Nov. 1, 1938. W. T. POWELL 2,134,952

AUTOMATIC TRAIN CONTROL SYSTEM

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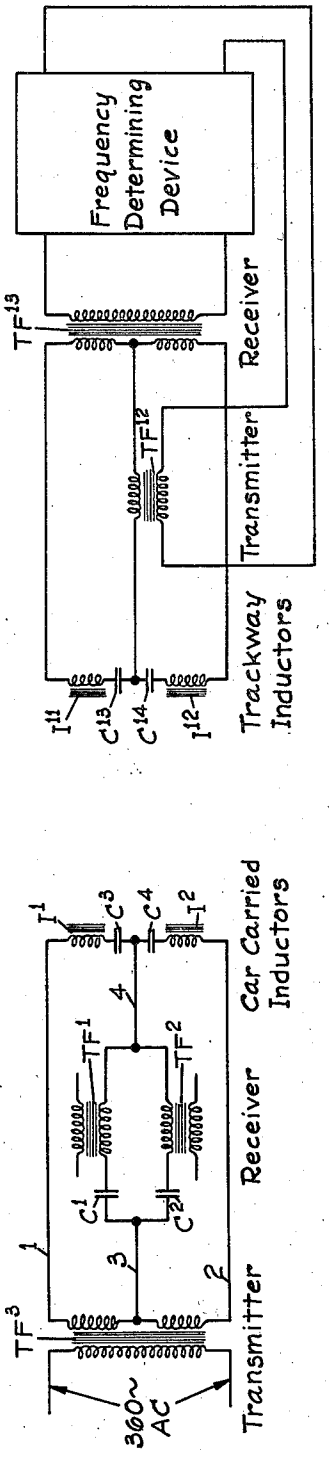


FIG. 1.

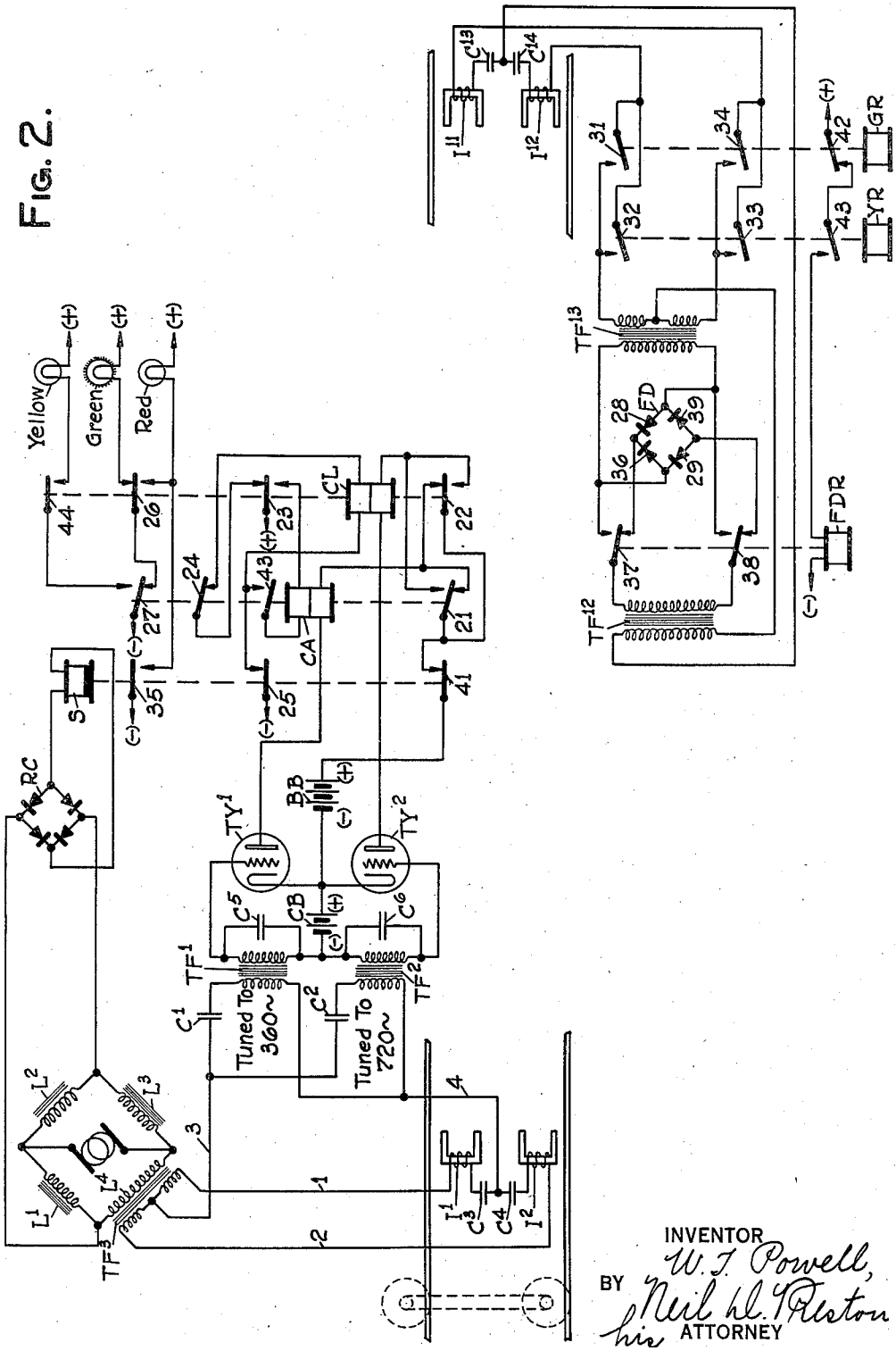
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FIG. 2.



