

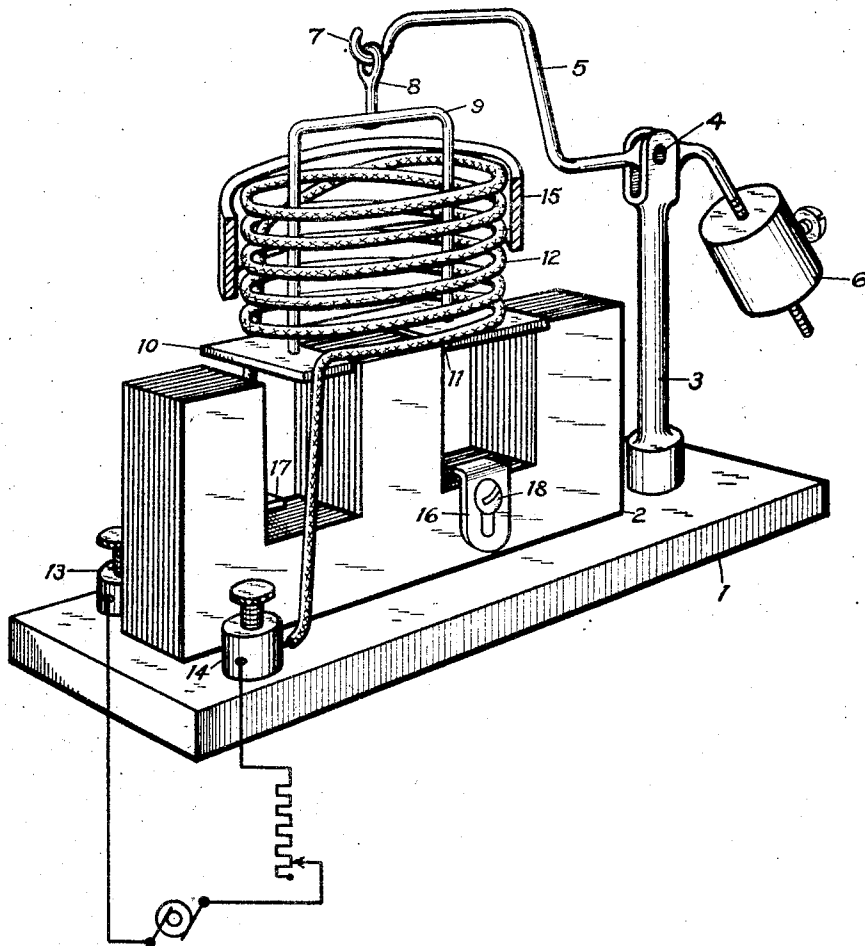
W. K. HOWE.
ALTERNATING CURRENT TRACK CIRCUIT SIGNALING.
APPLICATION FILED SEPT. 30, 1911.

1,056,993.

Patented Mar. 25, 1913.

4 SHEETS—SHEET 1.

FIG. I.



WITNESSES:

George T. Whitney.
Sherman A. Benedict

INVENTOR

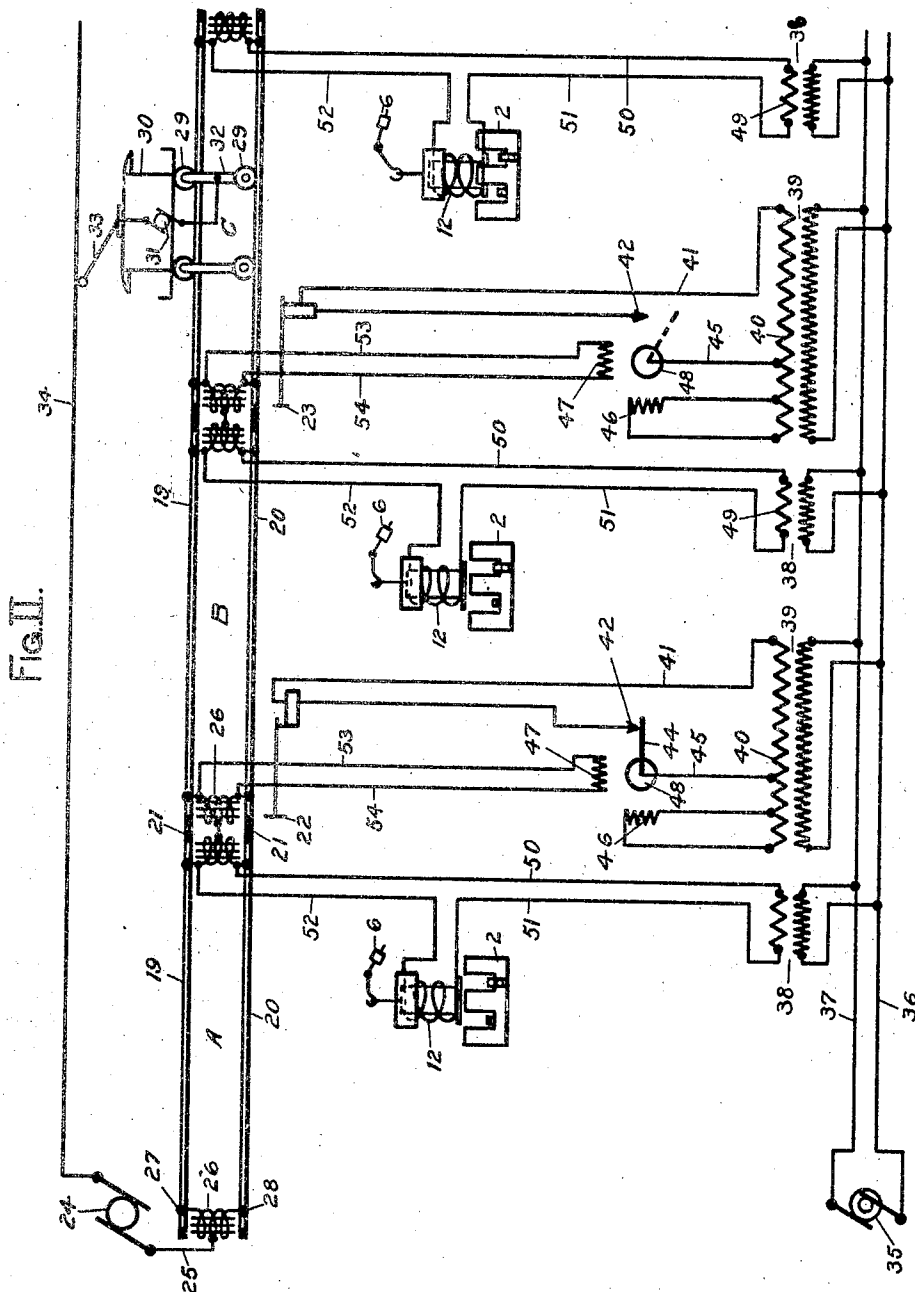
Winthrop K. Howe
BY
Lyman E. Dodge
ATTORNEY

