detector relay windings the said "off" period pulses of feed back energy that are received at the section exit whereby those pulses then operate the detector relay in code following manner, further means also controlled by said two-position contact but effective when that contact is in its second position for then impressing said "on" period pulses of master code energy upon the second of said detector relay windings and "off" period pulses of other energy upon the third of said detector relay windings whereby then to hold the detector relay continuously picked up under vacant section conditions, and traffic governing apparatus controlled by said detector relay and selectively responsive according as that relay is or is not continuously released.

16. In combination, adjoining first and second sections of railway track, means for supplying the rails of said second section with coded energy in the form of pulses that recur at a high rate under certain conditions and at a slow rate under other conditions, a code following

track relay at the junction of said two sections connected with said second section rails and responsive to the said coded energy which is received therefrom, a transformer, a source of exciting current for said transformer, a circuit connecting said transformer with said source over a pole changing contact of said track relay, a decoding relay which receives pick-up energy from said transformer and which responds thereto only when said track relay is following said high rate code, an approach relay at said junction which distinguishes between vacant and occupied conditions of said first section, means controlled by said approach relay for maintaining said transformer exciting source disconnected from said pole changing circuit at all times except when said first section is occupied whereby to conserve the power drain on said source, and traffic governing apparatus controlled by said approach and decoding relays.

17. In combination, adjoining first and second sections of railway track, means for supplying the rails of said second section with master code energy in the form of recurring pulses that are separated by "off" period intervals, a code following track relay operated by the said master code pulses which are received from said second section rails, an approach relay which distinguishes between vacant and occupied conditions of both of said two sections, a slow acting selector relay which is controlled by said track and approach relays and which responds only when said second section is occupied, normally inactive means brought into operation by said approach and selector relays when said first section is occupied and also for a short time following each passage of a train out of said second section for further supplying said second section rails with feed back energy in the form of pulses that recur in step with said master code "off" periods and that are of normal polarity under the operating condition first named and of reverse polarity under the operating condition last named, and traffic governing apparatus controlled by the pulses of said feed back energy which are transmitted over the second section rails.

18. In combination, adjoining first and second sections of railway track 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 inter-

vals, a code following track relay connected with said second section rails at the junction of said two sections and operated by the said master code pulses which are there received, an approach relay also at said junction which distinguishes between vacant and occupied conditions of both of said two sections, a slow acting selector relay which is controlled by said track and approach relays and which responds only when said second section is occupied, normally inactive means which when placed in operation further supply said second section rails with pulses of feed back energy that recur in step with said master code "off" periods, means controlled by said approach and selector relays for bringing said feed back supply means into operation when said first section is occupied and also for a short time following each passage of a train out of said second section, means controlled by said selector relay for causing the supplied pulses of said feed back energy to have normal polarity under the operating condition first named and reverse polarity under the operating condition last named, and traffic governing apparatus controlled by the rail transmitted pulses of said feed back energy and selectively responsive according as those pulses have said normal polarity or said reverse polarity.

19. In combination, a stretch of railway track that includes a track section, a detector relay connected in energy receiving relation with the rails of said section and being continuously released under all occupied conditions of that section, means effective under vacant conditions of said section that are accompanied by predetermined traffic conditions in other portions of said stretch for supplying said section rails with energy which holds said detector relay continuously picked up, further means effective under vacant conditions of said section that are accompanied by other traffic conditions in said other stretch portions for supplying said rails with energy which causes said detector relay recurrently to pick up and release, an approach relay energized over a back contact of said detector relay and having such delayed response characteristics that it picks up only when the detector relay is continuously released and occupies the released position at all other times, and traffic governing apparatus controlled by said approach relay and selectively responsive according as that relay is picked up or released.

FRANK H. NICHOLSON.