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RAILWAY SIGNALING SYSTEM

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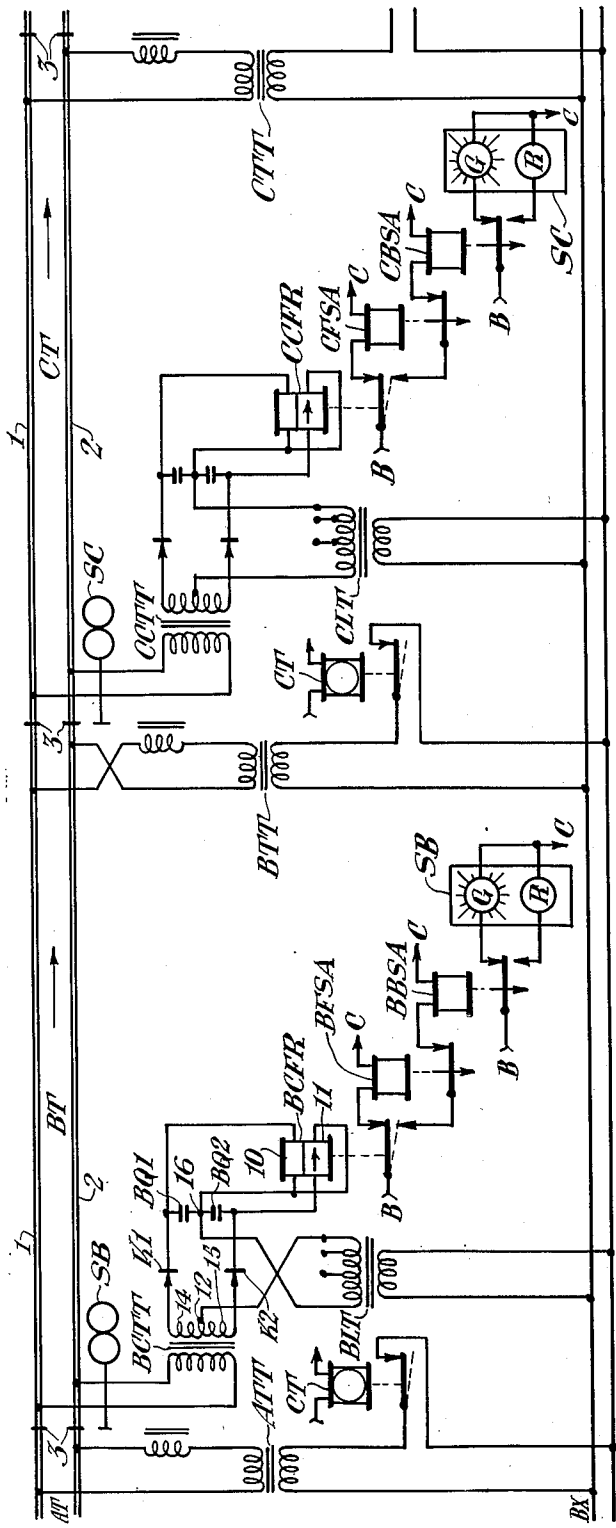


Fig. 1.

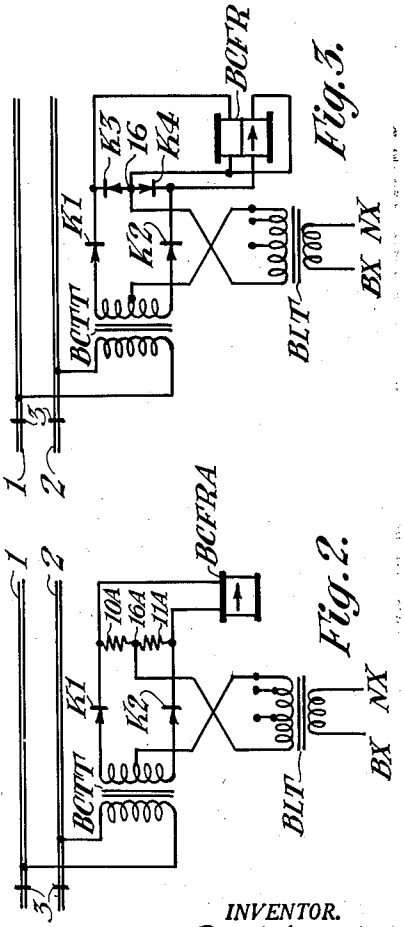


Fig. 3.

Fig. 2.

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RAILWAY SIGNALING SYSTEM

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6 Claims. (Cl. 246—34)

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This invention relates to railway signaling systems employing alternating current track circuits constituted by the track rails divided into sections in which alternating current energy is supplied to the track rails at one end of a track section, a direct current relay at the other end of the section being arranged to respond to the presence or absence of this energy which is rectified before being applied to the relay.

One of the problems attendant upon all signaling systems employing track circuits is how to guard against failure of the insulated block joints between adjoining sections.

This problem may be solved in systems employing direct current energy applied to the track rails by applying energy of opposite polarities to adjoining sections so that, upon the failure of a block joint between two sections the relay of one section, which is responsive only to energy of one polarity, will not be operated by energy fed from the adjoining section.