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4 SHEETS—SHEET 2.



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George T. Whitney.
Sherman A. Benedict

INVENTOR

Winthrop K. Howe

BY

Lyman E. Dodge
 ATTORNEY

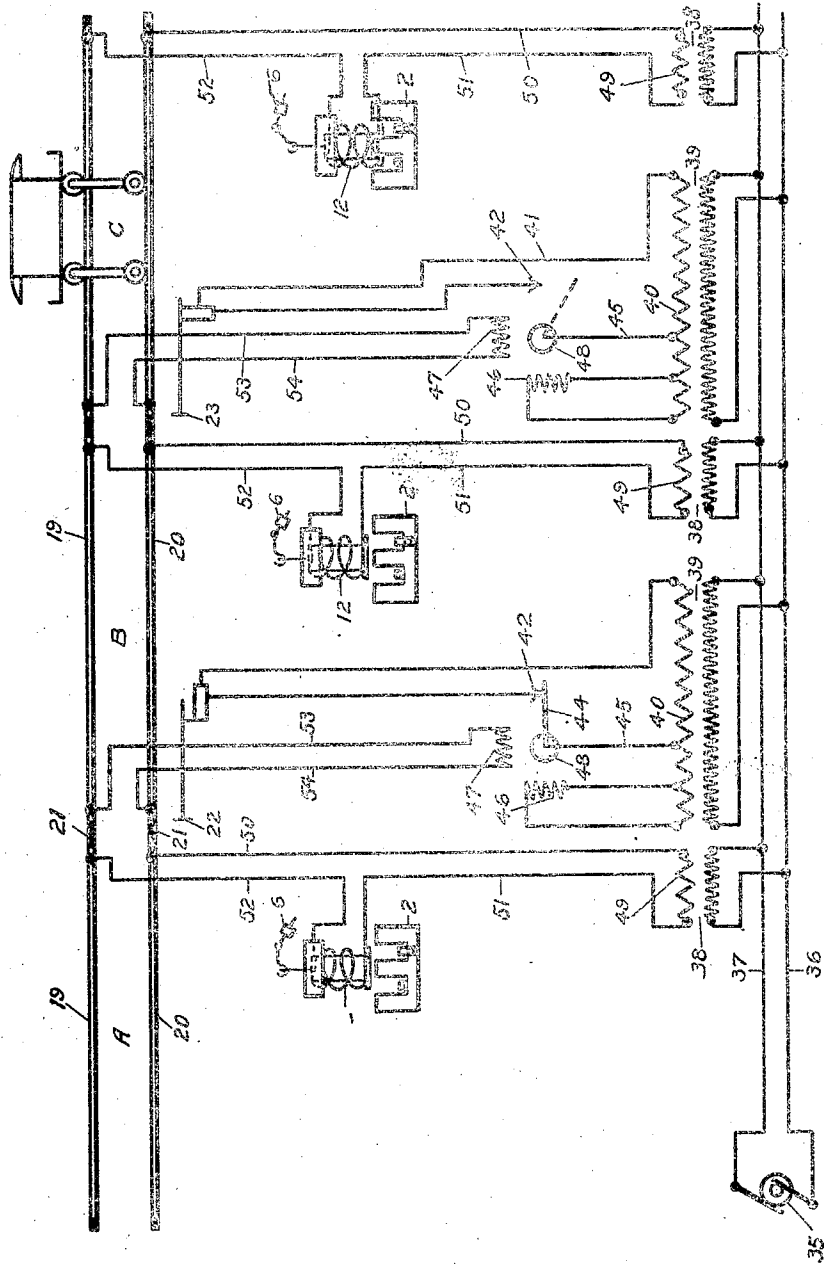
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4 SHEETS—SHEET 3.

FIG. III.



WITNESSES:

