

March 4, 1952

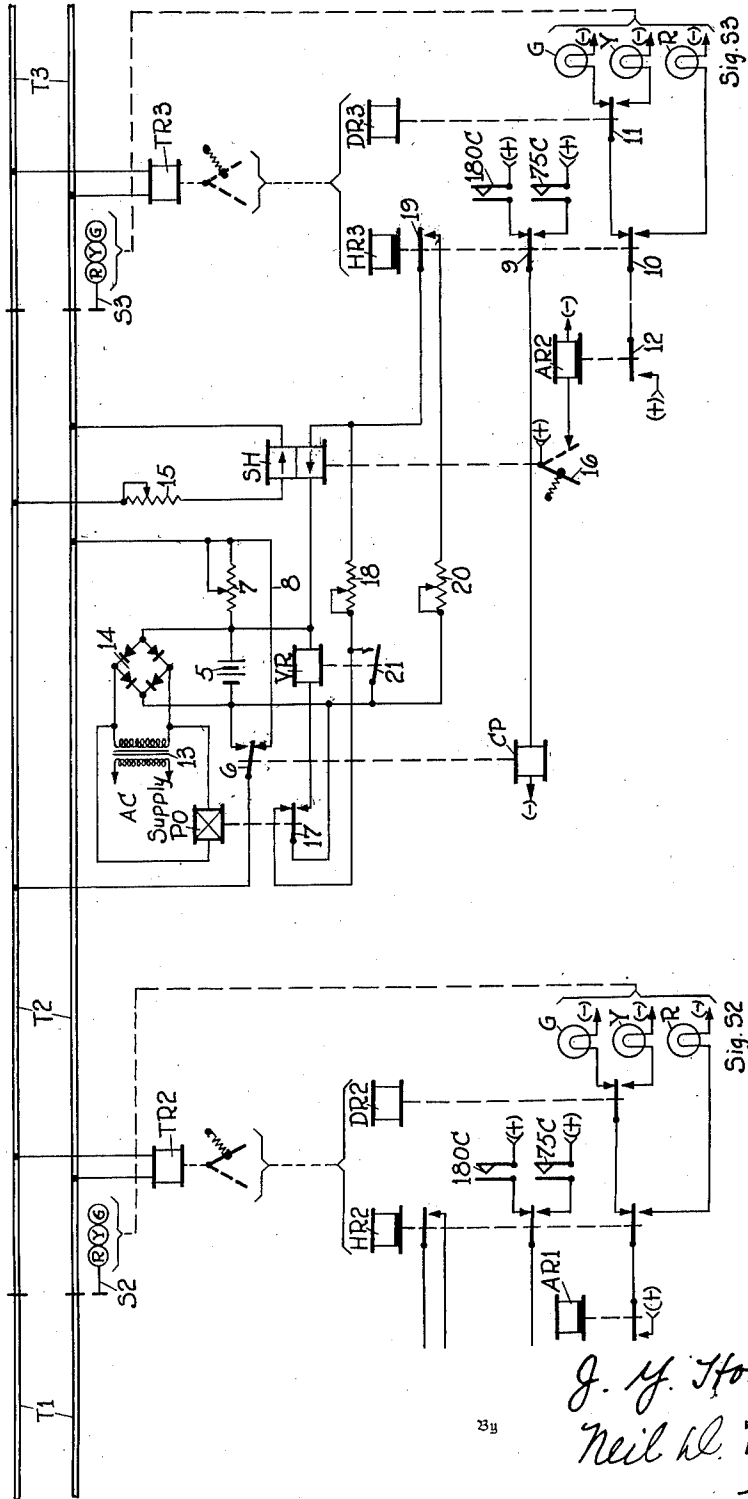
J. Y. HOWARD
APPROACH CONTROL IN CODED TRACK
CIRCUIT SIGNALING SYSTEMS

2,588,005

Filed June 16, 1945

4 Sheets-Sheet 1

FIG. 1.



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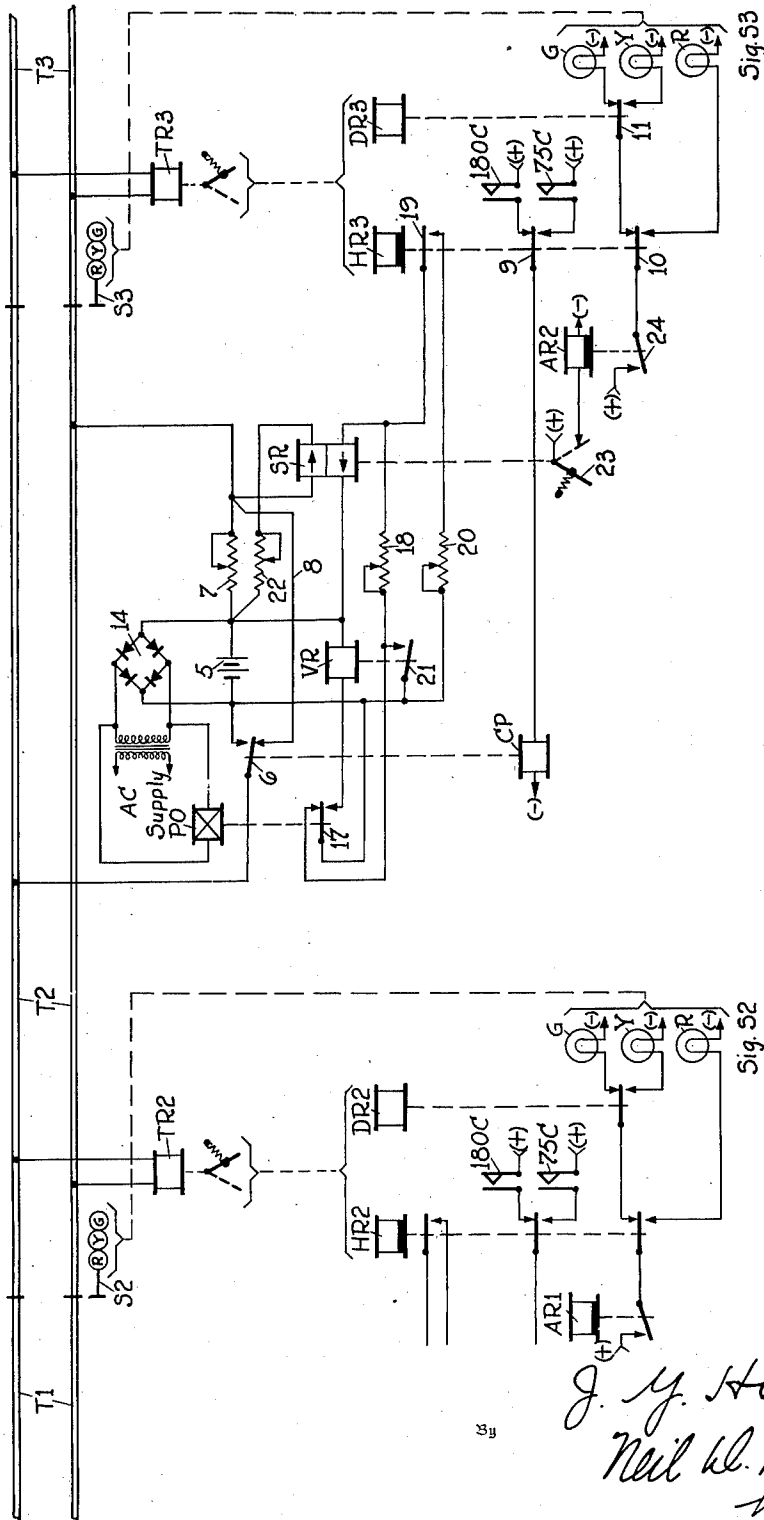
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FIG. 2.