In systems employing alternating current energy and direct current relays, however, the rectifier feeding the relay is equally responsive to an alternating current input of any phase so that the reversal of phase of energy supplied to adjoining track sections is not effective to give protection against block joint failure. This is particularly serious in systems where sections are separated by blocks joints in one rail only and in systems where block joints in both rails are employed in conjunction with impedance bonds since in both these cases failure of one block joint may result in false operation of the relay by energization from an adjoining section.

The object of the present invention is to overcome the above-mentioned difficulty. To this end, use is made of phase-sensitive rectification and according to the principal feature of the invention an alternating current reference voltage from a local source of supply, which may be the signaling supply lines, is fed into the rectifier network interposed between the alternating current supply received from the track rails and the direct current relay.

The polarity of the direct current voltage applied to the relay is in this manner made dependent upon the relative polarities of the two alternating current supplies and the normal technique of arranging for the alternating current energy supplied to adjoining track sections to be of opposite relative polarities and mutually 180 degrees out of phase provides the desired protection against block joint failure.

I shall describe several forms of railway signaling system embodying my invention and shall then point out the novel features thereof in claims.

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In the drawings,

Fig. 1 is a diagram of a stretch of railway track equipped with track circuits embodying this invention, and

Figs. 2 and 3 are fragmentary views showing modifications which I may employ.

Referring to Fig. 1 of the drawings, there is shown therein a stretch of railway track through which traffic normally moves in the direction indicated by the arrow, that is, from left to right. The track rails 1 and 2 of the track stretch are divided by insulated joints 3 into the customary track sections for signaling purposes. Two complete track sections, designated BT and CT, and a portion of a third track section, designated AT, are shown in the drawings.

Entrance of traffic into each of the track sections is governed by a signal located at the entrance end of the section and designated S with a prefix corresponding to that of the associated section. As shown, each of the signals is of the color light type and each has a red or stop lamp R, and green or clear lamp G.

Each of the track sections is provided with track circuit apparatus including a code following track relay at the entrance end of the track section and a supply transformer TT located at the exit end of the track section. The energy supplied from transformer TT is coded or periodically interrupted at a suitable code speed by code transmitters designated CT.

The track relays, which are designated CFR with a prefix corresponding to that of the associated track section, are of the code following type and control slow releasing code detecting relays FSA and BSA in such manner that the relay BSA is picked up when and only when the associated track relay is responding to coded energy. The relays BSA control the lamps of the signals so that the red lamp is lighted when the relay BSA is released and the green lamp is lighted when the relay BSA is picked up.

The track relays CFR are of the polar biased neutral type and each has a contact which is biased to a released position from which it is moved to a picked-up position when and only when energy of a particularly polarity is supplied to the relay winding, as indicated by the arrow on the relay winding.

The energy supplied to the track rails through the supply transformers is supplied from a suitable central source the terminals of which are

designated BX and NX and is distributed throughout the track stretch by a transmission line. The connections between the transmission line and the supply transformers, and between the supply transformers and the track rails, are arranged so that the energy supplied to adjoining sections is 180 degrees out of phase, that supplied to the one section being of normal relative polarity and that supplied to the other being of the reverse or opposite relative polarity.

Each of the track relays CFR is connected across the track rails through phase sensitive rectifying means which operates as hereinafter explained so that energy effective to pick up the contact of a track relay is supplied to the relay when and only when the energy supplied over the track rails has a predetermined phase relationship such that its relative polarity corresponds to that of the energy supplied locally from the transmission line to the rectifying means.

As shown in Fig. 1 the relay BCFR has an upper winding 10, one end terminal of which is connected to one terminal of the condenser BQ1 and through the asymmetric unit K1 to one end terminal of the secondary winding of a track transformer BCTT. The relay BCFR also has a lower winding 11, one end terminal of which is connected to one terminal of the condenser BQ2 and through the asymmetric unit K2 to the other end terminal of the secondary winding of transformer BCTT. The other terminals of the windings of relay BCFR are connected to the terminal 16 intermediate the condensers BQ1 and BQ2, which terminal is connected to one end terminal of the secondary winding of a line transformer BLT, the other end terminal of which is connected to the center tap 12 on the secondary winding of transformer BCTT. Energy from the transmission line is supplied to the primary winding of transformer BLT, while the secondary winding of this transformer is provided with taps so that the voltage of the energy supplied therefrom may be adjustably varied as desired. As is hereinafter explained, the equipment is arranged and adjusted so that the relative polarity of the energy from transformer BLT corresponds to that of the energy supplied to the rails of the section by transformer BTT, and its voltage always exceeds that of the energy derived from the rails of the section and supplied from one half of the secondary winding of transformer BCTT. As is apparent, the primary winding of the transformer BCTT is connected across the rails of section BT so as to be supplied with energy from transformer BTT over the track rails.

During the recurring half cycles of the supply voltage when terminal BX is positive with respect to the terminal NX, the energy supplied to the primary winding of transformer BTT, assuming the contact of the code transmitter CT in this circuit is closed, causes an impulse of energy to be supplied from the transformer secondary winding to the track rails to make track rail 2 positive with respect to track rail 1. This energy is supplied over the track rails of section BT, assuming the section to be vacant, to the primary winding of transformer BCTT and current flows through this winding from its upper to its lower terminal. As a result of this supply of energy through the primary winding of transformer BCTT, there is induced in each of the two track transformer secondary windings 14 and 15 an impulse of voltage which is of such polarity as to make the upper end terminal of each winding portion positive with respect to the lower end terminal of the same winding portion.

