

Oct. 25, 1938.

W. P. PLACE ET AL

2,134,416

APPARATUS FOR RAILWAY TRAIN COMMUNICATION SYSTEMS

Filed Aug. 11, 1937

3 Sheets-Sheet 1

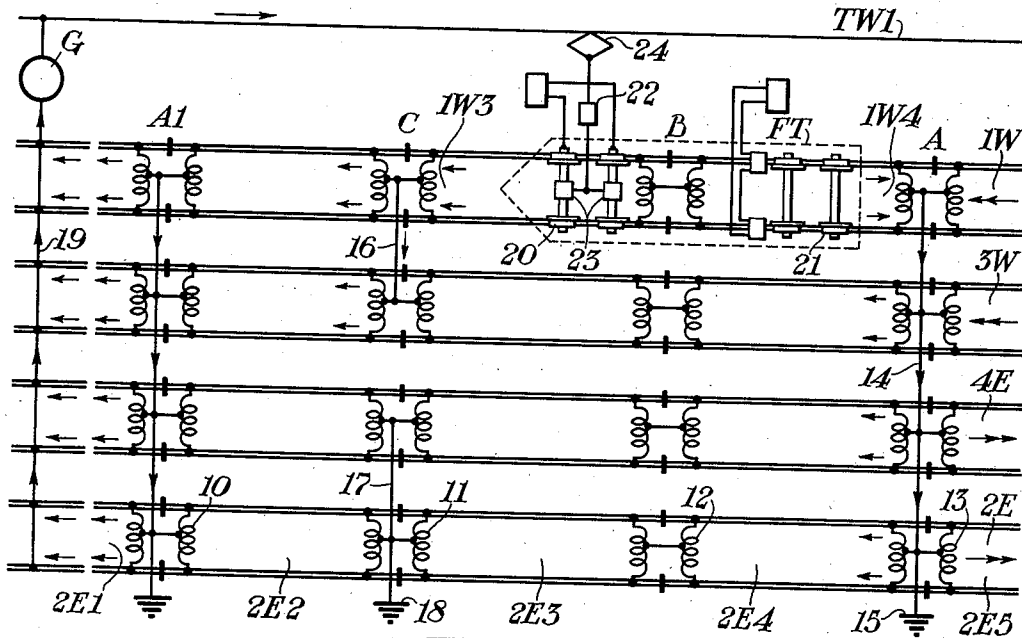


Fig. 1.

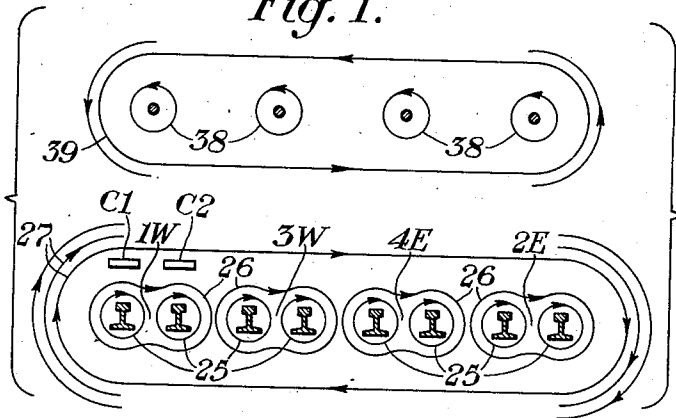


Fig. 2.

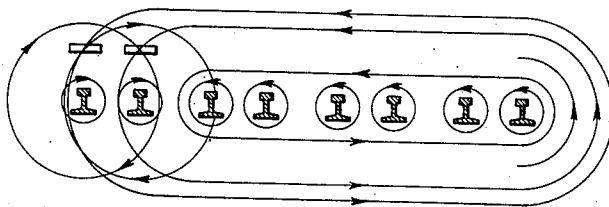


Fig. 4.