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2,134,952

AUTOMATIC TRAIN CONTROL SYSTEM

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Application February 18, 1937, Serial No. 126,423

18 Claims. (Cl. 246—63)

This invention relates to automatic train control systems for railroads and more particularly to an intermittent inductive system of the inert track element type, in which means are employed for transmitting signal indications between the wayside and the train.

The system of the present invention is characterized by the use of an inert wayside circuit, by the transmission of energizing electric energy from the train to the wayside circuit, the transmission of the energy back again to the train after having been controlled in accordance with traffic conditions and the actuation of the signal devices on the train by the return transmission.

The general purpose or object of the present invention is to provide a safe and efficient means for discriminating between the outgoing and the return transmission of electrical energy and of thereby insuring that the energy which is effective in operating the signal device is derived from the outgoing energy and that it has been subjected to wayside control in accordance with traffic conditions.

More specifically, distinctive clear, caution and stop indications are transmitted from the wayside to the train by the intermittent inductive cooperation of receiver carried inductors on a railway vehicle and inductors located along the track, which inductors comprise simple magnetic cores and coils energized only from a source of alternating current on the vehicle, and which provide an organization in which the receiver on the vehicle will not be adversely influenced by extraneous magnetic fields along the trackway and in which transmission of the indications is effective, without changing circuit connections or the like, for movement of the vehicle in either direction past the inductor location or with either end of the vehicle ahead.

The present invention is in the nature of an improvement on the invention disclosed in the co-pending application of W. H. Reichard, Ser. No. 70,259, filed March 23, 1936.

Various other characteristic features, advantages and objects of the present invention will be evident from the illustrated embodiments shown in the accompanying drawings in which:—

Fig. 1 is a schematic circuit diagram shown for the purpose of illustrating the theory of operation of the present invention.

Fig. 2 is a diagrammatic representation of the parts and circuits constituting the vehicle equipment and trackway equipment, these parts and circuits being shown in a manner to facilitate in an understanding of the invention, rather than to show the particular construction and arrangement of parts preferably employed in practice.

General operation

Referring to Fig. 1, alternating current energy generated aboard the vehicle is transmitted through transformer TF^3, through car carried inductors I^1 and I^2 in series with condensers C^3 and C^4. The series circuit including the secondary windings of transformer TF^3, inductors I^1 and I^2 and condensers C^3 and C^4 is tuned to the source of alternating current frequency, which may be, for example, 360 cycles per second. Each of these car carried inductor coils comprises a U-shaped laminated iron core (as illustrated in Fig. 2) and is so mounted on the train as to pass over and coact inductively with a complementary coil disposed along the trackway.

The trackway coils I^{11} and I^{12} are likewise provided with U-shaped laminated cores, these cores being made of large size because they are intended in themselves, without their coils, to effect the train carried circuit as will be described.

When the train passes the wayside control point, train carried inductor I^1 links magnetically with wayside inductor I^{11} and train carried inductor I^2 links magnetically with wayside inductor I^{12}. The wayside coils are connected together in a series circuit including condensers C^{13} and C^{14}, which circuit is tuned by these condensers and the inductors of the coils to the 360 cycle current.

The two train carried inductors and the two wayside inductors are so wound and connected in their respective circuits that current from the generator flowing through coils I^1 and I^2 in series induces current in coils I^{11} and I^{12}, which are connected in series aiding relation with respect to each other in the circuit including the two primary windings of transformer TF^{13} in series. The current which flows through this series circuit, including the primary windings of transformer TF^{13} in series, induces an E. M. F. in the secondary winding of transformer TF^{13} and this E. M. F. in the secondary winding transmits current through the frequency determining device (to be later described) to the primary (right hand) winding of transformer TF^{12}.