George T. Whitney.
Sherman A. Benedict

INVENTOR

Winthrop K. Howe

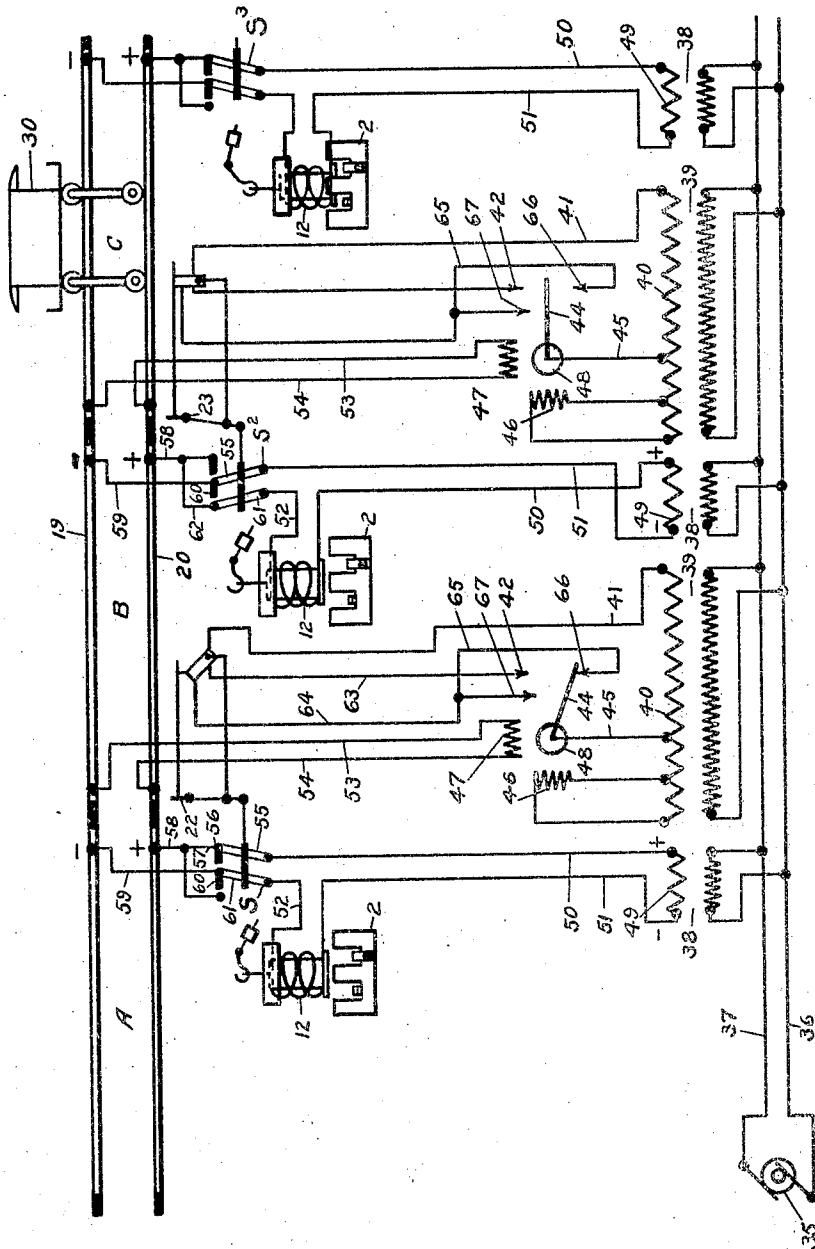
BY

Lynman E. Dodge
ATTORNEY

1,056,993.

4 SHEETS--SHEET 4.

Fig. IV.



George T. Whitney.
Sherman A. Benedict

Winthrop K. Howe
BY
Lyman E. Dodge
ATTORNEY

UNITED STATES PATENT OFFICE.

WINTHROP K. HOWE, OF ROCHESTER, NEW YORK, ASSIGNOR TO GENERAL RAILWAY SIGNAL COMPANY, OF GATES, NEW YORK, A CORPORATION OF NEW YORK.

ALTERNATING-CURRENT TRACK-CIRCUIT SIGNALING.

1,056,993.

Specification of Letters Patent.

Patented March 25, 1913.

Application filed September 20, 1911. Serial No. 310,127.

To all whom it may concern:

Be it known that I, WINTHROP K. HOWE, a citizen of the United States, and resident of the city of Rochester, in the county of Monroe and State of New York, have invented a new and useful Alternating-Current Track-Circuit Signaling, of which the following is a specification.

This invention relates to track circuit signaling and especially to alternating current track circuit signaling.

One object of this invention is to reduce the normal consumption of energy in a track circuit to a minimum.

Another object of this invention is to reduce the maximum energy consumption to a minimum.

As is well understood by those skilled in the art, the greatest amount of energy is supplied by the well known track transformer used in alternating current track circuit signaling when the transformer leads to the track are practically short circuited by the presence of a train upon the track at such point.

It is an object of this invention to reduce the energy consumption under such conditions to a value much less than the normal consumption of energy by the track circuit.

A further object of this invention is to nullify the extremely bad results caused by the short circuiting of the well known insulating joints used in track circuit signaling, and to thereby obtain what is technically known as "broken down joint projection."

Insulating joints in tracks are a great source of annoyance, but as yet no usable practical scheme of track circuit signaling without them has been thoroughly perfected, so that they must at present be endured. It is necessary, however, to provide against the danger caused by the "breaking down" or short circuiting of such joints. The danger resulting from such "breaking down" lies in the fact that the electrical energy in one track circuit section is liable to falsely operate the relay in the next section. Such operation may result either in holding a signal at danger when it should be at clear, or in holding a signal at clear when it should be at danger. The first of these results is extremely annoying and would cause great delay to traffic; the second is of such a nature

that any such possibility must be rendered absolutely incapable of occurring, as it might result in a collision.

In order to provide against the above mentioned results several methods have been heretofore employed. The first method used consists in placing a diagonal conducting bond from the right hand rail of one section to the left hand rail of the adjacent section, and at the other end of the section have the bond connect from the left hand rail of the section to the right hand rail of the adjacent section. As a relay would be connected to the two rails of one section close to the insulating joints and a supply of energy would be connected to the two rails of the adjacent section close to the insulating joints, a breaking down of either joint would result in either short circuiting the relay or the supply of energy, consequently the signal governing either one or the other of the sections would move to the danger position, and a false danger signal would be produced, which would immediately call attention to the defect in the insulating joint. Another method used consisted in so connecting the conductors from the supply of energy to each track circuit that the currents in adjacent track circuits would be displaced in phase one hundred eighty electrical degrees, thus giving opposed polarity, so that if the energy from one track circuit section reached the relay of an adjacent track circuit section it would be operated in a direction reverse to that which it would be operated by energy supplied to it from the proper source, as is well understood by those conversant with the types of relays used in alternating current track circuit signaling. Another method used to provide against the danger mentioned consists in the arrangements shown, described and claimed in the application filed in the name of Fitzhugh Townsend, Serial Number 297,105, January 22nd, 1903. The diagonal bond method of protection is applicable to a system of track circuit signaling employing alternating current in such a manner as to form a system which is similar to the ordinary so-called "polarized track circuit system of automatic block signaling," that is to say the conductors from the source of energy supply connected to a track circuit section may have interposed a pole changing switch