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FIG. 3.

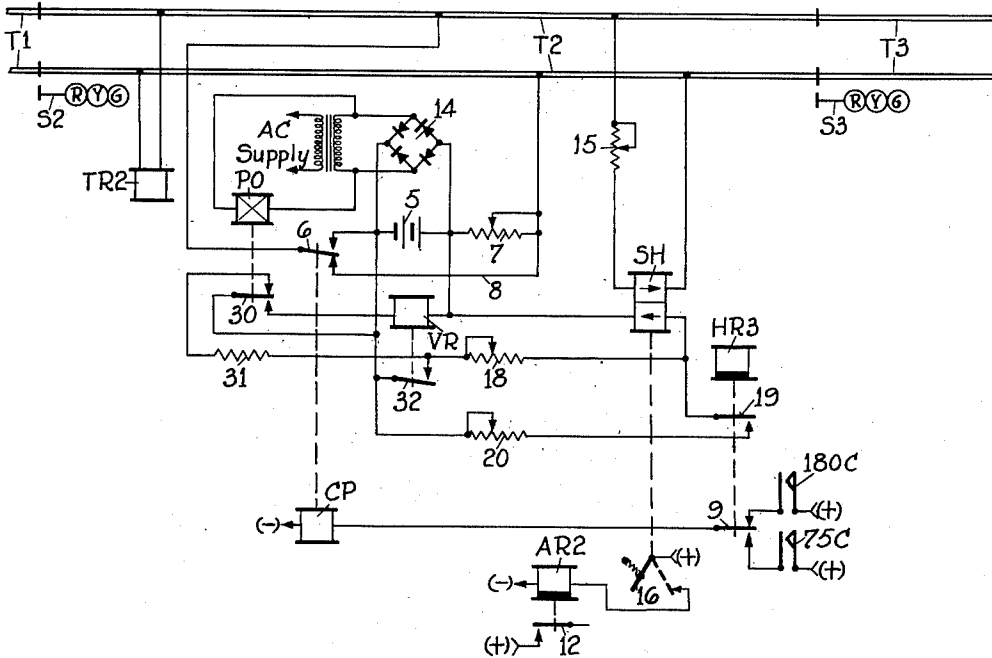
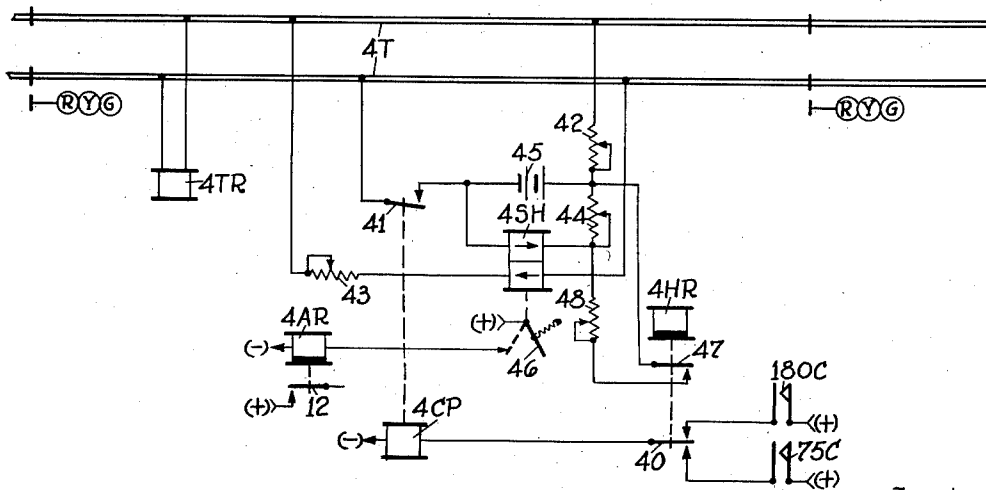


FIG. 4.



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FIG. 5.

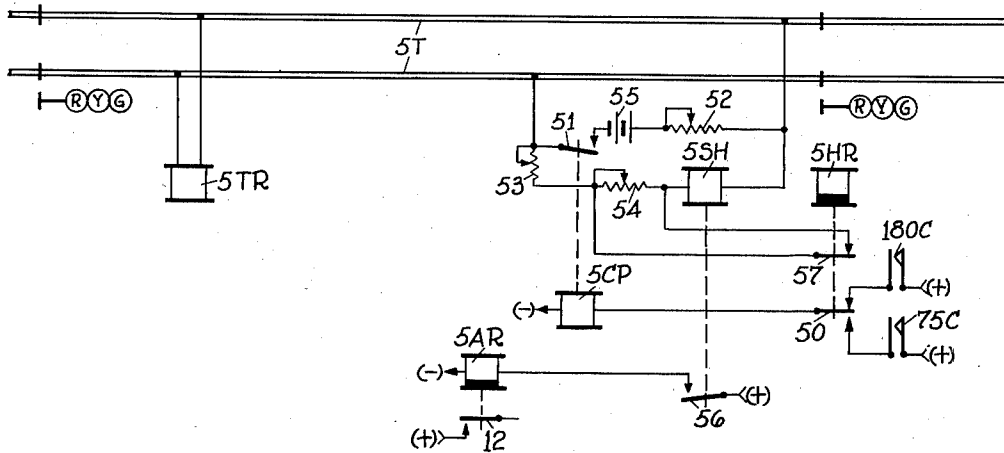
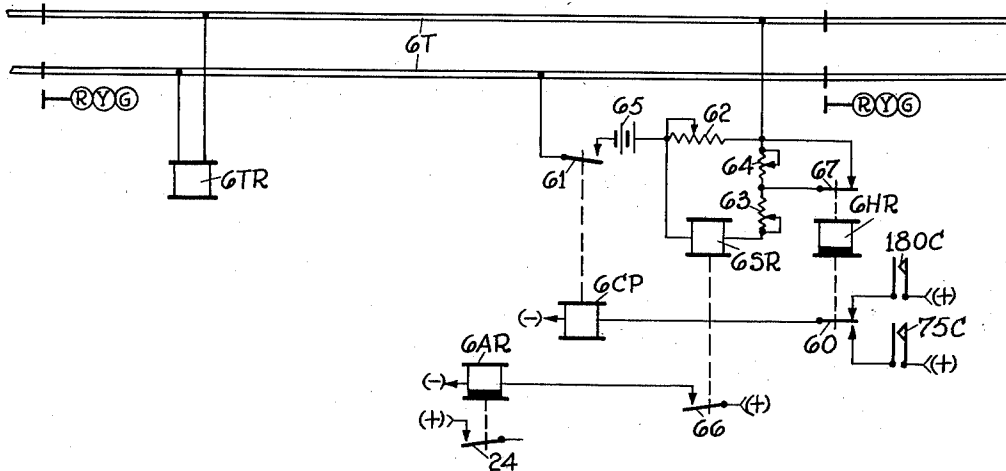


FIG. 6.



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2,588,005

APPROACH CONTROL IN CODED TRACK
CIRCUIT SIGNALING SYSTEMSJames Y. Howard, Greece, N. Y., assignor to
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Application June 16, 1945, Serial No. 599,827

19 Claims. (Cl. 246—34)

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The present invention relates to automatic block signalling systems for railroads using coded track circuits, and more particularly pertains to improved means for providing approach control in such signalling systems.

The conventional block signalling system having coded track circuits provides that impulses of current are supplied to the exit end of each coded track circuit section with spaced intervals between the impulses which have been conveniently termed "off" periods. These time-spaced impulses comprise a driven code, and are applied to the exit end of each section at different distinctive code rates in accordance with the traffic conditions in advance of that section.