The above discussion relates to the transmission of alternating current energy from the vehicle to the wayside apparatus over a series circuit including the car carried and trackway inductors. It will be seen that the car carried apparatus, including transformer TF^3 and inductors I^1 and I^2 in series, operate as a trans-

mitter and the wayside apparatus, including inductors I^{11} and I^{12}, together with transformer TF^{13}, act as a receiver.

The frequency determining device permits 360 cycle current, or double this frequency (720 cycles), to be applied to transformer TF^{12}, the secondary winding of which applies energy of this selected frequency to a parallel circuit including the primary windings of transformer TF^{13} and inductors I^{11} and I^{12}. The wayside inductor coils are thus energized in a mutually parallel and opposite sense for retransmission back to the train. The return transmission circuit is therefore balanced and non-interfering with respect to the wayside receiving circuit previously traced and including inductors I^{11} and I^{12} in series.

By virtue of the well known principle of superposition, the wayside inductors I^{11} and I^{12} may be regarded as excited by the return current independently of the initial exciting current present in these coils. The trackway inductors thus parallel reexcited, induce currents in the car carried inductors, with the E. M. F.'s set up in these car carried inductors mutually opposing and therefore neutralized with respect to the original current supply, in the series circuit above traced. These E. M. F.'s are, however, mutually aiding with respect to and cause current to flow in a circuit superimposed upon and balanced with respect to the above mentioned series circuit.

At a particular instant, the current flow in this superimposed circuit extends from the upper terminal of coil I^1 and the lower terminal of I^2 over conductors **1** and **2** in parallel, through the secondary windings of transformer TF^3, in opposing relation with respect to the primary winding of this transformer, conductor **3**, condenser C^1 and winding of transformer TF^1 or condenser C^2 and winding of transformer TF^2 (in accordance with the frequency of the current), conductor **4** and through condensers C^3 and C^4 to the opposite terminals of coils I^1 and I^2, which coils may be considered to be the source of superimposed current.

From the above discussion of the retransmission back to the car, it will be observed that transformer TF^{13} is the receiver of the original energy transmitted from the car, transformer TF^{12} is the transmitter for retransmitting energy back to the car in accordance with signal indications, as determined by the frequency determining device and that transformers TF^1 and TF^2 are the receivers for receiving this retransmitted energy in accordance with the frequency of the current retransmitted.

An analysis of the fundamental circuit shown in Fig. 1 and considering the above general description of the operation of this circuit, it will be observed that the car carried inductors and the trackway inductors act as simultaneous transmitters and receivers. With such an arrangement, two distinct transmission paths are established, one for transmitting the exciting current to the trackway signal location and the other for selectively transmitting the signal indication currents back to the train. The train carried inductors operate in one series circuit to deliver power to the wayside inductors, the wayside inductors receive the power and transmit it over a series circuit to the primary of transformer TF^{13}. The return transmission path may be regarded as originating in the secondary of transformer TF^{13}, the power in the secondary winding of this transformer being transferred to the parallel circuit including the secondary (upper) winding of transformer TF^{12} and trackway inductors I^{11} and I^{12}. Therefore, the wayside inductors operate in parallel for the return transmission to induce currents in the car carried inductors, which currents flow correspondingly in parallel along conductors **1**—**2**, through the windings of transformers TF^3 (in non-energizing relation), conductor **3** and the receiver back to the car carried inductors.

Detailed operation

The detailed circuit arrangement shown in Fig. 2 comprises the same arrangement of the circuits shown in Fig. 1 as applied to the car carried and trackway apparatus for transmitting clear, caution and stop indications from a wayside location to control green, red and yellow lamps on the vehicle, as an illustration of how the circuits of the present invention operate to transmit such indications.

The car carried and trackway inductors, the transformers and the condensers have been given reference characters corresponding with similar devices illustrated in Fig. 1. In addition to these devices, the frequency determining device has been illustrated in detail in Fig. 2 and comprises a frequency doubling rectifier unit FD and a frequency determining relay FDR, operating as will be later described in detail. Relays GR and YR are illustrated for the purpose of explaining how clear, caution and stop indications are transmitted from the trackway to the car. In this connection it will be assumed that relays GR and YR are in their deenergized conditions when a stop indication is to be transmitted, relay YR is in its energized condition when a caution indication is to be transmitted and relay GR is in its energized condition when a clear indication is to be transmitted.

The symbols (+) and (—) used in Fig. 2 designate the positive and negative terminals respectively of a source of direct current, such as a battery or the like, and the circuits to which these symbols are applied have current flowing in them in a single direction, that is, from (+) to (—).