The impulse of energy induced in the upper portion 14 of the secondary winding of transformer BCTT tends to cause current to flow from the upper end terminal of this winding through the asymmetric unit K1 to one terminal of the condenser BQ1 and the right-hand terminal of the upper winding 10 of relay BCFR, through this winding from right to left to terminal 16 between condensers BQ1 and BQ2, and thence through the secondary winding of transformer BLT to the center tap 12 on the secondary winding of transformer BCTT.

The impulse of voltage induced in the lower portion 15 of the secondary winding of the transformer BCTT tends to cause current to flow from terminal 12 through the secondary winding of transformer BLT to terminal 16, and thence through the lower winding 11 of relay BCFR from right to left, but the flow of current of this polarity is blocked by the rectifier K2.

At this time an impulse of voltage is also induced in the secondary winding of transformer BLT and is of such polarity that the left-hand end of the winding is positive with respect to the right-hand end. Accordingly, the voltage induced at this time in the secondary winding of transformer BLT tends to cause current to flow to terminal 16, and thence through the lower winding 11 of relay BCFR from right to left and through the upper winding 10 of relay BCFR from left to right. However, the rectifiers K1 and K2 block the flow of current of this polarity in the circuits of both of the windings of relay BCFR.

The various parts of the equipment are arranged and proportioned so that the impulses induced in the secondary windings of transformers BCTT and BLT are either substantially in phase or 180 degrees out of phase, and so that the voltage of the impulses induced in the secondary winding of transformer BLT exceeds that of the impulses induced in either portion of the secondary winding of the transformer BCTT.

The voltage induced in the secondary winding of transformer BLT at this time is of the polarity opposite to that induced in the upper portion 14 of the secondary winding of transformer BCTT, and as the voltage of the impulse from transformer BLT is assumed to exceed that of the impulse from the upper portion of the secondary winding of transformer BCTT, it follows that the resultant voltage is in the direction for which rectifier K1 blocks the flow of current. In other words, the voltage impulse from transformer BLT supplied to the circuit including the upper winding 10 of relay BCFR prevents the voltage impulse induced in portion 14 of the transformer BCTT, from causing the flow of current in the winding 10 of relay BCFR.

Accordingly, with the equipment operating as intended, energy is not supplied to either winding of relay BCFR during the half cycles in which terminal BX is positive with respect to terminal NX.

During the recurring half cycles of the supply voltage when terminal NX is positive with respect to terminal BX, the transformer BTT supplies to the track rails an impulse of energy which causes rail 1 to be positive with respect to rail 2, with the result that energy is supplied to the primary winding of transformer BCTT and causes to be induced in each of the portions

of the secondary winding of the transformer an impulse of voltage which is of such polarity that the lower end of the winding portion is positive with respect to the upper end of the same portion.

The voltage impulse induced in the lower portion 15 of the secondary winding of transformer BCTT causes current to flow from the lower end terminal of this winding through rectifier K2 to one terminal of the condenser BQ2, thence through a load or supply circuit comprising the lower winding 11 of relay BCFR from left to right to terminal 16, and through the secondary winding of transformer BLT to terminal 12.

The voltage impulse induced in the upper portion 14 of the secondary winding of transformer BCTT tends to cause current to flow from terminal 12 through the secondary winding of transformer BLT to terminal 16 and thence through another load of supply circuit comprising the upper winding 10 of relay BCFR but the flow of current of this polarity is blocked by the rectifier K1.

At this time an impulse of voltage is induced in the secondary winding of transformer BLT and is of such polarity that the right-hand terminal is positive with respect to the left-hand terminal. Accordingly, current from the secondary winding of transformer BLT flows from the right-hand end terminal of the winding to terminal 12, from which it flows through the upper portion 14 of the secondary winding of transformer BCTT, through rectifier K1, through the upper winding 10 of relay BCFR from right to left to terminal 16, and thence to the left-hand terminal of the secondary winding of transformer BLT. In addition, current supplied from the secondary winding of transformer BLT flows from the right-hand end terminal of the winding to terminal 12, thence through the lower portion 15 of the secondary winding of transformer BCTT, through the rectifier K2 to the lower terminal of condenser BQ2, and through the lower winding 11 of relay BCFR from left to right to terminal 16 and to the left-hand end terminal of the secondary winding of transformer BLT.

From the foregoing it will be seen that during the half cycles in which terminal BX is positive with respect to terminal NX there is no effective flow of energy in either winding of the relay BCFR.

In addition, it will be seen that during the half cycles in which terminal NX is positive with respect to terminal BX the energy impulse supplied over the track rails causes transformer BCTT to supply an impulse of current which flows from left to right through the lower winding 11 of relay BCFR. In addition, transformer BCTT applies to the circuit of the upper winding of relay BCFR a voltage which is of such polarity that flow of current through the relay winding due to this voltage is blocked by the rectifier K1.

Also, during these half cycles, the transformer BLT supplies to the circuits of both windings of the relay BCFR an impulse of voltage of the polarity effective to cause current to flow in the circuit of the relay winding. The current supplied from transformer BLT to the lower winding 11 of relay BCFR supplements or augments that supplied from the lower portion 15 of the secondary winding of transformer BCTT so that the effective energization of winding 11 of relay BCFR is determined by the sum of the impulses of voltage supplied thereto from transformers BLT and BCTT.