At the entrance end of each conventional coded track circuit section, a code following track relay is connected across the rails of that section to receive the driven code impulses and act upon suitable decoding apparatus which is distinctively controlled in accordance with the rate of the driven code received. This decoding apparatus acts to govern the indications of the associated signal in accordance with traffic conditions in advance of that signal, and also to select the code rate to be applied to the next track section in the rear.

In such an automatic block signalling system, it is often desirable to provide what is known as approach control, which may be employed for various purposes, such as approach lighting the signals, approach control of highway crossings, or approach locking control. It has been previously proposed that such approach control may be provided by using what is known as a "shunt" relay, i. e. a relay connected across the track rails at the leaving end of a section which acts to follow the applied driven code impulses, but is prevented from acting when the associated section is occupied and shunted by a train. Another form of approach control proposes to use a "series" relay governed in accordance with the current of the applied code impulses, and this current applied to the track rails is sufficient to operate the series relay only if the associated section is occupied by a train. In both of these proposed arrangements, the variations in current and voltage due to changes in the potential of the track source of energy, and the like, sometimes render such approach track relays ineffective to indicate an approaching train over the desired approach distance.

Another difficulty experienced with the use of approach track relays of the above type, is that the difference in code rate applied to the track

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rails changes the sensitivity of such approach relays, thus changing the distance over which they will reliably act to detect the presence of an approaching train under different traffic conditions.

In view of the above considerations, it is proposed in accordance with the present invention to provide means for compensating for various changeable conditions encountered in practice which will render the approach relays more uniform in their operation and more sensitive to the presence of a train in their associated track sections.

Generally speaking, and without attempting to define the exact nature or scope of the present invention, it is proposed to provide an approach relay which is governed in accordance with the driven code pulses applied to the exit end of a track section so as to be responsive to the presence of a train entering that track section, but provided with compensating means for changing the electrical characteristics of the approach relay in accordance with changes in the potential of the source of energy supplying the current for the driven code pulses, and also in accordance with the changes in the different code rates selected for the driven code pulses.

In providing compensation for an approach relay under the conditions above described, it is proposed in connection with the preferred form of the invention to effect such compensation by the use of an auxiliary compensating winding on the approach relay controlled in a manner to increase the inherent sensitivity of the approach relay organization, so that the approach control provided by such an organization will extend over a track section of increased length as compared to those used in connection with the conventional approach relays.

More specifically, it is proposed that a two-position biased polar relay will be provided with an operating winding and an auxiliary compensating winding. The main winding is governed in accordance with either the potential or the current supplied to the track rails by the application of the driven code pulses to the corresponding end of the track section; while the auxiliary winding is supplied with energy of a lesser degree but creating a magnetic flux in the relay in opposition to the magnetic flux produced by the energization of the main winding. With this organization, any particular percentage of change in the energization of the main winding of the approach relay due to the entrance of a train into the associated track section will have a much greater effect upon the net operating

magnetic flux of the relay, because the net operating flux of the relay is only a part of the flux produced by the main winding. This characteristic functioning of the present invention thus provides a more sensitive approach control organization.

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

In describing the present invention in detail, reference will be made to the accompanying drawings, in which:

Fig. 1 shows one form of the present invention having an improved shunt type approach relay organization;

Fig. 2 shows another form of the present invention having an improved series type approach relay organization;

Fig. 3 shows a modified form of Fig. 1 including an improved form of compensation in connection with a shunt type approach relay for changes in the potential used for the driven code pulses when a shift is made from a source of rectified alternating current to a reserve battery source upon failure of the alternating current;

Fig. 4 shows a simplification of the organization of Fig. 1 particularly illustrating compensation in shunt type approach relay for changes in the selected driven code rate;

Fig. 5 shows a simplified form of shunt type approach relay with compensation for changes in the driven code rate; and

Fig. 6 shows a simplified form of series type approach relay having compensation applied thereto for changes in the driven code rate.

For the purpose of simplifying the illustration, and facilitating in the explanation, the various parts and circuits constituting the embodiment of the invention have been shown diagrammatically and certain conventional illustrations have been employed, the drawing having been made more with the purpose of making it easy to understand the principles and mode of operation than with the idea of illustrating the specific construction and arrangement of parts that would be employed in practice. Thus, the various relays and their contacts are illustrated in a conventional manner, and symbols are used to indicate connections to the terminals of batteries or other suitable sources of electric current instead of showing all of the wiring connections to these terminals. The symbols (+) and (−) are employed to indicate the positive and negative terminals respectively of suitable batteries or other sources of direct current, and the circuits with which these symbols are employed are assumed to always have current flowing in the same direction, although it is to be understood that in some cases alternating current might be substituted for the direct current, if desired, and in such cases the (+) and (−) are to be considered as indicating the relative instantaneous polarities of the alternating current. Although symbols are employed in various cases, in certain instances the batteries and their associated connections are shown.

Compensated shunt relay of Fig. 1.—With reference to Fig. 1 of the accompanying drawing, a stretch of track has been divided into track sections by suitable insulated joints of which the track section T2 has been shown completely and track sections T1 and T3 in part only. Color light type signals S2 and S3 are shown at the

entrance ends of the track sections T2 and T3 respectively. These signals can of course be of any other suitable type desired.

At the exit end of the track section T2, code transmitting apparatus has been shown as including a code transmitting relay CP which, when actuated to an operated position, connects a source of energy across the track rails of section T2 through front contact 6 and including an adjustable series resistor 7. But when the code transmitting relay CP is deenergized and back contact 6 is closed, a shunt circuit including wire 8 shunts the track rails of section T2 to dissipate any stored energy in the track rails due to so-called storage battery action.

The code transmitting relay CP has its contact 6 operated to opposite positions alternately due to the successive time spaced energizations of this relay in accordance with the 75 or 180 code rate as selectively determined by the decoding apparatus associated with signal S3. This decoding apparatus at signal S3 has merely been indicated as including a code following track relay TR3 of the biased polar type which acts in turn to control the home and distance relays HR3 and DR3 in any suitable conventional way well known in the art. One such way of controlling these relays has been shown in detail in the prior application of F. X. Rees, Ser. No. 500,662, filed August 31, 1943 which has resulted in Patent No. 2,378,325, dated June 12, 1945. It should be understood, however, that regardless of the particular type of decoding apparatus associated at signal S3, similar apparatus will be associated with signal S2 and the other signals of the stretch of track to which the block signalling system is applied.

In this connection, it is sufficient for an understanding of the present invention to know that the relay HR3 is picked up due to the reception of code impulses of either the 75 or 180 code rates from the exit end of track section T3. When the relay HR3 is picked up and closes its front contact 9, the coding contacts 180C are effective to intermittently energize the code transmitting relay CP at the 180 code rate; whereas if the relay HR3 is deenergized due to the presence of a train in the track section T3, for example, then back contact 9 is closed and the relay CP is energized from the coding contacts 75C at the 75 code rate. These coding contacts 180C and 75C may be of any suitable type, that is, they may be motor driven, or may be code oscillators of the type disclosed, for example in the prior Patent No. 2,351,588, granted to O. S. Field, June 20, 1944. The coding contacts 180C and 75C are assumed to produce 180 code impulses per minute and 75 code impulses per minute respectively, although it is to be understood that different code rates may be employed, if desired.