operated by the signal controlling the track circuit section in advance so that in one position of said signal the pole changing switch will be in such a position as to cause current to be fed to the track circuit section in the rear having a difference of phase one hundred eighty electrical degrees removed from the phase of the current supplied to the track circuit section when the said signal and consequently the pole changing switch are in another position. By employing a relay which will assume a central position when no current flows therethrough and which will close a contact on one side of the center when current of one phase relation flows therethrough and which will close a contact on the other side of the center when current of the other phase relation flows therethrough, the three positions, danger, caution and clear, of a signal may be controlled. In such a system the adjacent rail end at an insulating joint may be considered to have like polarity at one time and unlike polarity at another, depending upon the position of the above mentioned pole changing switch, but it is immaterial whether they are of like polarity or of unlike polarity when the joints break down for either the relay of one section or the current supply of the adjacent section will be short circuited, consequently, the relay in one section or the relay in the other will move to the central position and cause a false danger signal, thus attracting immediate attention to the defect. It must be readily seen that the method of transposing the connections from the current supply to the track circuit in alternate sections would not provide for broken down joints in a three position polarized relay scheme of signaling. If the joints should break down there would be at times a current in the adjacent section of the proper polarity to actuate the relay to cause a false clear signal. The third method although applicable to a three position polarized relay scheme of signaling introduces other complications which at present it is not desired to introduce, in the way of a larger number of parts in the insulating joint. Although a diagonal bond scheme of broken down joint protection in a polarized relay track circuit system of signaling thus appears to be the most practicable method to use, it has manifest disadvantages. One disadvantage lies in the fact that with a steam road system a path for any foreign current which may be present at any part of the line is formed, which allows the current to flow unimpeded the full length of the line, and as at present most foreign current is of the direct current type, and may flow through the track relays, causing a magnetic saturation of the magnetic stator and so causing a slowing of the rate of movement of the rotor, it is necessary when

diagonal bonds are used to so construct the relays that they are immune to the effect of direct current, as for instance by the method fully shown, described and claimed in the application of Oscar A. Ross and Anthon H. Vogt, Serial No. 593,673, filed November 22nd, 1910. Another difficulty of greater moment is the fact that with road ballast having a low insulation resistance the leakage of current from one track circuit section to another track circuit section in another track as on a double track road may in wet weather amount to sufficient to wrongly operate the track relay in the track to which the leakage current flows, and might under extreme conditions cause a false clear signal, as such a construction increases the tendency for leakage.

Polarized track circuits have not only the difficulties above mentioned, but also the difficulties incident to ordinary track circuits, to-wit: a large normal energy consumption due to the fact that a resistance must be placed in series with the track leads from the energy supply in order to limit the current flow to a safe value when the track leads are short circuited as by a train standing on the track at the point of connection. As a train may short circuit the track leads for a considerable length of time, a means must be provided to dissipate the heat generated in the resistance, consequently it has heretofore been necessary to form such resistance into cast iron grids of a non-inductive construction and to place the same at some point close to the track in a box, to which the outside air has free access, thus forming an undesired and sometimes unsightly obstruction on the right-of-way. Applicant's invention obviates the necessity for resistances and heat dissipating structures and so removes another of the objectionable features of alternating current track circuit signaling. The use of a resistance in series with the track leads also obliges the use of a higher electromotive force than would otherwise be necessary, in order to cause the necessary current to flow in the track circuit to operate the relay, thus increasing the normal energy consumption. As applicant's invention limits the value of the maximum current flow in the track circuit to far below the value which it attains in systems as installed, it allows the use of smaller conducting members between the energy supply and the track and so effects a much desired economy of high priced material, and as a series of track circuit sections would consume very much less energy than present systems, the line wires from the central station supplying energy to all of the track circuit sections could be much reduced in size thereby effecting another economy. The generator at the central station could also be smaller and con-

sequently much less expensive in first cost and to install and to operate.

In order to explain the principle of the invention, and to describe the mode of operation and construction of the particular physical embodiment of the invention selected by the applicant to illustrate the principle of the invention reference will be had to the accompanying drawings and to the characters of reference therein, in which,

Figure 1, is a perspective view of a device used in connection with my system of track circuit signaling, with one element shown in section. Fig. 2, is a diagrammatic view of a track and the associated mechanism by which my system of track circuit signaling is effected, when applied to an electrically propelled road. Fig. 3, is a diagram, similar to Fig. 2, showing the system as applied to a steam propelled road. Fig. 4, is a diagrammatic view of a wireless automatic block signal system. Fig. 1, shows the construction of one of the improved elements of my system, to-wit: the so called automatic reactance.

Upon the base 1 is fastened the M shaped member 2, composed of thin sheet iron laminae. The post 3 rigidly attached to the base 1 has an upper bifurcated end through which extends a pivot pin 4 supporting a lever 5, having on one end an adjustable weight 6 and having the other end formed into a hook 7. The hook 7 passes through the eye of a rod 8, which is fastened to the center of a U shaped rod 9, the lower ends of the U shaped rod each being fastened to a plate of non-magnetic material 10 having a central cut-away portion 11 in order that the plate may pass over the middle limb of the M shaped member 2. A coil of insulated conducting wire 12 preferably made of copper is wound about both limbs of the U shaped member 9 and is supported by the plate 10, the ends of the coil being attached to the binding posts 13 and 14. If the coil 12 is connected in series with a source of current of constant electromotive force and an adjustable resistance, with the resistance so adjusted that not more than a certain predetermined quantity of current flows through the coil there will be no bodily movement of the coil, but if the quantity of current flowing through the coil is increased by cutting out resistance, the magnetic field produced by the current flowing in the coil 12 will, in its endeavor to flow through the path of least reluctance draw the coil downward upon the middle limb of the M shaped member 2, overcoming the torque produced by the weight 6 to hold it in its normal position as shown in Fig. 1. A gradual removal of the resistance in series with the supply of current and the coil 12, will cause the coil 12 to be drawn lower and lower upon the middle limb of the member