On the other hand the effect of the voltage supplied from transformer BLT to the upper winding 10 of relay BCFR is diminished by the opposing voltage supplied to the circuit of this winding by the upper portion 14 of the secondary winding of transformer BCTT. As explained above, the voltage supplied from transformer BLT exceeds that induced in one half of the secondary winding of transformer BCTT. Accordingly, some current flows in the circuit of the winding 10 of relay BCFR as a result of the impulse of voltage supplied from transformer BLT.

It will be seen, therefore, that the current supplied to the lower winding 11 of relay BCFR is due to the sum of the voltage impulses supplied from transformers BLT and BCTT, while the current supplied to the upper winding 10 of relay BCFR is due to the difference between the voltage of the impulses supplied from transformers BLT and BCTT. Accordingly, the current supplied to winding 11 substantially exceeds that supplied to winding 10. The current supplied to the upper winding 10 flows therethrough from right to left, while the current supplied to the lower winding 11 flows therethrough from left to right, and as the current supplied to winding 11 exceeds that supplied to winding 10, the relay BCFR is effectively energized by current flowing from left to right.

The relay BCFR is of the polar biased neutral type, the contacts of which normally occupy a released position from which they are moved to a picked-up position when and only when current of a selected polarity is supplied to the relay winding. The relay BCFR is connected in the circuit so that its contacts pick up when current flows through the relay winding from left to right. Accordingly, during the half cycles in which terminal NX is positive with respect to terminal BX energy effective to pick up the contacts of relay BCFR is supplied to the relay windings and the relay contacts pick up.

The condensers BQ1 and BQ2 are connected in multiple with windings 10 and 11, respectively, of relay BCFR so that during the half cycles in which energy is supplied to the windings of relay BCFR from the transformers a charge proportional to the voltage of the energy supplied to the relay windings is built up in the condensers, while energy from the condensers flows through the relay windings in the half cycles in which energy is not supplied from the transformers. The condensers BQ1 and BQ2 are of such size that energy supplied therefrom to the windings of relay BCFR maintains the relay contacts picked up during the half cycles in which the transformers BCTT and BLT do not supply energy to the relay BCFR. The condensers BQ1 and BQ2 are also of such size that energy supplied therefrom will not keep the contacts of relay BCFR picked up substantially longer than one half a cycle of the alternating current source.

From the foregoing it will be seen that, when the contact of the code transmitter CT governing the supply of energy to the transformer BTT is closed and the track section is vacant, the relay BCFR is energized from the transformers BLT and BCTT during alternate half cycles of the alternating current source, while the contacts of relay BCFR are maintained picked up during the remaining half cycles by the energy supplied from the condensers BQ1 and BQ2.

During the periods in which the contact of the

code transmitter CT governing the circuit of transformer BTT is open energy is not supplied over the rails of section BT to transformer BCTT and therefore is not supplied from this transformer to the windings of relay BCFR. However, the supply of current from transformer BLT to the circuits of the windings of relay BCFR continues. During the half-cycles in which terminal NX is positive with respect to terminal BX current is supplied over the circuits traced above from the secondary winding of transformer BLT to the windings 10 and 11. However, since at this time current is not supplied from transformer BCTT to the circuits of the windings of relay BCFR, current of substantially equal value is supplied from transformer BLT to each of the relay windings, and as the current supplied from transformer BLT to the windings of relay BCFR flows in opposite directions through the relay windings, no force is exerted to pick up the relay contacts.

During the half cycles in which terminal BX is positive with respect to terminal NX, the transformer BLT supplies to the circuits of the windings voltage impulses of a polarity such that the flow of current is blocked by the rectifiers.

Accordingly, during the open periods of the contact of the code transmitter governing the circuit of the transformer BTT, the contacts of relay BCFR release and remain released. Similarly, during the closed periods of the contact of the code transmitter governing the circuit of the transformer BTT, the contacts of relay BCFR pick up and remain picked up.

During the picked-up periods of the contacts of relay BCFR energy is supplied to the slow release relay BFSA, while during the released periods of relay BCFR energy is supplied over a front contact of relay BFSA to slow release relay BBSA and its contact is picked up to interrupt the circuit of the red lamp R and establish the circuit of the green lamp G of signal SB.

The equipment associated with section CT operates in substantially the same manner and a detailed explanation of its operation is unnecessary.

When a train moving in the normal direction of traffic enters section BT, the shunting effect of the wheels and axles of the vehicles forming the train substantially prevents the supply of energy to the transformer BCTT and thus prevents the supply of energy from this transformer to the relay BCFR. Accordingly, although energy continues to be supplied to transformer BLT, the relay BCFR releases and remains released so that energy is no longer supplied to relay BFSA and it releases to interrupt the circuit of the relay BBSA so that it releases to interrupt the circuit of the green lamp G and to establish the circuit of the red lamp R of signal SB.

When section BT is vacated, energy from transformer BTT is again supplied over the section rails to transformer BCTT so that it supplies energy to relay BCFR to cause the relay contacts to pick up. As a result of the code following operation of relay BCFR, the relays BFSA and BBSA are energized and the circuit of the green lamp G of signal SB is established.

The relay BCFR and associated apparatus are arranged so that if the insulated joints 3 separating sections AT and BT are defective so that energy supplied from transformer ATT to the rails of section AT feeds to the transformer BCTT, it will not cause improper operation of relay BCFR.