The decoding apparatus causes the distant relay, such as relay DR3 to be picked up only when the 180 code rate is received by the code following relay TR3. Thus, when the 180 code rate is received front contacts 10 and 11 of relays HR3 and DR3 are closed for preparing an energizing circuit for the green or proceed lamp G of the signal S3, which is energized when a train is in approach to signal S3 by reason of the deenergization of the approach repeater relay AR2 in a manner later to be explained, and the closure of back contact 12. On the other hand, if a 75 code rate is being received then the relay DR3 is dropped away and back contact 11 is closed so that the yellow or caution lamp Y of signal S3

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is energized assuming the back contact 12 to be closed because of an approaching train.

In the event that the code following relay TR3 fails to receive any code whatsoever, due to a train being in the track section T3, a broken rail, or the like, then both of the relays HR3 and DR3 are deenergized closing back contact 10 so that the red or stop lamp R of the signal S3 is energized upon the approach of a train and the closure of back contact 12.

The operation of the code transmitting relay CP, as above mentioned, closes front contact 6 for each impulse to connect the track source of energy in series with the adjustable series resistor 7 to apply a code pulse across the rails of the track section T2. Each application of a driven code pulse to the track rails at the exit end of the track section T2 effects the operation of the code following track relay TR2 at the entrance end of that track section. The operation of this code following track relay TR2 in accordance with the particular code rate applied at the exit end, causes the operation of the associated decoding apparatus including the home relay HR2 and distant relay DR2 to effect the control of the signal S2 in a manner similar to that already described in connection with signal S3. This decoding apparatus also acts to select the code rate applied to the next track section T1 in the rear, as well as effecting certain compensating functions, as will be later described more particularly in connection with the apparatus associated with signal S3. The approach repeater relay AR1 is controlled in the same manner as the relay AR2 associated with signal S3.

The source of track energy at the exit end of each track section, such as at the exit end of track section T2, includes a source of alternating current connected to a step-down transformer 13 having its secondary winding connected through a full-wave rectifier unit 14 supplying rectified alternating current in multiple with a track battery 5. This track battery 5 may be of any suitable type storage battery, or may be a suitable type primary battery. In the first case, the organization then takes the form commonly known as a trickle charge arrangement with the storage battery 5 normally supplied with potential from the rectifier unit sufficient to keep it fully charged. In this case, the load is normally supplied by the rectified alternating current, but in the event of a power failure, the storage battery 5 immediately carries the load at slightly reduced potential.

In the second case, where the battery 5 is a primary type battery, such as a caustic soda Edison battery, the rectified alternating current source supplies such a potential to the primary battery 5 so as to be below the normal no-load voltage of the battery but above the load carrying voltage of the battery. This is so that the rectified alternating current potential will not be higher than the inherent voltage characteristics of the primary battery and cause damage to the battery; while yet being sufficiently high as to normally carry the load while the alternating current supply is present. On the other hand, if there is a failure in the alternating current supply, then the primary battery takes over the load and supplies it at potential in accordance with the characteristics of such a battery. More specific consideration will be given to the different voltage characteristics of the track sources of energy as the description progresses.

Across the secondary winding of the trans-

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former 13 is connected an alternating current power-off relay PO which is picked up so long as the alternating current power supply is present, but in the event of power failure this relay PO drops away.

In this form of the invention shown in Fig. 1, an approach shunt type relay SH of the polar biased type is shown as having an upper main winding connected across the track rails through a series resistor 15. Each time a code pulse is applied to the track rails this relay SH has its upper winding energized so that its contact 16 is picked up which in turn energizes the relay AR2. Since this shunt relay SH follows the particular code applied to the track section T2, the relay AR2 is intermittently energized, but it is sufficiently slow acting as to remain picked up between successive energizations. Whenever the shunt relay SH becomes steadily deenergized and fails to follow any code, due to the presence of a train in the track section T2 or due to other causes, the relay AR2 drops away and closes its back contact 12 to effect the illumination of the signal S3 as previously described. In this connection, it should of course be understood that the relay AR2 may be employed in connection with the approach controlling of highway crossing signals, approach locking, or the like, and still be within the scope of the present invention.

While the alternating current supply is present and effectively maintains the power-off relay PO picked up, a circuit including front contact 17 of relay PO and a series resistor 18 of the adjustable type acts to connect the lower auxiliary winding of the relay SH across the opposite terminals of the battery 5 and the rectifier unit 14. It is noted that the flow of energy in the lower auxiliary winding of relay SH causes a magnetic flux which opposes the magnetic flux produced by the flow of energy in the upper main winding of relay SH as indicated by the arrows within the respective windings.

Under the above conditions, it is assumed that the adjustable resistor 7 is so set as to properly supply energy to the code following track relay TR2 under the existing possible variations in ballast conditions, and also to supply the energy for the upper winding of relay SH which is directly connected across the track rails of section T2 in series with the adjustable resistor 15. The adjustable resistor 18 is so set that the current flow in the auxiliary compensating winding of the relay SH for the existing potential across the terminals of the battery 5 will create a magnetic flux to oppose the magnetic flux produced in the main operating winding of the relay SH to the proper extent to give the desired net operating flux value so that the entrance of a train into the section T2 as it passes the signal S2 will cause the relay SH to remain dropped away although driven code pulses continue to be applied to the rails by relay CP. This of course assumes that the power-off relay PO is picked up and that the potential of the track power supply is actually provided by the rectified alternating current.

Under the conditions just described, the coding apparatus is assumed to be operating at the 180 code rate because the relay HR3 is picked up closing its front contact 9. But since the power required to operate the armature and contacts of relay SH at this 180 code rate is greater than that power required to operate it at the slower 75 code rate, it will be apparent that compensation should be made for such a change in rate.

This is accomplished by the relay HR3 when it drops away to close back contact 9 and change the code rate, by also closing the back contact 19 so as to connect the adjustable resistor 20 in multiple with the resistor 18 when the 75 code rate is being applied. This reduces the resistance of the circuit for the lower compensating winding of the relay SH, and results in its increased energization to give the relay SH a proper net operating magnetic flux so that the relay will have the same sensitivity of response to the entrance of a train into the track section T2 under the low code rate as it had for the high code rate. In other words, the net operating flux of the relay SH is of one particular value while the 180 code rate is being applied to the track section T2 by the transmitting relay CP, but such net operating value of magnetic flux is reduced during the operation of the relay CP by the 75 code rate. Although this compensation for a change in code rates has been shown with respect to only two different rates, it should be understood that the same principles of compensation may be applied for any desired number of different code rates.

Regardless of whether the 180 or 75 code rate is being applied to the track section T2, each of the code pulses acts to operate the code following track relay TR2 at the entrance end and the approach relay SH at the exit end. As above described, this operation of relay SH is sufficiently rapid under both code rates to maintain the approach repeater relay AR2 picked up. The relay SH is thus picked up during each code pulse and is deenergized between the code pulses regardless of the rate then selected.

When a train enters a track section T2, the shunt effect of the train reduces the resistance of the track circuit so that increased current flows through the adjustable resistor 7 and such current causes a potential drop across such resistor 7 which acts to reduce the potential applied to the track circuit. This reduction in potential across the track rails of the track circuit, and the potential drop in the track rails themselves results in the effective shunting of the track relay TR2 so that it stops operation. The reduction in the potential applied across the track rails at the exit end also results in a reduction of the effective energization of the upper winding of the shunt relay SH whereas the lower or compensating winding of the relay SH is maintained energized at the same value directly from the track source of energy. It is understood of course that only the resistor 18 is included in the compensating circuit when the 180 code rate is being applied and that the resistor 20 is included in multiple therewith when the 75 code rate is being applied. This reduction in the energization of the upper or operating winding of the relay SH reduces the net operating flux of the relay below that value which will effect the picking up of the relay commonly known as the pick-up value. Thus, the entrance of the train into the track section T2, regardless of the code rate applied thereto causes the relay SH to cease its operation and thus allow the approach repeating relay AR2 to become deenergized closing back contact 12 and approach lighting signal S3. This condition is of course maintained as the train proceeds from the entrance of the section T2 throughout its length until it leaves the section at the right-hand end.