2, but the downward movement is resisted by a greater and greater torque exerted by the weight 6 as it is apparent that the weight 6 as it moves upwardly to a horizontal position exerts a greater and greater torque this torque being proportional to the increasing torque of the coil 12 as it is drawn down farther and farther upon the middle limb of the member 2. In practice the device is so designed, however, that a very slight increase of current is required to start the coil 12 to moving downward. As the coil moves downwardly upon the middle limb of the member 2, the reactance of the coil to alternating current is gradually increased. The increased reactance in the coil caused by its movement downward upon the middle limb of the member 2 is a phenomenon well understood by those versed in the electrical art. As the reactance of the coil increases, the same electromotive force which caused the normal predetermined current to flow in the coil would necessarily cause less current to flow in the coil, but if at the same time the adjustable resistance in series with the coil and the source of current were gradually made less and less by the same amount, the same electromotive force which caused the normal predetermined quantity to flow through the coil when in its upper position would still cause the same predetermined amount of current to flow. It is to be observed that although the current in the coil remains the same, the electromotive force across the terminals of the coil changes, for the drop of potential which formerly existed across the adjustable resistance has now been transferred across the terminals of the automatic reactance thus largely increasing it. The increase in the reactance of the coil results in an increase in the apparent resistance or impedance and also results in a displacement of the phase of the current so that it lags a greater or less extent behind the electromotive force, therefore, the power factor of the circuit is changed. In the case of the coil just described, as the reactance increases the ohmic resistance of the coil remaining the same, the cosine of the angle as shown upon a system of rectangular coordinates between an abscissa and a line representing the phase of the current when the coil is drawn downward to its greatest extent is much less than the cosine of the angle between the same abscissa and the line representing the phase of the current when the coil is in the position as shown in Fig. 1, consequently, as the power factor is proportional to the cosine of such angles it is very much greater when it is in the position as shown in Fig. 1, and so closer to unity. It is also to be observed that as the power factor decreases, under such conditions the current is displaced in phase more and more as the coil is drawn down upon the middle

limb of the member 2 as the ohmic resistance remains constant but the reactance of the coil changes.

About the coil 12 is placed the copper annulus 15 which is rigidly supported in the fixed position shown in any approved manner. As it may be possible that the power factor of the coil 12 when in the upper position as shown in Fig. 1, is too low, it may in some cases be necessary to raise it, which may be done by placing the copper annulus 15 so that when the coil is in its upper position it will be surrounded by the annulus. Under such conditions an alternating current flowing in the coil 12 will generate a current in the annulus 15 which will react in the well known manner upon the coil 12 to reduce its reactance and thus the ohmic resistance of the coil remaining the same, increases the power factor and as the power factor is increased by a change in the reactance only, the current will be brought nearer in phase with the electromotive force. In the great majority of cases it will probably be unnecessary to use the annulus 15, it being merely shown and described to illustrate the most perfect embodiment of applicant's invention making it applicable to the most extreme condition.

Upon the front and back faces of the M shaped member 2 the limiting stops 16 and 17 are adjustably mounted, being held in adjusted position by screws as 18. As the coil 12 is drawn lower and lower upon the middle limb of the M shaped member 2, the reactance gradually increases and the power factor gradually decreases and the current is displaced in phase more and more as the coil is drawn down upon the middle limb of the member 2 as heretofore pointed out, but in some cases it may be undesirable to have the coil drawn entirely down upon the middle limb of the member 2, therefore the adjustable stops 16 may be used to prevent the coil moving down too far, for in some cases it may be advisable to prevent too great a decrease in the power factor of the circuit containing the coil 12 and thus prevent too great a displacement of the phase of the current therein.

Referring to Fig. 2, 19 and 20 designate the two rails of an electrically propelled road, separated at intervals by the insulating joints 21, thus forming blocks each of which is governed by a signal as 22 or 23 at the entrance thereof. A generator 24 is located as is customary at one end of the line, one terminal of which is connected by the wire 25 to a central point of the winding upon the well known iron core track reactance bond 26, the two ends of which are connected as at 27 and 28 to the two rails of a block at one end thereof. At the other end of the same block and at the beginning of the next adjacent block, similar iron core re-

actance bonds are placed connected in the usual and well known manner and at the meeting points of all of the subsequent blocks reactance bonds are likewise connected, thus furnishing an unimpeded two rail return for propulsion current from the wheels 29 of an electrically propelled car 30 to the source of current 24 at the terminal station. The motor 31 of the car 30 is connected by one terminal to the axle 32 upon which the wheels 29 are placed and the other terminal is connected by means of the trolley pole 33 to the trolley wire 34 which is connected to one terminal of the generator 24 at the terminal station.

A source 35 of alternating current is located at the central station and is connected to the two line wires 36 and 37 extending the length of the track-way. At suitable points the primary windings of the transformers 38 and 39 are connected to the line wires. The secondary winding 40 of the transformer 39 supplies the two position signal 22 with current through the wire 41, point 42, contact arm 44 and wire 45, and also supplies electrical energy to one winding 46 of the relay. The relay is of the well known polyphase type having two windings 46 and 47 and a shell rotor 48 bearing the contact arm 44 which, when the relay is energized is adapted to bear against the contact 42. The secondary winding 49 of transformer 38 through the wire 50 connects to one track rail 20 and by means of wire 51 connects to one end of coil 12 upon the automatic reactance device and from the other end of the coil 12 connects by means of wire 52 to the other rail 19 of the trackway, thus supplying energy to the track circuit. At the other end of the block section thus supplied with energy, one wire 53 connects with one rail 19 and with one end of winding 47 of the relay and another wire 54 connects with the other track rail 20 and with the other end of winding 47 of the relay.