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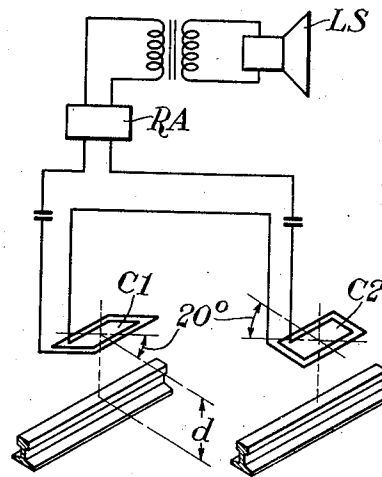
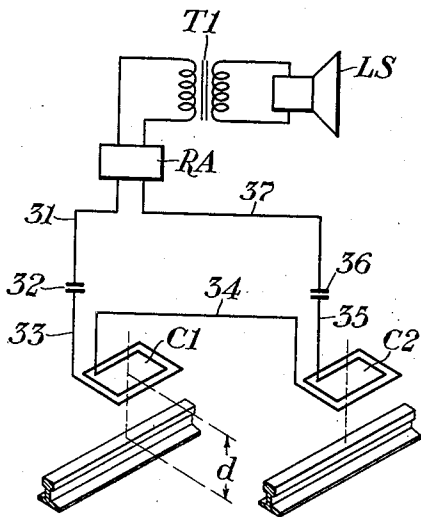
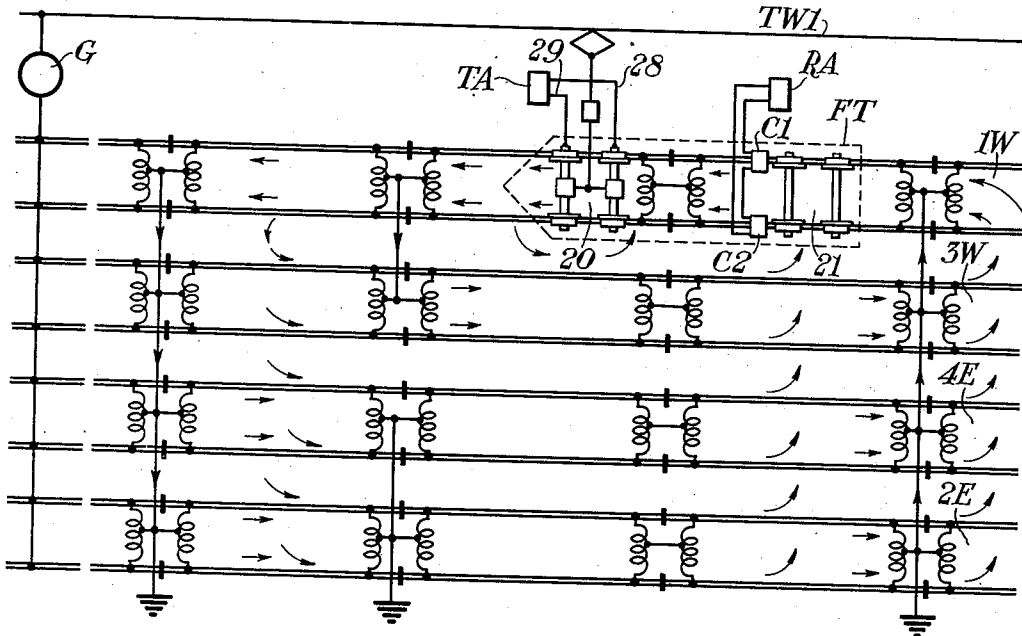
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

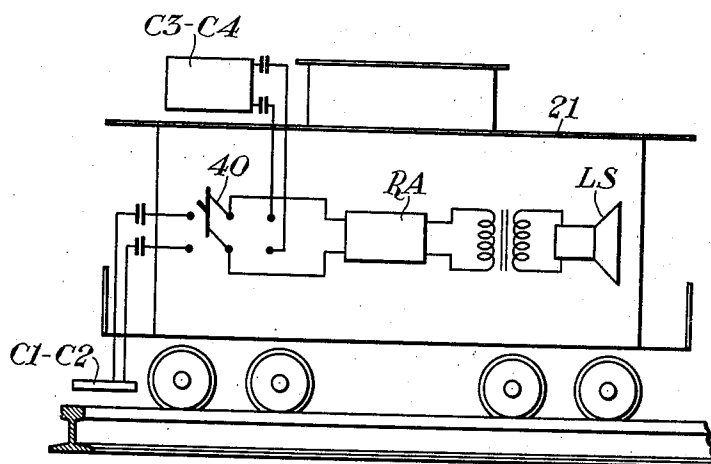


Fig. 7.

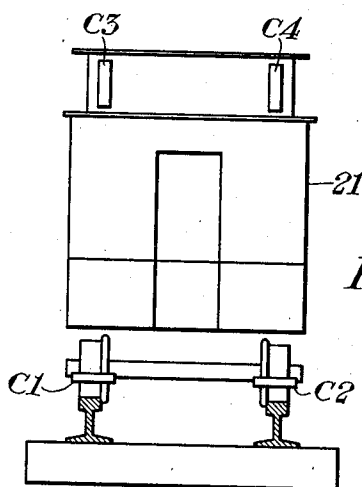


Fig. 8.

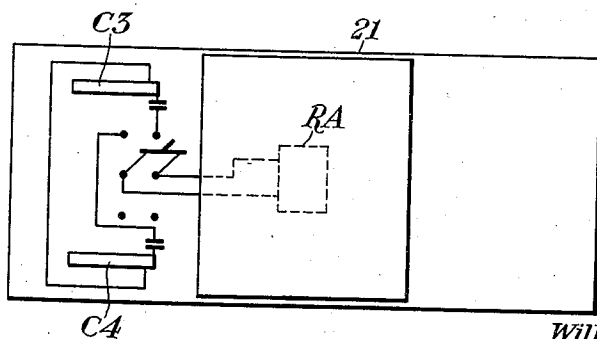


Fig. 9.