The source of alternating current energy is illustrated in Fig. 2 as being connected to diagonally opposite points of a Wheatstone bridge, made up of inductors L^1, L^2, L^3 and L^4 (the primary winding of transformer TF^3) in the four arms thereof. The secondary winding of transformer TF^3 is connected to the car carried inductors and the primary windings of transformers TF^1 and TF^2. The secondary windings of transformers TF^1 and TF^2 are tuned to 360 cycles and 720 cycles respectively by condensers C^5 and C^6, with the secondary terminals of these two transformers being connected to the input circuits of vacuum tubes TY^1 and TY^2.

It is proposed to use vacuum tubes of the mercury vapor or gas filled type (one type being commonly known as a "thyratron" tube). Such a tube is rendered conductive, or "fired", by an increase in its grid potenial above a critical value, and also has the characteristic feature that once "fired" by such an increase in grid potential, it remains conductive even after the grid potential is restored to normal, until the tube is deionized and quenched by interrupting its plate circuit or the like. The grids of these two tubes are normally biased negative by battery CB and their plate circuits are energized by battery BB. Although no source of current is shown connected to the filaments of these tubes, it will be understood

that their filaments may be energized in any desired manner, such as from a battery or a rectified source of alternating current, which arrangement may also be used for applying the plate and grid potentials to these tubes.

Full wave rectifier RC is connected to opposite diagonal points of the Wheatstone bridge and to the winding of slow acting relay S, which relay in combination with caution relay CA and clear relay CL, control the circuits for the indication lamps as will be described in detail.

Normal condition.—The circuits of Fig. 2 indicate that the last signal indication received was a clear indication, this effecting the picking up of relay CL. With front contact **21** of relay CA open and with back contact **22** of relay CL open, the plate circuit of tube TY^2 is opened, which extinguishes this tube. A stick circuit is completed for relay CL which extends from (+), front contact **23** of relay CL, back contact **24** of relay CA, upper winding of relay CL and front contact **25** of relay S, to (—).

With relay CA down and with relay CL up, a circuit is closed for lighting the green lamp which extends from (+), through the lamp, front contact **26** of relay CL and back contact **27** of relay CA, to (—).

The bias of signalling used in the present discontinuous type of system is one wherein the wayside control elements are made to tend normally to give a stop indication and wherein the giving of a caution or a clear indication is accomplished by overcoming the stop indication condition and substituting for it a less restrictive indication. Accordingly, there is provided in the present circuit organization a tripping means which gives a stop indication unless positively displaced by a caution or clear indication. The tripping means comprises a normally unbalanced impedance bridge (shown in the upper left hand portion of Fig. 2) which, under normal conditions, permits alternating current applied to one pair of diagonal or conjugate points of the bridge to flow in the opposite pair of diagonal or conjugate points of the bridge and thence through rectifier RC and the winding of relay S. This arrangement permits uni-directional current to flow through the winding of relay S for maintaining it in its picked up condition, as illustrated, as long as the impedance bridge is unbalanced.

Stop indication.—It will be assumed that trackway relays YR and GR are both down, for transmitting a stop indication to the vehicle when the car passes the wayside control point. The impedance bridge shown in the upper left hand portion of Fig. 2 is normally unbalanced, as above mentioned, and the trackway inductor circuit is open because front contacts **31**, **32**, **33** and **34** of relays GR and YR are all in their open positions. When the car carried inductors pass over the trackway inductors, with the trackway inductor series circuit open as illustrated, the inductive reactance of the circuit, including the car carried inductors and the two windings of transformer TF^3 in series, is changed to a value which substantially balances the impedance bridge.

There appears to be several electrical and magnetic phenomena involved in thus changing the inductive reactance of the L^4 arm of the bridge when the car carried inductors come into juxtaposition with the wayside inductors. According to one theory of operation, the series circuit including inductors I^1—I^2 and condensers C^3—C^4 is substantially resonant under normal conditions, when the car carried inductors are not over the wayside inductors, but when the cores of the car carried inductors are magnetically coupled to the cores of the wayside inductors, the resonant condition of the circuit is destroyed and losses are reflected into this series circuit so that there is a substantial change in the impedance of arm L^4. Among other things, the presence of the cores of inductors I^{11} and I^{12} may be considered as changing the magnetic reluctance of the cores of inductors I^1 and I^2 respectively. The inductive reactance of the coils of the car carried inductors are therefore changed, thereby disturbing the critical resonant condition of the series circuit so that the impedance of arm L^4 of the bridge changed to bring the bridge substantially into balance, thus resulting in no current flowing in the circuit including rectifier RC and relay S. This drops relay S and closes an obvious circuit at its back contact **35** for lighting the red lamp.

It is well known that an impedance bridge effects a great gain in sensitivity by detecting the percentage change in impedance of one arm, over that obtained by detecting the magnitude change. It is of course understood that the bridge is balanced when the product of the impedance of arms L^1—L^3 equals the product of the impedances of arms L^2—L^4. Therefore, by properly choosing the impedance values of the various arms of the bridge, a small change in inductance in arm L^4 produces sufficient change in the relationship between the arms of the bridge, so that it is brought into balance and substantially no current flowing in the circuit connected to the opposite conjugate points from those to which the source of current is connected.