Aside from the automatic reactance device the system as shown in Fig. 2, is constructed and would operate exactly the same as the common and well known forms of alternating current block signaling systems, that is to say, the presence of a train upon either block section B or C would cause in the well known manner the signal such as 22 or 23 governing the entrance to said block to move to the danger position. By the use of the automatic reactance, however, the various objects herein before stated are attained.

In ordinary systems in place of the coil 12 between wires 51 and 52 a non-inductive grid resistance is inserted so that in order to produce the necessary available drop of potential across the terminals of wires 53 and 54 at the points where they are connected with bond 26, a greater voltage must be present at the terminals of the secondary

coil 49 of the transformer 38 than would otherwise be necessary, consequently, the normal consumption of energy in such a track circuit is greater than one in which the coil 12 is in series with wires 51 and 52, as the coil 12 as constructed by applicant is of a great deal less ohmic resistance than the non-inductive grids as ordinarily used, therefore, the normal consumption of energy by a track circuit section is decreased.

As the purpose of the non-inductive grid resistance is to limit the amount of current which may flow when the wheels and axles of a car bridge the terminals of wires 50 and 52 and as at times a car may remain in such a position for a great length of time, the resistance grids must be of a size to properly limit the current and at the same time be so constructed and installed as to dissipate the heat generated by the flow of current through them under the most adverse conditions, at the same time their resistance must be of as low a practicable value as possible in order to decrease as much as possible the normal energy consumption of a track circuit section. It is impracticable to so design a non-inductive grid resistance that the amount of current flowing when the terminals of wire 50 and 52 are short circuited by a train is no greater than the amount of current flowing when no train is present upon the track circuit section. In fact there is an enormous difference between the amount of current flowing under normal conditions and the amount flowing upon the short circuiting of the wires 50 and 52 so that the consumption of current by a track circuit section under abnormal conditions is very great. By the insertion of the automatic reactance in series with wires 51 and 52, the presence of a train across the terminals of wires 50 and 52 causes the coil 12 to be drawn down upon the middle limb of the member 2, as shown in Figs. 2, 3 and 4, and as it is drawn down upon the member 2 the impedance of the coil 12 is increased and the coil 12 may be so designed by principles well known to electrical engineers that the current flowing through coil 12 will be the same whether a train is present, short circuiting the terminals of wires 50 and 52 or whether no train is present, the train and the track rails taking the place of the adjustable resistance heretofore described in connection with the coil. As soon as a train which has short circuited the terminals of wires 50 and 52 passes on, the weight 6 returns the coil to its initial position.

As the coil 46 upon the relay is connected directly to the secondary 40 of the transformer 39 and as it is wound upon the magnetic stator of the motor, it is as ordinarily constructed, highly reactive and consequently the power factor is low and the current is displaced in phase from the electromotive

force by a considerable electrical angle. In order to get good operation of the relay it is therefore necessary that the current flowing through winding 47 of the relay be displaced as little as possible in phase from the electromotive force. With the connections from the secondary 49 of the transformer 38 through the automatic reactance 12 to the track-rails 19 and 20 as herein shown, the circuit containing winding 47 has a high power factor. This is so because the ohmic resistance of coil 47 is a very small fraction of the ohmic resistance of coil 46 and because the reactance in the circuit including winding 47 is both very much less than the reactance in the circuit including winding 46, and the circuit including the winding 47 is furthermore highly resistive. The current flowing through winding 47 is therefore more nearly in phase with the electromotive force. By reason of such facts a good difference of phase between currents in windings 46 and 47 is maintained thereby resulting in a good torque in the relay. With the arrangements and constructions as shown by Fig. 2, if the insulating joints 21 should become short circuited a current would flow from the rails of one section to the rails of the next section and so through the track winding of the relay. It must be readily understood that an operation of the relay would result, if the current thereby reaching the track winding of the relay was displaced in phase, from the current flowing in the local winding of the relay as 46. As heretofore pointed out, an operation of the relay under such conditions is objectionable and in some cases absolutely dangerous and heretofore, in order to provide against such difficulty as already pointed out, connections from the line wires to the track from the supply of energy have been transposed in adjacent sections thus causing an operation of the relay under such conditions of broken down insulating joints that will result in a danger signal not in a clear signal. As heretofore pointed out such a method is not applicable to the so-called "alternating current polarized track circuit" and recourse has been had to the diagonal bond heretofore mentioned but the diagonal bond method of protection also has its difficulties which have been fully pointed out and in addition has the difficulty that its connection to the track rails may become broken without in any way impairing the normal operation of the system, but such a broken connection absolutely destroys broken down joint protection and is extremely difficult to detect in some cases. In applicant's system, occurrence of broken down joints furnishes a path of very low resistance from the supply of energy in one section to the relay in the adjacent section and therefore acts upon the automatic re-

actance device exactly as does the presence of a train short circuiting its terminals so that the movable coil thereof is drawn down upon the middle limb of the iron member, the reactance of the coil is largely increased and consequently the current flowing there-
 5 through is largely displaced in phase from that of the electromotive force so as to lag considerably behind the same. As has
 10 already been pointed out the current which is caused to flow through the track winding of the relay in order to produce a good rotation of the relay is displaced very slightly in phase from the electromotive force, consequently the current which flows to the
 15 track phase of a relay from an adjacent section when the joints break down, does not have the proper phase relation as regards the current flowing in the local phase
 20 of the relay to produce the rotation, for, the current flowing through the track winding of the relay, under such conditions is or can be made to have the same phase displacement from the electromotive force that
 25 the current flowing in the local winding of the relay has.