As is obvious from the drawings, the transformers ATT and BTT are oppositely connected with the track rails with the result that, when energy supplied from transformer BTT causes rail 1 to be positive with respect to rail 2, the energy supplied from transformer ATT causes rail 2 to be positive with respect to rail 1 and vice versa.

For purposes of illustration it will be assumed that the joints 3 separating sections AT and BT become defective as a result of passage of a train so that energy of normal relative polarity from transformer ATT feeds to the transformer BCTT at a time when the supply of energy of reverse relative polarity from transformer BTT to transformer BCTT is cut off because of occupancy of section BT.

Under these conditions, current continues to be supplied from transformer BLT to the circuits of the windings of the relay BCFR. During the half cycles in which terminal NX is positive with respect to terminal BX, the current supplied from transformer BLT to the circuits of both windings of relay BCFR is of the polarity effective to flow through the rectifiers included in these circuits.

In addition, during the half cycles when terminal NX is positive, and assuming the contact of the code transmitter CT governing the supply of energy to transformer ATT to be closed, energy from transformer ATT is supplied to transformer BCTT and causes to be induced in each of the two portions of the transformer secondary winding an impulse of voltage of the polarity in which the upper end of the winding portion is positive with respect to the lower end of the winding portion.

Accordingly, the voltage impulse induced in the upper portion 14 of the secondary winding of transformer BCTT causes current to flow from the upper end terminal of the secondary winding through the rectifier K1, through the upper winding 10 of relay BCFR from right to left to terminal 16 and thence to terminal 12. The current supplied from the upper portion 14 of the secondary winding of transformer BCCT to the upper winding 10 of relay BCFR supplements or adds to that supplied to this winding from transformer BLT.

At this time, an impulse of voltage is supplied from the lower portion 15 of the secondary winding of transformer BCTT to the circuit of the winding 11 of relay BCFR and tends to cause current to flow from terminal 12 through the secondary winding of transformer BLT to terminal 16, and thence through the lower winding 11 of relay BCFR from right to left but this current is blocked by the rectifier K2. Although the voltage supplied from portion 15 of the secondary winding of transformer BCTT is prevented from causing the flow of current in the circuit of winding 11 of relay BCFR by the rectifier K2, this voltage acts to reduce the effect of the voltage supplied from transformer BLT.

Accordingly, during the half cycle in which terminal NX is positive with respect to terminal BX the current supplied to the upper winding 10 of relay BCFR is due to the sum of the voltage impulses supplied to the circuit of this winding from the transformers BLT and BCTT, while that supplied to winding 11 of relay BCFR is due to the difference between the voltage impulses supplied to the circuit of this winding from the transformers BLT and BCTT. The current supplied to the windings 10 and 11 flows

through the windings in opposite directions, but the current supplied to winding 10 predominates. However, the current supplied to winding 10 flows therethrough from right to left and the relay BCFR is of a type the contacts of which pick up only when current flows through the relay winding in the opposite direction so the relay contacts remain released.

During the half cycles in which terminal BX is positive with respect to terminal NX, the transformer BLT supplies voltage to the circuits of windings 10 and 11 of relay BCFR of a polarity such that the flow of current is blocked by the rectifiers K1 and K2.

In addition, during the half cycles in which terminal BX is positive with respect to terminal NX, the energy supplied from transformer ATT and feeding over the defective joints to transformer BCTT induces in each of the two portions of the secondary winding of transformer BCTT a voltage of such polarity that the lower end of each winding portion is positive with respect to the upper end of the same winding portion.

The voltage induced in the lower portion 15 of the secondary winding of transformer BCTT tends to cause current to flow from the lower end terminal of this winding through the rectifier K2 and through the lower winding 11 of relay BCFR but this current is prevented from flowing by the presence of the opposing voltage of greater value supplied to this circuit from transformer BLT.

The voltage induced in the upper portion 14 of transformer BCTT tends to cause current to flow from terminal 12 through the secondary winding of transformer BLT to terminal 16 and through the upper winding of relay BCFR but this current is prevented from flowing by the rectifier K1.

Accordingly, it is clear that during the half cycles in which terminal BX is positive with respect to terminal NX, the energy supplied over the defective joints from transformer ATT to transformer BCTT cannot result in the supply to relay BCFR of energy effective to pick up its contacts.

It will be seen, therefore, that under the conditions stated, that is, that the insulated joints 3 separating sections AT and BT are defective so that energy from transformer ATT feeds to transformer BCTT, the energy supplied from transformer ATT cannot cause to be supplied to relay BCFR energy effective to pick up its contacts. Accordingly, if section BT is occupied so that energy from transformer BTT is not supplied to transformer BCTT, the relay BCFR is certain to remain released so that relays BFSA and BBSA remain released and cause the red or stop lamp R of signal SB to be lighted.

In like manner the transformers BTT and CTT are oppositely connected with the rails of the track stretch, while the transformer CLT is connected with the circuit of the transformer CCTT and the windings of relay CCFR in such manner that relay CCFR will be effectively energized only when the energy supplied over the track rails is of the same relative polarity as that supplied from transformer CTT and will not be effectively energized when the energy supplied over the track rails is of the relative polarity opposite to that supplied from transformer BTT. This insures that relay CCFR will not be operated by energy supplied from transformer BTT in the event the insulated joints separating sections BT and CT are defective and thus insures that signal SC will not improperly display a permissive indication at such times.