The approach relay SH is more sensitive in its response to the entrance of a train not only

due to the fact that its net operating value is so compensated as to be maintained at a proper value for different conditions, but also because of the inherent characteristics of such an organization where the approach relay has a differentially connected auxiliary winding. This can perhaps be best understood by considering certain possible operating characteristics of a relay somewhat more in detail.

In a conventional organization where the approach relay has only one winding, let us assume that its pick-up value of energization is about half of its normal operating value. It will then be readily appreciated that in order for a train to shunt such a relay and cause it to remain dropped away, the train shunt must be effective to reduce the potential applied across the track rails to at least fifty percent of its normal value.

In the present organization, let us assume that the relay SH has the same net operating magnetic flux as the conventional relay just considered, and that the compensating winding is energized to a value equal to a normal operating value. Then the main operating winding must be energized to double the normal operating value in order to give a net resultant operating flux of a normal value. With such a set of assumed values, it will be seen that a reduction in the potential across the track rails equal to twenty-five percent will result in a twenty-five percent reduction of the flux in the main winding, but since this twenty-five percent is with respect to the full value of existing energization of the main operating winding then the net operating flux of the relay has been reduced fifty percent.

With this comparison, it can be seen that the differential winding provides that the net operating flux in such a relay will be reduced to a much greater extent than the actual percentage change in potential across the track rails, whereas the operating flux in the conventional organization can never change a greater degree than the actual percentage change in interrail potential. It is to be understood that these relative values and percentages have merely been selected for the purposes of explanation, and that various combinations of operating values, pick-up values and the like may be employed depending upon the circumstances of practice.

From the above brief explanation, it will be appreciated that a train shunt will be required to be less effective in connection with the present invention when such a train enters a track section, than would be required for maintaining the approach relay deenergized in a conventional organization. For this reason, the approach relay organization of the present invention may be employed with longer track sections and still provide for the desired response of the approach relay upon the entrance of trains into such track sections. On the other hand, sometimes in practice the coded track circuit sections become so long between signal locations that it is not possible to have the approach relays operate as soon as a train enters the section. In such cases, it will be appreciated that the present organization will give a much longer approach control distance than can possibly be provided by a conventional approach relay organization.

Thus far in the description, it is assumed that the alternating current power supply has been maintained, so that the power-off relay PO remains picked up closing front contact 17 and thus maintaining the energization of the com-

compensating winding of the relay SH. However, it may happen that the alternating current source of energy may fail, due to a break in the power line, or other reasons, causing the relay PO to drop away and close its back contact 17 to connect the voltage regulating relay VR across the terminals of the battery 5. Immediately upon such power failure, the load ceases to be supplied by the rectified alternating current so that the battery 5 begins to carry the load without any interruption. The potential across the battery 5 under such circumstances is usually substantially the same as if the alternating current supply were still present, and in such a case the voltage regulating relay VR is caused to pick up and close its front contact 21 to continue the energization of the compensating winding of the relay SH through the resistor 18.

After a time, with either a storage type battery or a primary type battery, the voltage across the battery 5 will decrease, and when this decrease has reached a predetermined amount, the voltage regulating relay VR drops away and opens the front contact 21 removing the current supplied to the compensating winding through resistor 18. In other words, the potential applied across the opposite rails of the track section T2 is reduced to such a degree that there is no need for the counter-action of the lower winding of the relay SH to maintain a proper net operating magnetic flux for the relay.

It is noted that, regardless of whether the voltage of the battery 5 is high or low as indicated by the relay VR when the alternating current power supply has failed, a change in the code rate as indicated by the picking up or dropping of the relay HR3, acts to exclude or include the adjustable resistor 20 in series with the lower compensating winding of the relay SH across the terminals of the battery 5. In the case that the resistor 18 also is included in the circuit, then a greater compensating current will flow when the resistor 20 is included in multiple therewith; but in the case that the resistor 18 is not included in the compensating winding circuit, then of course a smaller compensating current flows. In other words, the circuit including the back contact 19 and the resistor 20 are intended to compensate for the difference in energy required for the relay SH under the changes in code rates under all conditions; while the resistor 18 is intended to compensate for a difference in terminal voltage across the battery 5.

In case battery 5 is of the storage battery type, it is observed that the potential of the battery drops off rather gradually from the terminal voltage supplied by the rectified alternating current through the rectifier unit 14, so that the relay VR is preferably adjusted under such circumstances to drop away when the decrease in terminal voltage has reached a predetermined value. For this reason, the change from rectified alternating current energy supplied by the rectifier 14 to energy from the battery 5 results in no immediate change in voltage upon the failure of the alternating current power supply.

In case battery 5 is of the primary type, such as a caustic soda battery then the terminal voltage of this battery 5 will drop away rather rapidly following the failure of the alternating current and will stabilize at what may be termed a load carrying or discharging potential. After the load has been carried for a time at this discharging potential, the battery potential will gradually

begin to drop off until such primary battery becomes fully discharged. Although the arrangement and description of the invention disclosed in Fig. 1 is applicable to both storage batteries and primary batteries, it may be desirable under certain circumstances where primary batteries are employed to take into consideration the relatively rapid dropping of potential immediately following the failure of the alternating current power supply. For this reason, a simplified form of differentially connected shunt type approach relay has been shown in Fig. 3 with what may be termed a three-step compensating organization.

Referring to Fig. 3, it will be noted that the same reference characters have been applied to those devices of this figure which correspond to the same devices of Fig. 1.

In this form of the invention, the alternating current supply acts through the rectifier unit 14 to normally supply the power for the track circuit organization with the primary battery 5 floating across this rectified alternating current supply in a manner previously described. Under the normal conditions, the lower auxiliary winding of the approach relay SH is energized through front contact 30, resistor 31 and resistor 18 in series through the lower winding of relay SH. The energy which flows in this auxiliary winding creates a magnetic flux in the relay SH in opposition to the magnetic flux created by the energization of the main winding of this relay so that the net operating flux of the relay is proper for causing this relay to follow a 180 code. If the code rate is shifted to the 75 code rate then the resistor 20 is connected through back contact 19 in the same manner, as described in connection with Fig. 1.

In the event that the alternating power current fails, the relay PO drops away and closes back contact 30 to connect the relay VR across the terminals of the battery 5. This causes the relay VR to pick up and close its front contact 32 and connect the resistor 18 directly in series with the compensating winding with relay SH. In other words, the resistor 31 which is included in series with the resistor 18 under normal conditions when rectified alternating current is supplied, has been excluded from the compensating circuit in anticipation that the voltage of battery 5 will rather rapidly drop off to its normal discharge voltage, which will require the lowered resistance in the compensating circuit. The relay VR is then adjusted so as to drop away when the potential of battery 5 falls just below its load carrying potential, and thus at such time entirely removes the voltage compensation resistors from the circuit leaving the lower winding of relay SH deenergized, unless the code rate is reduced to the 75 code rate. Thus, three-step compensation for voltage changes has been provided. In this connection, it might be noted that the potential of battery 5 will rather quickly drop from its no-load potential to its discharging or load carrying potential when a train is present in the associated track section, and for this reason the added step in the compensation is especially useful in case primary batteries are employed.

Whenever a train leaves a track section, the load on the battery 5 is, of course, reduced and its potential may again rise to a point which will cause the relay VR to pick up both in the case of storage batteries and in the case of primary batteries. Such pick-up of the relay VR will, of course, restore the energization of the compen-

sation winding for the relay SH maintaining its sensitivity for response to the approach of another train.