The dropping of relay S also opens the stick circuits for relays CA and CL at front contact **25**, which causes both of these relays to drop, so that an additional circuit is closed for the red lamp, extending through back contacts **27** and **26** of relays CA and CL respectively.

An examination of the circuits, particularly the schematic of Fig. 1, will indicate that, although alternating current is applied to inductors I^1 and I^2 over the above described series circuit, no current from this source reaches transformers TF^1 and TF^2 for operating the tubes, because these latter transformers are in a neutral or mutually inert circuit which is not affected by current flowing in the series circuit. Likewise, transformer TF^{12} of the wayside apparatus is not affected because it is in a neutral or mutually inert circuit with respect to the series circuit including inductors I^{11} and I^{12} and furthermore because this series circuit is open at the open front contacts of relays GR and YR.

Clear indication.—It will now be assumed that relay GR is up and relay YR is down for transmitting a clear indication to the vehicle. The above described series circuit including the two windings of transformer TF^{13} and inductors I^{11} and I^{12} is now completed through front contacts **31** and **34** of relay GR. This closed circuit condition of the trackway inductors maintains the inductance bridge unbalanced when the car carried inductors pass over the trackway inductors and the power transmission channel from the car to the trackway is terminated and turned back upon itself for transmitting back to the car over the superimposed balanced parallel channel.

The current which is retransmitted back to the car and which flows over the parallel circuit including inductors I^1—I^2 and the two windings

of transformer TF^3, flows through these two windings in opposite directions from that which flows through the windings in the series circuit, so that current in this parallel circuit has no effect on the inductance in arm L^4 of the bridge.

It will be understood that the unbalance of arm L^4 permits current from the alternating current source to flow through rectifier RC and relay S for maintaining this relay energized. It will further be understood that the discussion relating to the reflection of losses from the trackway inductors to the car carried inductors is merely a theoretical explanation of the phenomena to which the results obtained in practice are attributed.

With the series circuit of the trackway inductors complete when the car carried inductors pass over the trackway inductors, the disturbance of the resonant condition of the car carried inductor series circuit and the reflection of energy losses is small, so that there is only a small change in the impedance reflected into the single winding of transformer TF^3, which winding is arm L^4 of the bridge. The operating characteristics of relay S and the constants of the different arms of the impedance bridge are so chosen, that this relatively small change in impedance in arm L^4 is not sufficient to bring the bridge into balance to the extent that relay S is released.

The non-effective condition of the cores of inductors I^{11} and I^{12}, when the closed series circuit exists, including the coils of these inductors, is attributed, among other things, to the choking effect of the circulating current in these coils, which tends to reduce the magnetic flux of the cores of the inductors, when these cores come into close relation with each other and thus reduce the influence on the car carried inductors, previously mentioned when the series circuit including the wayside inductors is open. There may be other contributing factors to be considered in a precise theoretical analysis of the operation above discussed, but the general effect is that closing the series circuit including inductors I^{11}—I^{12} renders these inductors ineffective to bring the impedance bridge into balance for dropping relay S.

Thus, in accordance with the above discussion, with relay GR picked up, current from the 360 cycle source on the car is transmitted from the series circuit, including inductors I^1—I^2, to the series circuit including inductors I^{11}—I^{12}, the latter circuit including the two primary windings of transformer TF^{13} in series aiding relation. The secondary winding of transformer TF^{13} is connected through frequency doubler FD to the primary winding of transformer TF^{12}. By means of this frequency doubler, each half-cycle of the alternating current flows through the primary (right hand) winding of transformer TF^{12} in the same direction.

For example, when the upper terminal of the left hand winding of transformer TF^{13} is (+), current flows from this terminal, rectifier **36**, back contact **37** of relay FDR, downward through the right hand winding of transformer TF^{12}, back contact **38** of relay FDR and rectifier **39** to the lower terminal of the left hand winding of transformer TF^{13}. When the lower terminal of the secondary winding of transformer TF^{13} is (+), then current flows from this terminal, through rectifier **28**, back contact **37** of relay FDR, downward through the right hand winding of transformer TF^{12}, back contact **38** of relay FDR and rectifier **29** to the upper terminal of the secondary winding of transformer TF^{13}.

Current of a frequency double that of the 360 cycle current received from the vehicle (720 cycles) is thus induced into the left hand winding of transformer TF^{12} and applied to the above described parallel circuit, including the primary windings of transformer TF^{13} in opposing relation and the windings of inductances I^{11} and I^{12} in opposition.