The equipment is also arranged so that failure of the supply of energy to a line transformer, such as transformer BLT, cannot result in improper operation of the associated track relay. If energy ceases to be supplied to transformer BLT, this transformer will cease to supply energy to the circuits of the windings of relay BCFR. If transformer BTT continues to supply energy to transformer BCTT, current will continue to be supplied therefrom to the windings of relay BCFR. During half of the time the voltage induced in the two portions of the secondary winding of transformer BCTT is of the polarity in which the upper end terminal of the winding portion is positive with respect to the lower end terminal of the same winding portion. At this time, therefore, current from the upper portion 14 of the secondary winding of transformer BCTT flows through rectifier K1 and upper winding 10 of relay BCFR from right to left, and thence through the secondary winding of transformer BLT to terminal 12. At this time current from the lower portion 15 of the secondary winding of transformer BLT tends to flow through the lower winding 11 of relay BCFR but is blocked by the rectifier K2.

In similar manner, during the remaining half of the time the voltages induced in the two portions of the secondary winding of transformer BCTT are of the polarity in which the lower end terminal of each winding portion is positive with respect to the upper end terminal of the same winding portion. At this time, therefore, current induced in the lower portion 15 of the secondary winding of transformer BCTT flows through rectifier K2 and through the lower winding 11 of relay BCFR from left to right and thence through the secondary winding of transformer BLT to terminal 12. The voltage induced in the upper portion 14 of the secondary winding of transformer BCTT tends to cause current to flow from terminal 12 through the secondary winding of transformer BLT and thence through the upper winding 10 of relay BCFR but it is blocked by the rectifier K1.

It will be seen that, after energy ceases to be supplied from transformer BLT, the windings 10 and 11 of relay BCFR are alternately energized from transformer BCTT, and that the current supplied to the two windings of relay BCFR flows through one winding in one direction and through the other winding in the other direction so that they develop flux of opposite polarity in the relay core. The relay BCFR will only respond to energy of the polarity supplied to the lower winding and the impulses of energy supplied to this winding when offset by opposing impulses supplied to the winding 10 are ineffective to pick up the relay contacts. Hence, the relay contacts remain released and relays BFSA and BBSA are released and hold signal SB at stop.

The equipment is also arranged so that failure of either or both of the rectifiers K1 and K2 cannot result in improper operation of relay BCFR.

If rectifier K1 breaks down and permits current to flow therethrough in both directions, current will be supplied to the upper winding 10 of relay BCFR from the secondary winding of transformer BLT during both half cycles of the alternating current source. In the half cycles

in which terminal BX is positive with respect to terminal NX, current from the secondary winding of transformer BLT flows to terminal 16, through the upper winding 10 of relay BCFR from left to right, through rectifier K1, which is assumed to be defective, and through the upper portion 14 of the secondary winding of transformer BCTT to the other terminal of the secondary winding of transformer BLT. At this time flow of current from the secondary winding of transformer BLT through winding 11 of relay BCFR is blocked by rectifier K2.

During the half cycles in which terminal BX is positive with respect to terminal NX, the energy supplied from transformer BTT to transformer BCTT causes voltage to be induced in both portions of the transformer secondary winding, this voltage being of the polarity in which the upper end terminal of each winding portion is positive with respect to the lower end terminal of the same winding portion. The voltage from the upper portion 14 is supplied to the circuit of the upper winding 10 of relay BCFR and opposes the voltage supplied at this time from transformer BLT. As explained above, the voltage from transformer BLT is of greater value than that from winding portion 14, so the voltage from transformer BCTT reduces but does not completely prevent the supply of current from transformer BLT through winding 10 of relay BCFR. The voltage induced in the lower portion 15 of the secondary winding of transformer BCTT tends to cause current to flow through the winding 11 of relay BCFR but is blocked by rectifier K2. During this half cycle, therefore, the winding 10 of relay BCFR is energized from left to right by current due to the difference between the voltages of the impulses supplied from transformer BLT and from portion 14 of the secondary winding of transformer BCTT.

During the other half cycles, that is, when terminal NX is positive with respect to terminal BX, the transformer BLT supplies to the circuits of both of the windings of relay BCFR voltage of the polarity effective to cause current to flow through the rectifiers, and the current supplied to winding 10 flows therethrough from right to left and the current supplied to winding 11 flows therethrough from left to right.

During these half cycles the energy supplied over the track rails from transformer BTT to transformer BCTT causes to be induced in both portions of the secondary winding of transformer BCTT an impulse of voltage of the polarity in which the lower end terminal of the winding portion is positive with respect to the upper end terminal of the same winding portion.

The current induced in lower portion 15 of the secondary winding of transformer BCTT is supplied to winding 11 of relay BCFR and supplements that supplied at this time from transformer BLT. The voltage induced in the upper portion 14 of the secondary winding of transformer BCTT tends to cause current to flow from terminal 12 through the secondary winding of transformer BLT and thence from left to right through the winding 10 of relay BCFR, but this voltage is opposed by voltage of the opposite polarity and of greater value supplied at this time from transformer BLT.

Accordingly, after rectifier K1 breaks down, the relay BCFR will be energized substantially the same as normally, except for the supply to winding 10 of current of the polarity effective to pick up the relay contacts.