It should, of course, be understood that following a power failure, the restoration of the power will result in the reenergization of the power-off relay PO so that it will pick up its contact 17 and restore the normal conditions with respect to the control of the compensating winding on the relay SH.

It was pointed out above that relay SH is of the polar biased type of relay, that is, the relay armature and its associated contacts have two polar positions, and are biased to one of those positions. The connections to the windings of the relay are so made that the energy in the compensating winding tends to move its contacts toward their biased positions, while energy in the main winding tends to actuate its contacts toward their operating positions. When the magnetic flux produced by the two windings results in a net value of flux equal to the pick-up value, and in a direction to operate the relay against its bias, its contacts are actuated to their picked-up or operated positions. This polarization of the relay has the function of preventing false operation of the relay under certain conditions, such as when a train is adjacent the exit end of the track section and the net operating magnetic flux tends to move the contacts of the relay toward their biased positions, because, under such conditions, the contacts of a conventional neutral relay would be falsely operated. By using the polarized relay, the contacts remain in their normal biased positions regardless of whether the compensating winding overpowers the main operating winding or not during the passage of a train through the track section T2.

Compensated series relay of Fig. 2.—Fig. 2 of the accompanying drawings has been shown to illustrate how a series approach track relay having the features of compensation provided by the present invention can be used in place of the shunt relay of Fig. 1. In this form of the invention those parts corresponding to the same parts in Fig. 1 have been given the same reference characters.

The same general organization is provided wherein the rectifier unit 14 normally supplies the load with the battery 5, which may be of the storage battery type or of the primary battery type, floated across the opposite terminals of the rectifier unit. Each time the code transmitting relay CP is energized, it closes front contact 6 to apply a code pulse through series resistor 7 across the rails of the track section T2. Each time the code transmitting relay CP is deenergized, its back contact 6 closes a circuit including wire 8 for shunting the track rails.

In this form of the invention, the main winding of the series relay SR is connected in series with resistor 22 which in turn is connected across the terminals of the series resistor 7. The lower or auxiliary winding of the relay SR is controlled in exactly the same way as described in connection with Fig. 1, and in this connection it should be understood that the relay SR is of the polarized type having its contacts and armature biased to one particular position. Under normal conditions, the voltage drop across the series resistor 7 is too low to cause sufficient current flow through the resistor 22 and the upper winding of relay SR to result in a net flux of a value to cause operation of the relay. However, when a train enters the track section T2, it shunts the track

rails causing an increased current flow from the track energy source through the series resistor 7. This increased current flow causes an increased potential drop across the series resistor 7, which is sufficient to produce a considerably higher flux in the upper winding of the relay SR so that the net flux of the relay SR is sufficient to operate its contacts.

In other words, the relay SR is normally at rest and does not follow the code applied to the track section 22 by the operation of the code transmitting relay CP, as does the relay SH of Fig. 1. Thus, the approach repeating relay AR2 is normally deenergized and its front contact 24 is normally open. When a train enters the track section T2 and shunts the track rails to cause an increased track current to flow, a voltage drop across the resistor 7 causes sufficient current flow through the upper winding of the series relay SR to establish a net operating flux value in the relay. Then the series relay SR is caused to follow the code as is then being applied to the track section. This intermittent operation of the relay SR intermittently closes contact 23 to cause intermittent energization of the approach repeating relay AR2 and cause it to pick up so long as such intermittent operation is maintained. This operation occurs both during the transmission of the 180 code and during the transmission of the 75 code.

It will be apparent that in this form of the invention the energization of the operating winding of relay SR and the compensating winding is such as to maintain the net operating flux of the relay SR below the pick-up value of the relay under normal conditions; whereas when a train enters a track section the winding is energized to a degree that the flux produced thereby minus the flux produced by the compensating winding results in what might be termed a normal net operating value. This form of the invention gives exactly the same characteristic features of sensitivity to the approach relay under the different conditions involved as described in connection with Fig. 1. For example, the back contact 19 of relay HR3 provides for governing the degree of energization of the auxiliary winding of relay SR to compensate for changes in the code rates applied to the track section T2 by the code transmitting relay CP. Similarly, the relay VR and its associated relay PO both act to govern the auxiliary or compensating winding of the relay SR in accordance with voltage changes of the track source of energy as described in connection with Fig. 1. It should also be understood that this Fig. 2 may be similarly modified, as described in connection with Fig. 3, so as to provide what has been conveniently termed three-step voltage compensation. It is believed unnecessary to further discuss the details of operation of Fig. 2, since they will be readily understood by analogy to the operation described in connection with Figs. 1 and 3.

With reference to Fig. 4, a simplified illustration has been shown of the differentially connected shunt relay compensated for changes in code rate as disclosed in Fig. 1. This figure simplifies the embodiment shown in Figs. 1, 2 and 3 to illustrate how still the same characteristic features of compensation with respect to changes in the rate of code transmitted can be provided without the use of voltage compensation.

In this Fig. 4, it is assumed, as will occur under some conditions of trackway and battery supply, that the source of supply will be rela-

tively stable because of the conditions involved. The operation of the code transmitting relay 4CP at the 180 code rate through front contact 40 of relay 4HR, or at the 75 code rate through the back contact 40, causes the contact 41 to be intermittently operated to apply code pulses to the track rails of the track section 4T through the series resistor 42. These pulses of course operate the code following track relay 4TR at the entrance end and likewise energize the main operating winding (the lower winding in this case) of relay 4SH through a resistor 43. The auxiliary (upper winding in this case) of relay 4SH is energized through the resistor 44 directly across the opposite terminals of the track battery 45. Since the main winding (lower) of relay 4SH is energized to a greater degree during each code pulse than the differential auxiliary winding, there is a net operating flux in the relay that causes it to normally follow the code applied to the exit end of the track section causing its front contact 46 to be intermittently operated to cause the approach repeating relay 4AR to be maintained picked up. It will be observed that this organization corresponds exactly with the organization disclosed in Fig. 1 with the exception that the compensating winding is permanently connected to a source of energy through the series resistor 44. Thus, the relay 4SH has a normal condition of sensitivity to the entrance of a train into a track section for 4T while a 180 code rate is being applied to that section by the code transmitting relay 4CP.

When the relay 4HR drops away to shift the code transmission from the 180 rate to the 75 rate, the back contact 47 of relay 4HR is closed connecting the resistor 48 in multiple with the resistor 44 to increase the energization of the auxiliary winding of the shunt relay 4SH. This is to compensate for the decrease of the energy requirements of the relay 4SH in following the slower 75 code rate.

This organization thus provides for compensation for changes in code rates and also provides that the shunt relay 4SH is provided with a permanently energized differentially connected auxiliary winding, so that this relay has the added sensitivity characteristic of this type of organization, as previously described in connection with Figs. 1, 2 and 3.

The entrance of a train into the track section 4T shunts the track rails of that section and causes increased current to flow from the track battery 45 and through the series resistor 42. The added potential drop which occurs in the resistor 42 results in the effective shunting of the track relay 4TR and the approach relay 4AR. As soon as the approach repeating relay 4AR ceases to be energized intermittently, its contacts drop away closing its back contact 12 to approach light the associated signal in the usual way. Other feature characteristics of this simplified form of the invention will be readily understood by analogy to the preceding description and other forms of the invention.

In Fig. 5 of the accompanying drawings a simplified form of the invention has been shown to illustrate that the principles involved in the present invention in compensating for changes in the rate of code transmission may be applied to a simple shunt relay of the more conventional form. Referring to Fig. 5, it will be seen that the code transmitting relay 5CP is energized intermittently in accordance with the 180 code rate while front contact 50 of relay 5HR is

closed, but is energized at the 75 code rate when the back contact 50 is closed.