Alternating current of 720 cycles is thus applied to the channel circuit leading back to the train, received by the parallel circuit including the car carried inductors and the windings of transformer TF^3 in opposing relation and applied to the circuits leading to transformers TF^1 and TF^2. The primary and secondary windings of transformer TF^1 are tuned to 360 cycles, therefore the 720 cycle current is not effective to "fire" tube TY^1. The primary and secondary windings of transformer TF^2 are tuned to 720 cycles, so that sufficient potential is impressed across the terminals of the right hand winding of transformer TF^2 and thus to the input circuit of tube TY^2 for "firing" this tube.

Current now flows in the plate or output circuit from the (+) terminal of battery BB, front contact **41** of relay S, back contact **22** of relay CL, lower winding of relay CL and plate filament circuit of tube TY^2 to the (—) terminal of battery BB. Relay CL is picked up and the above described stick circuit is completed for maintaining this relay picked up until dropped in response to a caution or a stop indication. The circuit is completed for lighting the green lamp, which circuit was previously traced. Tube TY^2 is of course extinguished, as soon as relay CL picks up its contact finger **22**.

Caution indication.—With relay YR picked up and relay GR down, the same operation is effected with respect to maintaining the impedance bridge unbalanced and with respect to the transmission from the vehicle to the trackway and the retransmission from the trackway back to the vehicle. This is because front contacts **32** and **33** of relay YR complete the same circuits as contacts **31** and **34** of relay GR, previously described. However, with relay GR down and relay YR up, a circuit is closed for picking up relay FDR extending from (+), back contact **42** of relay GR, front contact **43** of relay YR and winding of relay FDR to (—). With relay FDR picked up and the consequent shifting of contacts **37** and **38**, frequency doubler FD is removed from the circuit and the left hand winding of transformer TF^{13} is connected directly to the right hand winding of transformer TF^{12}. This effects the retransmission of 360 cycle current back to the car, where it is received and caused to "fire" tube TY^1 by means of the circuit tuned to the 360 cycle current, which circuit includes transformer TF^1.

Current now flows from the (+) terminal of battery BB, front contact **41** of relay S, back contact **21** of relay CA (and in multiple therewith, front contact **22** of relay CL if relay CL is up), lower winding of relay CA and plate filament of tube TY^1 to the (—) terminal of battery BB. Current in the plate circuit of tube TY^1 picks up relay CA and drops relay CL (if up) by opening its stick circuit at back contact **24**. The dropping of relay CL closes a stick circuit for relay CA extending from (+), back contact **23** of relay CL, upper winding of relay CA, front contact **43** of relay CA and front contact **25** of relay S, to (—).

The opening of the plate circuit of tube TY1 at back contact 21 of relay CA and at front contact 22 of relay CL extinguishes this tube.

A circuit is now closed for lighting the yellow lamp which extends from (+), through the yellow lamp, back contact 44 of relay CL and front contact 27 of relay CA, to (—). Relay CA, when picked up, remains stuck up until a stop or a clear indication is received on the train. The operation for dropping relay CA in response to a stop or a clear indication will be understood by analogy to the above description relating to the dropping of relay CL in response to a stop or caution indication.

Relays CA and CL are interlocked so that each sticks through a back contact of the other. Furthermore, since the tubes are of the gas filled or arc discharge type, the picking up of relay CL and the dropping of relay CA in response to a clear signal opens the plate circuit of the amplifier which effected this relay operation, in order to quench the tube. Likewise, the picking up of relay CA and the dropping of relay CL in response to a caution signal opens the plate circuit of the amplifier which effected this operation, in order to quench the tube.

From the above it will be seen that the unbalance of the impedance bridge is thrown in or out by relays YR and GR, with the frequencies of the current retransmitted back to the train during this unbalance being controlled by these relays in accordance with clear and caution signals.

Although not shown or described, it will be understood that the relays on the car may be used for providing the desired safety of train operation, such as the partial or full application of the brakes, providing an audible warning signal or the like, all as shown in detail in the above mentioned prior application of W. H. Reichard, Ser. No. 70,259.

From the foregoing explanation of the operation of the circuit disclosed in the accompanying drawings, it will be seen that a simple and efficient system of intermittent inductive train control may be constructed in accordance with this invention, which satisfies the requirements and conditions for practical operation and which has the various important features and advantages pointed out.

Having now particularly described the invention and in what manner it is to be performed, what I claim is:—

1. In an automatic train control system, a car carrying an inductor, a trackway having an inductor, means including said inductors for transmitting current of a first frequency from said car to said trackway, and means including said inductors for transmitting current of a second frequency derived from the current of said first frequency from said trackway to said car.

2. In an automatic train control system, a car carrying an inductor, a trackway having an inductor, means including said inductors for transmitting current of a first frequency from said car to said trackway, and means including said inductors for selectively transmitting current of said first frequency or of a second frequency derived from the current of said first frequency from said trackway to said car.