During the open periods of the contact of the code transmitter CT governing the circuit of transformer BTT, energy will not be supplied over the track to transformer BCTT. At this time energy continues to be supplied from transformer BLT, and during the half cycles in which terminal NX is positive with respect to terminal BX voltage is supplied from transformer BLT to both windings of relay BCFR and currents flow through them in opposite directions so that they offset each other. During the half cycles in which terminal BX is positive with respect to terminal NX, voltage from transformer BLT is supplied to the circuits of both windings of the relay but current is prevented from flowing in winding 11 by the rectifier K2. As rectifier K1 is assumed to be defective current from transformer BLT flows through the upper winding 10 of relay BCFR from left to right, and, therefore, is of the polarity effective to pick up the contacts of relay BCFR or to hold them picked up if they are already picked up. If the current supplied to the winding 10 is of such value as to prevent release of relay BCFR, the relay contacts will remain continuously picked up and relay BBSA will release to cause signal SB to display its red or stop indication.

The equipment operates in substantially the same manner if the supply of energy to transformer BCTT is cut off because of occupancy of section BT instead of because of interruption of the supply of energy to transformer BTT. If, during occupancy of section BT, the current supplied from transformer BLT to relay BCFR through the defective rectifier K1 picks up the contacts of relay BCFR, the relay contacts will be steadily picked up and relay BBSA will remain released and maintain the display of the stop indication by signal SB.

If the rectifiers K1 and K2 both become defective, alternating current from transformer BLT will flow in the windings of relay BCFR, the current in one winding offsetting that in the other winding so no force is exerted to pick up the relay contacts. The voltage supplied from transformer BCTT to the circuits of the windings of relay BCFR is of the polarity such that it tends to cause current to flow in the same direction through both of the relay windings, the direction of flow being from left to right during alternate half cycles of the alternating current source and being from right to left during the other half cycles. Accordingly, the current from transformer BCTT alternately increases and decreases the force exerted tending to pick up the relay contacts. The relay BCFR, although of a type the contacts of which are quick to respond, will not respond to impulses of the duration of one half a cycle of the source so the relay contacts remain released. As the contacts of relay BCFR remain released the relays BFSA and BBSA are released and signal SB remains at stop.

Modification shown in Fig. 2

In Fig. 2 of the drawings there is shown a modification which may be employed in place of that shown in Fig. 1 when the code following relay is provided with a single winding. As shown, resistors 10A and 11A are connected in series across the terminals of the winding of relay BCFRA, while the left-hand end terminal of the secondary winding of transformer BLT is connected to

terminal 16A intermediate the resistors 10A and 11A.

The resistors 10A and 11A thus constitute two load or supply circuits for the relay which replace the windings 10 and 11, and in Fig. 2, the transformers BCTT and BLT supply to the circuits of the resistors 10A and 11A currents of a polarity and value substantially equivalent to that supplied to the corresponding windings of relay BCFR of the species shown in Fig. 1. As the resistors 10A and 11A are connected in series, the resultant voltage across the resistors is proportional to the difference between the opposing currents supplied to the resistors individually, and as the winding of relay BCFRA is connected in multiple with the resistors 10A and 11A, the current supplied to the winding of relay BCFRA is proportional to the difference in the two currents supplied to the resistors 10A and 11A.

As explained in connection with Fig. 1, when the energy supplied over the track rails to transformer BCTT and that supplied from transformer BLT has the proper phase relationship, and terminal NX of the source is positive with respect to terminal BX, the voltage supplied to the circuit of resistor 11A is the sum of the voltage impulses supplied from transformers BLT and BCTT and is of the polarity in which the lower end terminal of the resistor 11A is positive with respect to terminal 16A. At this time resistor 10A is supplied with voltage of the polarity in which its upper end terminal is positive with respect to terminal 16A and of the magnitude determined by the difference between the voltages supplied from transformers BLT and BCTT. As a result the voltage supplied to resistor 10A in part offsets that supplied to resistor 11A, but there is a resultant voltage across the resistors and the winding of relay BCFRA which is of the polarity such that current flows through the winding of relay BCFRA from left to right. This current is effective to pick up the contacts of relay BCFRA, while the resistors 10A and 11A snub the relay BCFRA to prevent release of its contacts during the half cycles in which terminal BX is positive with respect to terminal NX.

This modification operates in substantially the same manner as that shown in Fig. 1 when the supply of energy over the track rails to transformer BCTT is cut off or when energy of the wrong relative polarity is supplied thereto, or in the event one or both of the rectifiers or resistors is defective, and a detailed description of the operation of the equipment at such times is unnecessary.

Modification shown in Fig. 3

The modification shown in Fig. 3 of the drawings is similar to that shown in Fig. 1 but differs therefrom in that the condensers employed in Fig. 1 are replaced by rectifiers or asymmetric units K3 and K4 which are poled to permit flow of energy of the polarity supplied from terminal 16 and to prevent flow of energy in the opposite direction.

The operation of this species is similar to that shown in Fig. 1 except that the rectifiers K3 and K4 serve in place of condensers BQ1 and BQ2 to snub the windings of the relay BCFR to prevent release of the relay contacts during the half cycles in which the relay windings are not effectively energized. The operation of this species is otherwise substantially the same as that shown in Fig. 1 and a detailed explanation of its operation is not necessary.