In Fig. 4 has been shown a three position automatic signal system employing no line wires, that is, a system ordinarily known
 30 as a wireless system. In its broad features it differs from the system as shown in Fig. 2 merely by the means used to obtain the third position of the signal, to-wit: the pole changing switch designated generally by S.
 35 This switch is inserted in the leads from the track transformer and the automatic reactance device to the track and is actuated by the movement of the signal blade, so that when the signal blade is in the full
 40 clear or 90° position the switch will make the same contacts that it is making as shown at S, but when the signal blade moves below the 45° or caution position, the switch will make the contacts as shown at S². Considering
 45 the left hand section as shown on Fig. 4, and also considering that part of an alternating current wave above a middle ordinate as positive, and that below as negative, and that at a certain instant positive current
 50 starts from the right hand end of transformer 38 in section A, then the current will flow by means of wire 50, arm 55, contact 56, wires 57 and 58 to the lower track rail 20,
 55 and the return current will flow from track rail 19, through wire 59, contact 60, arm 61, wire 52, reactance coil 12, and wire 51 to the other side of the secondary of the transformer. These different polarities have been
 60 indicated by the usual positive and negative sign. If we consider the same instant of time that current is flowing in section A, as herein described, current would also flow in section B, from the right hand end of transformer 38 in section B, to wire 50,
 65 through reactance coil 12, wire 52, arm 61,

wires 62 and 58 to the lower track rail 20, thus impressing positive polarity current upon the lower track rail, the current flowing to and through the track winding of the relay at the other end of the section to the upper rail 19, thence by means of wire 59
 70 to contact 60, through arm 55 and wire 51 to the negative side of the transformer. It should be observed, however, that the switch S² has been moved to a position differing
 75 from that of switch S, on account of the fact that the signal 23 has its blade at the danger position, but if the switch had not been moved but were in the same position as switch S, connected with section A, then the lower rail instead of being of positive
 80 polarity would be of negative polarity. The polarity of the rails with the parts as shown is indicated by the usual polarity signs at the connections of the wires 58 and 59 to the rails 19 and 20. The polarity of the
 85 rails in section C, with the switch S³ as indicated, will be the same as that in section A. It must be readily seen, that the polarity of the rails in adjacent sections with all signals at clear is reversed so that abutting rail ends separated by an insulating
 90 end post will be of different polarity throughout the system, consequently any breaking down of the joints, while all signals are at clear, would act upon the relay
 95 exactly as does the breaking down of the insulating joints in the case of a system connected as is shown by Fig. 2. Even if by use of the ordinary reactance device the
 100 phase of the current flowing through the track winding of the adjacent relay were not exactly the same as the phase of the current flowing through the local winding of the same relay and so connected to cause
 105 rotation, the very worst that could happen would be the actuation of the relay in a direction opposite to that which would cause the signal to go to the clear position and so such a movement could only cause the
 110 signal to move to the 45° or caution position. The circuit in which current flows to cause the signal to move to the 90° position is as follows: secondary 40 of transformer 39, wire 41, signal mechanism wire
 115 63, relay point 42, relay contact bar 44, wire 45 to the other terminal of the secondary of the transformer. The circuit in which current flows for the 45° position, is wire 41, connected to the secondary 40 of the trans-
 120 former 39, signal mechanism wires 64 and 65, contact point 66, contact bar 44, and wire 45 to the other terminal of the transformer. It will be observed that connection is made to wire 64 and to the negative
 125 terminal of the transformer when the contact arm 44 is in a position to cause current to flow through the circuit to move the signal to the full clear position. This is the
 130 usual custom and is for the purpose of mov-

ing the signal blade from the zero or danger position to the 45° or caution position so that it may thereafter by current flowing in the full clear circuit be moved to the full clear position as at times the contact arm 44 moves to the position opposite to that as shown by the relay connected to section B, when the signal blade is in the zero or danger position and as soon as the connection were made to move the signal blade to the 90° position, no movement at all of the signal blade would take place as it must on account of the construction of the operating mechanism be first moved to the 45° position before being moved thereafter to the full clear position by the current flowing in the full clear circuit. A car 30 is shown upon the rails of section C, consequently current is shunted from the track winding of the relay and the contact arm 44 moves to the central or neutral position and in so doing, breaks both the caution circuit and the full clear circuit, so that the signal moves to the danger position as shown, and also moves the pole changing switch S² to the position as shown, reversing the polarity of the current ordinarily supplied to the track section B, consequently moving the contact arm 44 from its normal position from contact with contact points 42 and 67 to a position in contact with contact point 66 as shown, thus causing the signal blade attached to signal 22 to move to the 45° or caution position as shown. With the signal 22 at the caution or 45° position caused by the movement of the pole changing switch S², the polarities of the abutting rails at the insulating joint at signal 22 will be the same, consequently, the occurrence of a broken down joint at such a time would not result in a full clear signal, for even if the current passing through the automatic reactance device in section A were out of phase with the current supplied to the local winding of the track relay in section B, any movement which took place would be in the same direction as that caused by the current in the section itself. If the insulating joint between sections B and C were broken down and the phase of the current passing through the automatic reactance device connected to section B had not been exactly balanced with the phase of the current flowing through the local winding of the relay in section C and enough movement of the contact bar 44 of the relay connected to C had been caused to complete the circuit for the 45° indication, then upon the approach of a train, the current would all be shunted through the wheels and axles of the train and the relay attached to the rails of section C would be deenergized and the signal would go to the danger position and after the train had passed the insulating joint and gone