3. In an automatic train control system, a car carrying an inductor, a trackway having an inductor, means including said inductors for transmitting current of a first frequency from said car to said trackway, and means including said inductors for selectively transmitting current of said first frequency or of a second frequency derived from the current of said first frequency from said trackway to said car in accordance with traffic conditions along the trackway.

4. In an automatic train control system, a car carried inductor, a trackway inductor, means including said inductors for transmitting current of a first frequency from said car to said trackway, means including said inductors for selectively transmitting current of said first frequency or of a second frequency derived from the current of said first frequency from said trackway to said car in accordance with traffic conditions along the trackway, and car carried means selectively responsive to said frequency.

5. In an automatic train control system, a car carried inductor, a trackway inductor, means including said inductors for transmitting current of a first frequency from said car to said trackway, means including said inductors for selectively transmitting current of said first frequency or of a second frequency derived from the current of said first frequency from said trackway to said car in accordance with traffic conditions along the trackway, and car carried means selectively responsive to said frequency and the absence of both said frequencies.

6. In an automatic train control system; the combination with car carried apparatus including a plurality of thermionic devices and a plurality of relays; a source of alternating current of a first frequency on said car; trackway controlled means for receiving said first frequency and translating it into a second frequency; trackway controlled means for transmitting said first, said second or neither of said frequencies to said car; a Wheatstone bridge network on said car; means responsive to the reception of said first or said second of said frequencies for causing said thermionic devices to selectively operate a first or a second of said relays respectively; and means controlled by said Wheatstone bridge network for controlling the operation of a third one of said relays when neither of said frequencies is received.

7. In an automatic train control system; a plurality of car carried electro-responsive devices; a pair of car carried inductors and a pair of wayside inductors; means for transmitting current impulses of a first frequency from the car to the wayside through the medium of said car carried and said wayside inductors; and means controlled by traffic conditions along the wayside for selectively transmitting current impulses of said first frequency or a second frequency derived from said car-carried current from the wayside to the car through the medium of said car carried and said wayside inductors, whereby said electro-responsive devices are selectively controlled in accordance with traffic conditions along the wayside.

8. In an automatic train control system; a plurality of car carried electro-responsive devices; a pair of car carried inductors and a pair of wayside inductors; means for transmitting current impulses of a first frequency from the car to the wayside through the medium of said car carried and said wayside inductors; and means controlled by traffic conditions along the wayside for selectively transmitting current impulses of said first frequency or a second frequency, and each derived from said first fre-

quency current from the car, from the wayside to the car through the medium of said car carried and said wayside inductors, whereby said electro-responsive devices are selectively controlled in accordance with traffic conditions along the wayside.

9. In an automatic train control system; a car carried source of alternating current; a car carried inductor unit including combined transmitting and receiving inductor coils, said coils being balanced with respect to the direct effect of said source; an inert wayside inductor unit including a pair of inductor coils for receiving energy from said source and for selectively energizing the car carried inductor coils with alternating current of the frequency of said source or a multiple thereof; and traffic controlled means for determining the frequency with which said car carried inductor coils are to be energized.

10. In an automatic train control system; a car carried source of alternating current; a car carried inductor unit including combined transmitting and receiving inductor coils, said coils being balanced with respect to the direct effect of said source; an inert wayside inductor unit including a pair of inductor coils for receiving energy from said source and for selectively energizing the car carried inductor coils with alternating current of the frequency of said source or a multiple thereof; traffic controlled means for determining the frequency with which said car carried inductor coils are to be energized; and car carried indicators selectively controlled by said car carried inductor coils.

11. In an automatic train control system; a first car carried inductor winding and a first coacting wayside inductor winding forming a first inductive coupling; a second car carried inductor winding and a second coacting wayside inductor winding forming a second inductive coupling; a connecting circuit on the car which combines the inductive effects of said first and second car carried windings in a series circuit for the transmission of signalling current in one direction between the car and the wayside and in a parallel circuit for the transmission in the reverse direction; a Wheatstone bridge circuit on the car; an electro-responsive device connected to said Wheatstone bridge circuit; means controlled by traffic conditions along the wayside and rendered effective during the coactive coupling between said car carried and said wayside windings for applying or not applying signalling current to said series circuit; and means controlled by the presence or absence of signalling current in said series circuit during said coactive coupling for unbalancing or balancing said Wheatstone bridge circuit, whereby said electro-responsive device is selectively controlled.