Although I have illustrated and described only a few forms of railway signaling apparatus embodying my invention, it should be 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 a coded railway signaling system for a stretch of railway track in which the track rails are divided into insulated track sections including a rear section and a forward section, the entrance end of said forward section adjoining the exit end of said rear section, a coded track circuit system for said stretch comprising, in combination, a source of alternating current, means for each section for supplying coded alternating current from said source to the rails at the exit end of such section, so arranged that the current supplied to the rails of adjoining sections is opposite in phase, a polarized relay for detecting occupancy of said forward section having a contact biased to a released position, a first and a second supply circuit for said relay each including a half wave rectifier for governing the operation of its contact, a track transformer having a primary winding connected across the rails at the entrance end of said forward section and a secondary winding having a first portion connected to said first supply circuit and a second portion connected to said second supply circuit, the rectifiers in said supply circuits being so poled that when alternating current is supplied to said primary winding the voltage induced thereby in said portions during one half of each alternating current cycle tends to cause current to flow in a first direction in the first supply circuit only while during the other half of each cycle it tends to cause current of the same value to flow in the opposite direction in the second supply circuit only, phase discriminating means which locally superimposes a voltage of constant effective value derived from said alternating current source on both said supply circuits, said superimposed voltage being higher in value than said induced voltage and of such phase that when the induced voltage is due to current supplied at the exit end of the same section the local and induced voltages are additive in said first supply circuit and in opposition in said second supply circuit, the resultant voltage being effective during said one half only of each cycle to cause pulsating current to flow in said first direction in said first supply circuit and in the opposite direction in said second supply circuit, means comprising said supply circuits for causing the relay contact to assume its picked-up position when and only when the pulsating current in said first supply circuit exceeds the opposing current in said second supply circuit, and code detecting means governed by said contact.

2. In a coded railway signaling system, a coded track system of the type recited in claim 1, in which the phase discriminating means comprises a line transformer which has a primary winding supplied locally with alternating current and a secondary winding connected to both of the relay supply circuits and adapted to supply sufficient voltage thereto to block the flow of pulsating current in either supply circuit during one half of each alternating current cycle irrespective of the relative polarity of the voltage supplied thereto by the associated track transformer, and to cause

the flow of pulsating current in said first direction in the first supply circuit and in the opposite direction in the second supply circuit during the other half of each alternating current cycle.

3. In a coded railway signaling system, a coded track circuit system of the type recited in claim 1, in which the phase discriminating means comprises a line transformer which has a primary winding supplied locally with alternating current and a secondary winding connected to both of the relay supply circuits and adapted to supply sufficient voltage thereto to block the flow of pulsating current in either supply circuit during one half of each alternating current cycle and to cause the flow of pulsating current in said first direction in the first supply circuit and in the opposite direction in the second supply circuit during the other half of each alternating current cycle, said track transformer being effective to increase the pulsating current in the first supply circuit and to decrease that in the second if supplied with alternating current of one relative polarity, and to decrease the pulsating current in the first supply circuit and to increase that in the second if supplied wilh alternating current of the opposite relative polarity.

4. In a coded railway signaling system, a coded track circuit system of the type recited in claim 1, in which the polarized relay is of the differential type and has two windings one of which is connected in series in said first supply circuit in such manner that current flowing therein tends to cause the relay to move its contact to the picked-up position, and the other is connected in series with the second supply circuit in such manner that current flowing therein in said opposite direction tends to cause the relay to move its contact to the biased position, said relay also having a snubbing circuit for each winding effective to prevent the vibration of said contact due to the pulsation of the currents in said supply circuits.

5. In a coded railway signaling system, a coded track circuit system of the type recited in claim 1, in which the polarized relay has a single winding which is connected in a bridge circuit across the end terminals of two series connected resistors through which pulsating currents flow in opposite directions, said resistors constituting the supply circuits for said relay, said relay winding being connected in such manner that the relay tends to move its contact to the picked-up position when the pulsating current in the first supply circuit exceeds that in the second, and to move its contact to the biased position when the pulsating current in the second supply circuit exceeds that in the first, said resistors also providing a snubbing circuit for the relay winding effective to prevent the vibration of said contact due to the pulsation of the currents in said supply circuits.

6. In combination, a source of alternating current, a polarized relay having a contact movable between two positions, a first and a second supply circuit for said relay each including a half wave rectifier for governing the operation of its contact, a transformer having a primary winding supplied at times with alternating current from said source and a secondary winding having a first portion connected to said first supply circuit and a second portion connected to said second supply circuit, the rectifiers in said supply circuits being so poled that when alternating current is supplied to said primary winding the voltage induced thereby in said portions during one half of each alternating current cycle tends to cause current to flow in a first direction in the first supply circuit only while during the other half of each cycle it tends to cause current of the same value to flow in the opposite direction in the second supply circuit only, phase discriminating means for superimposing a voltage of constant effective value derived from said alternating current source on both said supply circuits, said superimposed voltage being higher in value than said induced voltage, said voltages being effective to cause pulsating current to flow in proportion to their sum in the first supply circuit and an opposing current to flow in proportion to their difference in the second supply circuit during said one half only of each alternating current cycle provided the superimposed voltage is of a given relative polarity, said voltages being also effective to cause corresponding currents to flow in both circuits during the other half only of each alternating current cycle, in the event the superimposed voltage is of the opposite relative polarity, in which case the pulsating current in the first supply circuit is correspondingly less than that in the second, and means for effectively energizing said relay in proportion to the difference in the currents in said first and second supply circuits, so arranged as to cause the relay to move its contact in one direction when the pulsating current in the first supply circuit is the greater and in the other direction when the opposing current in the second supply circuit is the greater as determined by the relative polarity of the voltage supplied by said phase discriminating means.

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