upon the rails of section C, the signal would still remain at danger, for although the phase of the current supplied to section B through the automatic reactance device might be under unusual conditions slightly displaced from the current supplied to the local winding of the relay C, it would never be so largely displaced that it would be able to cause sufficient movement of the contact bar of the relay in section C to close the contacts after the relay had once been brought to rest, and especially while a shunt was present, caused by the presence of a car upon the rails to which it is attached. Whenever the insulating joints break down between two sections as between sections B and C with no train present, the signal governing the advance section as 23 will be placed to danger and at the same time the signal governing the rear section as 22 will also be placed at danger for the path of low resistance furnished to the current from the automatic reactance device 12, connected to section B causes the coil 12 to be drawn down so far upon the middle limb of the member 2 and the reactance of the coil thereby so largely increased, that the phase of the current supplied to the track winding of the relay connected to section B is so largely displaced from normal and approaches so closely to the phase of the current supplied to the local winding of the relay connected to section B that sufficient torque is not exerted upon the rotor of the relay to hold the contact bar 44 in the very extreme position. Even if the current supplied to section B should reach the track winding of the relay connected to section C and even if it should be displaced in phase sufficiently to operate the relay, no dangerous results could flow, for the direction in which the contact bar 44 would be moved, would be toward the central or neutral position as the polarities would be opposite in the two sections, consequently, the signal would go to danger, but as soon as it did go to danger the pole changing switch S² would be changed to the position as shown in Fig. 4, thereby reversing the polarity of the current supplied to the rails of section B, then the current would flow from the section B to the relay connected to the section C in a direction to cause the signal to move to the 45° or caution position, but as soon as it did so move, the pole changer would be again reversed, reversing the polarity of the current supplied to the section B and the same conditions would re-occur that were present in the beginning, so that the signal would again go to danger, the total result being a constant "pumping" of the signal from the zero degree position to the 45° position.

It is to be observed that the application of the automatic reactance device to a po-

larized track circuit, just as in the case of its application to an unpolarized track circuit, does not necessitate any connections which are at any time idle in the normal working of the system, consequently a poor connection or a broken connection which would destroy the effect of the protective apparatus would also so disturb the normal operation of the system that the signals affected thereby, which would under broken down insulated joint conditions be affected by the automatic reactance device, would be moved to the danger position.

Although applicant has herein shown and described his new and useful means in connection with what are ordinarily termed "two rail" track circuits, it is obvious to those skilled in the art that the new and useful means described by applicant are equally applicable to any form of rail circuits and applicant considers that the application of his novel and useful means to the so-called "single rail" track circuits, is well within his invention.

As the power factor of the circuit including the automatic reactance device is decreased by short circuiting the terminals of its coil, there is no large increase of current flow in broken down joint conditions as there is in systems as ordinarily installed, therefore, another big drain upon the capacity of the central station and of the alternating current generator is eliminated. Another great advantage of this system of broken down joint protection lies in the fact that all of the connections concerned in the method of protection are merely the wires and connections which must be intact in order for the system to operate normally, so that if any of the connections relied upon to secure broken down protection are not intact the condition is immediately notified by the failure of the system to operate as it is intended to normally operate.

It might well be that the short circuiting of the insulating joints 21, thus allowing current to flow from the track rails of one section to the track phase of the relay of the next, would cause the coil 12 to be drawn so far down upon the middle limb of the member 2 that the reactance would be so greatly increased and the power factor of the circuit would then become so low that the current flowing in such circuit would be displaced in phase so as to agree with the current in the local winding of the relay 46, but it might be displaced still further so that a rotation of the relay would occur in a direction to open the same. In order to avoid this difficulty the adjustable stops can be so placed that the power factor of the circuit containing the coil 12 and the track winding of the relay in the adjacent section is never decreased to a point below the power factor of the current containing the

local winding of the relay in the adjacent section.

The system as shown diagrammatically by Fig. 3, is constructed upon the same principle and operates in exactly the same manner as does the system shown in Fig. 2, and it is shown merely for the purpose of bringing out the fact that the principle underlying applicant's invention is as applicable to a steam propelled road not making use of reactance bonds as it is to an electrically propelled road making use of devices for insuring the unimpeded return of the propulsion current through one or both rails.

Although applicant has herein shown and described a copper annulus as being placed about the coil 12 of the automatic reactance device, it must be distinctly understood that such is not a necessary part of applicant's invention and that the same would only be used under extreme conditions when, for instance, the phase of the current flowing to the track phase of the relay under normal conditions is displaced at too great an electrical angle to the phase of the electromotive force.

Although applicant has herein shown and described his invention as applied to an automatic block signal system, applicant wishes it to be understood that the invention is by no means limited to such a system, for the principle underlying the invention is applicable in connection with track circuit sections used for any purpose.

Having explained the principle of my invention and described the construction and mode of operation of a particular physical embodiment thereof, what I claim as new and desire to secure by Letters Patent, is:

1. In a system of track circuit signaling: a source of alternating current; a trackway composed of rails; insulating joints in the rails at intervals forming sections; a translating device in each section having two windings; connections from one of the windings to the source of current; connections from the other winding to the track rails; connections between the source of current and the rails in each section; and a device inserted in said last named connections adapted to change the phase of current flowing therethrough upon a breaking down of the insulating joints between two abutting sections and the completion of a circuit from the connections from the source of alternating current in one section through the winding of the translating device of the adjacent section connected to the track rails, the change being such that the current will have a phase different from that of the current which properly flows in the adjacent section, so that the improper flow of current will not cause the same operation of the

translating device in the adjacent section, as the proper flow of current would cause.

2. In a system of track circuit signaling, a source of alternating current, a trackway
5 composed of rails, insulating joints in said rails at intervals for forming sections, a translating device in each section, connections between the translating device and the rails, connections between the rails and the
10 source of alternating current in each section, and a device inserted in said last mentioned connections adapted to change its power factor when the insulating joints break
15 down and current flows from the supply of one section to the translating device of the adjacent section, for preventing the current in one section from improperly operating the translating device of the adjacent section.

3. In a system of track circuit signaling,

a source of alternating current, a trackway 20 composed of rails, insulating joints in the rails at intervals forming sections, a translating device in each section having two windings, connections from one of the windings to the source of current, connections 25 from the other winding to the track rails, connections between the source of current and the rails, and a device inserted in said connections adapted to change its power factor to approach the power factor of the 30 winding of the relay in the adjacent section connected directly to the source of current upon a breaking down of said insulating joints.

WINTHROP K. HOWE.

Witnesses:

LESLIE J. PHILLIPS,
MARY G. DALBY.