12. In an automatic train control system; a car carried source of alternating current connected to a pair of conjugate points of a Wheatstone bridge circuit; a first electro-responsive device connected to an opposite pair of conjugate points of said Wheatstone bridge circuit; a pair of car carried inductor coils supplied with alternating current from said source; a car carried signal receiving circuit utilizing said pair of car carried inductor coils; a second electro-responsive device connected to said receiving circuit; circuit means connecting said receiving circuit and said source to said pair of car carried inductor coils so as to prevent alternating current from said source from directly affecting said receiving circuit; a pair of wayside inductor coils; circuit means connecting said wayside inductor coils in parallel for the transmission of signalling current in one direction from or to the train and in series for the transmission of signalling current in the reverse direction; means controlled by the presence or absence of signalling current in the series connection of said wayside inductor coils for balancing or unbalancing said Wheatstone bridge circuit, whereby said first electro-responsive device is selectively controlled; and means controlled by signalling current in the parallel connection of said wayside inductor coils for affecting said receiving circuit, whereby said second electro-responsive device is selectively controlled.

13. In an automatic train control system; a car carried source of alternating current connected to a pair of conjugate points of a Wheatstone bridge circuit; a first electro-responsive device connected to an opposite pair of conjugate points of said Wheatstone bridge circuit; a pair of car carried inductor coils supplied with alternating current from said source; a car carried signal receiving circuit utilizing said pair of car carried inductor coils; a second and a third electro-responsive device connected to said receiving circuit; circuit means connecting said receiving circuit and said source to said pair of car carried inductor coils so as to prevent alternating current from said source from directly affecting said receiving circuit; a pair of wayside inductor coils; circuit means connecting said wayside inductor coils in parallel for the transmission of signalling current in one direction from or to the train and in series for the transmission of signalling current in the reverse direction; means controlled by the presence or absence of signalling current in the series connection of said wayside inductor coils for balancing or unbalancing said Wheatstone bridge circuit, whereby said first electro-responsive device is selectively controlled; and means controlled by signalling current in the parallel connection of said wayside inductor coils for affecting said receiving circuit, whereby said second and said third electro-responsive devices are selectively controlled.

14. In an automatic train control system; a two wire circuit for transmitting current impulses in one direction betwen the train and the wayside; a superimposed circuit derived in part from said two wire circuit comprising a third wire connected to the mid-point at each end of the two wire circuit and completed by the wires of the two wire circuit in parallel; a transformer along the wayside including primary and secondary windings, said mid-point connection at one end being connected to the mid-point of said primary winding and said primary winding being included in said two wire circuit; means associated with said secondary winding for receiving current impulses of one frequency from said two wire circuit, translating them into current impulses of another frequency and transmitting current impulses of said another frequency over said superimposed circuit; and train carried means controlled by said another frequency in said superimposed circuit.

15. In an automatic train control system; a two wire circuit for transmitting current impulses in one direction between the train and the wayside; a superimposed circuit derived in part from said two wire circuit comprising a third wire connected to the mid-point at each end of the two wire circuit and completed by the wires of

the two wire circuit in parallel; a transformer along the wayside including primary and secondary windings, said mid-point connection at one end being connected to the mid-point of said primary winding and said primary winding being included in said two wire circuit; means associated with said secondary winding for receiving current impulses of one frequency from said two wire circuit, translating them into current impulses of another frequency and transmitting current impulses of said one and said another frequency over said superimposed circuit; and train carried means controlled by said one and said another frequency in said superimposed circuit.

16. In an automatic train control system; a car carried source of alternating current; car carried inductor coils connected in series in a series circuit energized from said source; a normally deenergized clear indication receiving circuit on the car connected to said coils in a parallel circuit; said parallel and said series circuits being mutually inert; and trackway means receiving energy from said coils when said series circuit is energized for applying current of a frequency different from said source to said coils and said parallel circuit only if a clear condition is to be transmitted from the trackway to the car, whereby said clear indication receiving circuit is energized.

17. In a system of intermittent inductive train control; in combination with a car carried receiving circuit into which a momentary voltage of a first or a second frequency is induced from the trackway; a first and a second electronic tube coupled to said circuit, said first tube rendered conductive by a voltage of said first frequency in said circuit and said second tube rendered conductive by a voltage of said second frequency in said circuit and each tube remaining conductive until quenched by means independent of said circuit; indication means controlled by said tubes; and means controlled in response to each tube becoming conductive for quenching this tube and conditioning the other tube for response to the voltage in said circuit which renders the other tube conductive.

18. In an automatic train control system; a pair of wayside inductors; a train carrying a periodically varying current transmitter; a first means connecting the two wayside inductors in series with each other in a first circuit for receiving inductively current from said transmitter; a second means including said first means connecting said two inductors in parallel with each other in a second circuit for inductively retransmitting current from said inductors to said train; means controlled by traffic conditions in advance for deriving current from said first circuit, determining its frequency and retransmitting it over the second circuit to said train; and receiving means on said train responsive to current in said second circuit and the frequency of said current and non-responsive to the current in said first circuit.

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