Regardless of the particular rate at which the relay 5CP is energized, each time it closes the front contact 51 it causes an impulse to be applied to the rails of the track section 5T from the track battery 55 and through the series resistor 52. These impulses of course operate the code following track relay 5TR, as well as also supplying energy through the resistors 53 and 54 to the relay 5SH while the 75 code is being applied and through only the resistor 53 while the 180 code is being applied. This is because the front contact 57 of relay 5HR shunts the resistor 54 while the 180 code is applied but unshunts such resistor 54 while the 75 code is being applied.

Under normal conditions the shunt relay 5SH is normally operating in response to the transmission of code pulses applied to the associated track section 5T so that its front contact 56 intermittently energizes the approach repeating relay 5AR. This relay 5SH is shown as a neutral relay, but may be polarized if it is desired to improve the time characteristics of the relay. However, it should be understood that polarization of the relay is not essential in this form since there is no compensating auxiliary winding.

Whenever a train enters the track section 5T, it shunts the rails and causes an increased track circuit current to flow increasing the potential drop across the series resistor 52. This results in the decrease of the potential applied to the track relay for operating the track relay 5TR and also a decrease in the potential applied to the circuit for energizing the shunt relay 5SH. Such decrease of course causes both the track relay 5TR and the relay 5SH to cease operation because the energy in these relays has been reduced below their pick-up values. The cessation of intermittent energization of the approach repeating relay 5AR results in its dropping away and the closure of back contact 12 to approach light the associated signal in a manner previously described. When the train leaves the track section 5T, normal conditions are restored with relay 5SH following the code and relay 5AR picked. The primary feature to be noted with respect to this Fig. 5 is that a compensating resistor 54 is included in series in the circuit for relay 5SH which resistor is shunted or unshunted depending upon whether a 180 code or a 75 code is being transmitted. As previously mentioned, a relay following a code requires more energy at the fast code rate so that the resistor 54 is shunted by the front contact 57 so as to supply the relay 5SH with more energy during the transmission of the 180 code than it receives during the transmission of the 75 code. In this way, the effective operation of relay 5SH is maintained constant for different code rates so as to have more uniform sensitivity to the entrance of a train into the track section 5T.

Fig. 6 of the accompanying drawings shows a simple series relay having compensation for changes in code rate. In this Fig. 6, it will be readily appreciated that the operation of the code transmitting relay 6CP is at the 180 code rate while front contact 60 of relay 6HR is closed, but is at the 75 code rate while back contact 60 of relay 6HR is closed. Each operation of the transmitting relay 6CP closes front contact 61 to apply a code pulse from the track battery 65 through the series resistor 62 to the rails of the track section 6T for operation of the code

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following track relay 6TR at the entrance end of the section. The series relay 6SR is connected through a series resistor 63 and another series resistor 64 across the opposite terminals of the series resistor 62 while the 75 code rate is being transmitted. But, while the 180 code rate is being transmitted, front contact 67 is closed, shunting the resistor 64. Each time a code pulse is transmitted, there is a certain potential drop across the series resistor 62 which causes some energy to be applied to the relay 6SR which is insufficient to operate the relay while no train is in the track section 6T. However, when a train enters the track section 6T, increased current flow from the track battery 65 is caused so that the potential drop across the series resistor 62 increases to a point sufficient to cause an operating current to flow through the series relay 6SR. This operation of relay 6SR causes intermittent closure of front contact 66 and the intermittent energization of the relay 6AR to maintain the relay energized closing front contact 24 and effecting the approach lighting of the associated signal in a manner previously described.

The main point to note with respect to this Fig. 6 is that if a 75 code is being transmitted, the front contact 67 is open to unshunt resistor 64 in series with the winding of the relay 6SR thus reducing the energy supplied to this relay for its operation. In other words, this form of the invention illustrates how a change in code rates can act to compensate for the degree of energization required to operate a simple series approach relay.

From the above description of the several figures of disclosure, it will be seen that the various characteristic features of the present invention may be employed in combination with each other or may be used separately under varying conditions and circumstances of actual practice. However, these features when combined to provide a composite approach control organization, as disclosed in the preferred forms of the present invention, result in a highly effective and efficient approach control organization giving a substantial increase in the length of track circuits that can be used in connection with such control and still provide for approach lighting of an advance signal immediately upon an entrance of a train into the associated track section. However, as above mentioned, it is not essential in the practice of the invention to have the approach control zone extend throughout the length of its associated track section because some coded track sections are longer than required for approach lighting. In such cases, however, the effective control zone is greatly increased over that which is capable of being provided by the usual conventional approach control organization.

Having described several forms of a coded track circuit automatic block signalling system, employing approach control apparatus organized to give increased sensitivity, as embodying the principles of the present invention, it is desired to be understood that the invention is shown in this connection and in this manner for the purpose of facilitating the disclosure, and that the invention may be applied to various other applications of coded track circuits. It is to be further understood that the specific embodiments of the present invention may have various modifications, adaptations and alterations made to the forms shown to meet the re-

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quirements of practice, without in any manner departing from the spirit or scope of the present invention except as limited by appended claims.

What I claim is:

1. In a coded track circuit for railroads, the combination with a source of current and coding means for intermittently connecting said source across the track rails at one end of a track section, an approach relay at said one end having two differential windings and a biased polar armature, means for connecting one winding of said approach relay across the track rails at said one end, and means for independently steadily energizing the other winding of said approach relay from said source of current to provide a magnetic biasing effect tending to operate said polar armature to its biased position.

2. In a coded track circuit for railroads, a source of current and a limiting resistance associated with a track circuit, means including coding contacts for intermittently connecting said source of current in series with said resistance across the track rails at one end of said track circuit to energize it with code pulses, a differential approach relay of the biased polar type having one winding energized from the track rails at said one end by the code pulses applied thereto, and circuit means for connecting the other winding of said approach relay across said source of current alone to provide a substantially uniform flux in said relay tending to move the polar armature of said relay to its biased position.

3. In a coded track circuit for railroads, code transmitting and approach control apparatus at one end of the track circuit comprising a source of energy and a limiting resistor, coding means for intermittently connecting said source of energy and said resistor in series across the track rails to transmit code pulses over the track circuit, control means governed in accordance with traffic conditions for causing said coding means to operate at different selected rates, an approach relay, a compensating resistor connected in series with said approach relay, circuit means including said compensating resistor for supplying said approach relay with current in accordance with the potential of the code pulses supplied to the track circuit, and means governed by said control means for changing the value of said compensating resistor in accordance with the selected code rate.

4. In a coded track circuit for railroads, the combination with a source of current and coding means for intermittently connecting said source of current across the track rails at one end of a track section to transmit code pulses, an approach relay having a main winding and a differential compensating winding associated with a biased polar armature, means for energizing said main winding in accordance with the code pulses applied to said track section for causing the operation of said polar armature to be dependent upon the presence and absence of a train in the track section, means for independently and steadily energizing the other winding of said approach relay to provide a steady magnetic biasing effect tending to operate said polar armature to its biased position, and means associated with said coding means for at times changing the degree of energization of said compensating winding.

5. In a coded track circuit for railroads, a track section having a track relay connected at one end and code transmitting means at the other end comprising a source of current and

coding contacts for intermittently connecting said source of current across the track rails at said other end of said track section, an approach relay at said other end having a main winding and a differential compensating winding associated with a polar armature biased to one position, means for energizing said main winding of said approach relay in accordance with the energization of said track rails by said coding means from said source, and means for independently energizing the compensating winding of said approach relay with a steady energization from said source of current to provide a steady magnetic bias effect tending to operate said polar armature to its biased position.

6. In a coded track circuit for railroads, the combination with a source of current and coding means for intermittently connecting said source of current across said track rails at one end of a track section, an approach relay having two windings and a biased polar armature, means for connecting one winding of said approach relay across the track rails of said section at said one end so as to be intermittently energized from said source, and means for independently steadily energizing the other winding of said approach relay from said source of current to provide a magnetic flux opposing the magnetic flux produced by the energization of said main winding but being of a smaller degree to only tend to operate said polar armature to its biased position, whereby said approach relay is rendered more sensitive to a train shunt on said track section.

7. In a coded track circuit for railroads, a track section having a code following track relay at one end and code transmitting means at the other end including a source of current, coding contacts operated intermittently at different rates, an approach relay, means for connecting said source intermittently across the track rails at said other end of said track section at different selected rates, circuit means for supplying said approach relay with energy during said pulses in accordance with the current supplied to said track section, control means for governing said code transmitting means to select a different code rate in accordance with traffic conditions, and steadily energized electrical biasing means governed by said control means for changing the operating current values of said circuit means for said approach relay in accordance with the selected code rate.

8. In a coded track circuit for railroads, a track section having a code following track relay at one end and code transmitting means at the other end, said code transmitting means including a source of current and coding contacts operating intermittently for applying code pulses to the track rails at that end of the track section at one selected code rate, control means for governing said coding means to select a different code rate in accordance with traffic conditions, an approach relay of the biased polar type and having a main winding connected across the track rails at said other end of said track section so as to be responsive to the code pulses applied to said track section at that end, said approach relay also having a steadily energized compensating winding, and means governed by said control means for changing the degree of energization of said compensating winding dependent upon a change in the selected code rate.

9. In a coded track circuit for railroads, a coding means including a source of current and

coding contacts at one end of a track section, said coding means operating to apply code pulses across the track rails at different selected rates in accordance with traffic conditions, control means for governing said coding means to select the different code rates in accordance with traffic conditions in advance, an approach relay associated with said coding means and having a main winding associated with said track section so that its degree of energization is responsive to the entrance of a train into the corresponding track section, and also having a compensating winding, and means governed by said control means for changing the degree of energization of said compensating winding of said approach relay in accordance with the different selected code rates.

10. In a coded track circuit for railroads, a track section, a source of rectified alternating current and a reverse battery connected in multiple therewith at one end of said track section, code transmitting means at said one end of said section for intermittently connecting said source and said battery across said track rails to apply code pulses at a rate selected in accordance with traffic in advance, an approach relay of the biased polar type associated with said one end of said track section and having a main winding and a compensating winding, said main winding being associated with that end of said track section so as to be responsive to the presence of a train in that track section, and means including a power-off relay responsive to the failure of the alternating current supply for changing the operating current of said approach relay by changing the degree of energization of said differential compensating winding as the energization of the track circuit is changed from the rectified alternating current to the reserve battery.

11. In a coded track circuit for railroads, coding means at one end of a track section including a battery source of energy and acting to intermittently apply code pulses to the track rails at that end at a rate selected in accordance with traffic conditions, an approach relay associated with said one end of said track section and having a main winding and a steadily energized compensating winding energized from said source, said main winding being connected across the track rails of said section at said one end, and a regulating means responsive to changes in the voltage applied to the track rails from said source for changing the degree of energization of said differential winding of said approach relay as variations in the potential of said battery source occur.

12. In a coded track circuit for railroads, coding means including a source of rectified alternating current and a reserve battery connected in multiple therewith for intermittently applying code pulses to the track rails at one end of a track section for energizing a code following track relay at the other end of the track section in accordance with traffic conditions, an approach relay associated with said one end of said track section and having a main winding and a compensating winding, a power-off relay responsive to the failure current, and means controlled by said power-off relay for changing the degree of energization of said differential winding of said approach relay if the energization of the track circuit is changed from the rectified alternating current to the reserve battery.

13. In a track circuit for railroads, the combination with a rectified alternating current

source of supply and a multiple connected floating battery for supplying energy to the track rails of a track section at one end for energizing a track relay at the other end, an approach relay connected across said track rails at said one end, a power-off relay responsive to the failure of alternating current supply, a regulating relay connected across said battery only when said power-off relay is deenergized upon failure of the alternating current supply, means for changing the operating current requirements of said approach relay as the energization of the track circuit is changed from the rectified alternating current to the reserve battery as indicated by said power-off relay and as the energization of the track circuit is changed upon the falling off of the voltage of said battery as indicated by said regulating relay.

14. In a track circuit for railroads, the combination with a primary battery for applying energy to the track rails of a track section at one end and for energizing a track relay at the other end, an approach relay having two windings one connected across said track rails at said one end, a regulating relay connected to said battery and responsive to variations in its voltage, and circuit means governed by said regulating relay for changing the degree of energization of the other winding of said approach relay dependent upon the voltage of said source.

15. In a coded track circuit for railroads, a source of current and a series limiting resistance associated with the exit end of a track section, means including coding contacts for intermittently connecting said source of current in series with said resistance across the track rails at said one end, an approach relay associated with said exit end of said track section and having two windings, means for connecting one winding across the track rails so as to be energized by said code pulses, and circuit means for connecting the other winding of said approach relay across said source of current for energizing it to a limited degree to provide a steady opposition to the intermittent energization of said one winding, whereby said approach relay is rendered more sensitive to the entrance of a train into said track section.

16. In a coded track circuit for railroads, a source of current and a limiting resistor associated with the exit end of a track section, coding contacts operating to intermittently connect said source of current in series with said resistor across said track section to apply code pulses of selected rates to said track section, control means for governing said coding means to select the different code rates in accordance with traffic conditions, an approach relay having a winding connected across the rails of said track section so as to be energized by the code pulses and to be responsive to the entrance of a train into a corresponding track section, and means governed by said control means for changing the effective energization of said approach relay in accordance with the different selected code rates.

17. In a coded track circuit for railroads, a source of current and a limiting resistor associated with one end of a track section, code transmitting means for intermittently connecting said source of current and said resistor in series across

the track rails of the track section to apply code pulses in accordance with different selected code rates, control means for governing said code transmitting means to select the different code rates, an approach relay having a winding connected across the terminals of said limiting resistor so as to be effectively energized only when a train enters said track section, and means governed by said control means for changing the effective degree of energization of said approach relay dependent upon the different selected code rates.

18. In a coded track circuit for railroads, a track circuit section having code receiving means connected to its rails at one end, a source of current and a limiting resistance associated with the other end of the section, code transmitting contacts for intermittently connecting said source of current in series with said resistance across the rails of said section for applying code pulses thereto at different selected rates, an approach relay having a winding connected to the coded track circuit of said section at said other end so as to be normally responsive to the inter-rail potential during the application of said code pulses to thereby operate its contacts at a rate corresponding to the rate of said code pulses but to cease such operation when said section is shunted by a train, control means for selecting the rate of operation of said code transmitting contacts in accordance with traffic conditions, and means also governed by said control means for modifying the effective energization of said approach relay in accordance with the selected code rate, whereby said approach relay is caused to follow the code pulses with the same degree of lag regardless of their different rates.

19. In a coded track circuit for railroads, a source of current, a series resistor, and coding contacts acting intermittently to connect said source and said series resistor to apply energy to the track rails of a track section at one end for intermittently energizing a track relay at the other end with code pulses, an approach relay having a winding energizable in accordance with the inter-rail potential of said track rails at said one end, a regulating relay connected to said source and responsive to variations in its voltage, and means governed by said regulating relay for modifying the effective energization of said approach relay dependent upon the variations in voltage of said source.

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