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UNITED STATES PATENT OFFICE

2,134,416

APPARATUS FOR RAILWAY TRAIN COMMUNICATION SYSTEMS

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Application August 11, 1937, Serial No. 158,518

9 Claims. (Cl. 246—8)

Our invention relates to apparatus for railway train communication systems, and particularly to apparatus for railway train telephone systems.

We shall describe certain forms of apparatus embodying our invention, and shall then point out the novel features thereof in claims.

A feature of our invention is the provision of novel and improved train-carried apparatus for reception of communication current in electrified territory of a railway with minimum annoyance due to noise energy. A further feature of our invention is the provision of receiving apparatus for railway train communication systems which can be set either for best operation in electrified territories or for best operation in steam territories. Other features and advantages of our invention will appear as the specification progresses.

In railway train communication systems, it has been proposed to include the track rails in the circuit used for transmitting the communication current between a station located on a train and another station such as, for example, a wayside station or a station located on another train or on a second vehicle of the same train. When the two stations are located on the same train, they may, for example, be located on the locomotive and caboose of a freight train. To send current from a location, an electromotive force corresponding in frequency to that of the communication current is produced in the track rails, and as a result of such electromotive force communication current flows in the rails from the point where the electromotive force is produced by virtue of the rail-to-ground impedance and the ground path. This communication current flowing in the rails causes an energy transfer to be effected to neighboring parallel conductors by virtue of the distributed conductance and distributed mutual inductance between the rails and such conductors. Such energy transfer causes, in turn, communication current to flow in the paralleling conductors by virtue of their distributed impedance to ground. In multi-track railways, the track rails of the tracks other than the rails of the track to which the current is originally supplied serve as conductors for carrying the communication current. Especially is this true in electrified zones where the rails are cross connected and the rails of the different tracks all serve as a part of a common rail return circuit for the propulsion current. Hence, communication current supplied to the rails of any one track of a multi-track railway is present in the rails

of the adjacent tracks and other paralleling conductors.

In telephone systems for railway trains, it has been proposed to use a carrier telephone current, the carrier of which is of a frequency high enough to be substantially free from interference by current of commercial power frequencies, high enough to be above the highest voice frequencies to be transmitted, and low enough to be substantially free from electromagnetic wave radiation. For example, the telephone current may be the upper side band of a carrier of 7000 cycles per second modulated with voice frequencies extending from 500 to 2500 cycles, the telephone current thus having a frequency range of 7500 to 9500 cycles.

In such telephone systems, an inductor coil mounted on a vehicle of a train, such as the caboose of a freight train, in inductive relationship with the track rails inductively receives an electromotive force when telephone current is supplied to the rails at a remote location, such as, for example, the locomotive of the freight train. Extraneous magnetic fields exist along a railway which may induce electromotive forces in such train-carried inductor, with the result that noise may be produced at the telephone receiver or loud speaker, especially since amplifiers are used in the receiving apparatus. In general, it may be said that such extraneous magnetic fields are strongest in the neighborhood of the rails. Thus, the ratio of telephone energy to noise energy picked up by a train-carried inductor varies for different positions of the inductor on the train and is ordinarily the best for an inductor mounted relatively high on the vehicle. In electrified territories of a multi-track railway, especially where alternating current is used for propulsion purposes, the magnetic field resulting from the propulsion current contains frequency components that may produce noise in the receiving apparatus of the train telephone system, and we have found that such noise energy is present for all positions within the clearance limits for railway trains and within which limits any train-carried inductor must, of course, be mounted.

In steam territory of a railway an effective position for such train-carried inductor is the roof of the caboose with the inductor disposed in a vertical plane for inductive relationship to the rails of adjacent tracks, as well as to the rails of the track occupied. After a great deal of exploration along electrified zones, we have discovered that with an inductor carried at the

height of a few inches above the top of the rails and in a horizontal plane (axis perpendicular) the telephone energy to noise energy ratio is relatively high and telephone communication can be effectively accomplished in electrified zones with minimum annoyance due to the propulsion current. The height of the inductor above the top of the rails may be varied but the preferred height is confined within relatively narrow limits.

The height may vary from around six inches up to around fourteen inches. In our explorations we have discovered that best results are obtained when the inductor is positioned at the height of the order of ten inches. It will be understood, therefore, that the position of the inductor is an essential element but that our invention is not limited to any exact height above the top of the rails for the inductor and a height of the order of ten inches is preferred. To illustrate the advantage obtained for an inductor positioned according to our discovery, under certain given operating conditions the noise energy for a horizontal inductor positioned above the rails at the height of the order of ten inches was reduced to about one-tenth of that picked up by the inductor mounted at the same height and disposed in a vertical plane. The telephone energy picked up by the inductor positioned at the height of ten inches above the top of the rails in a horizontal plane was reduced to about one-half of that picked up by the inductor disposed in the vertical plane, and thus the net advantage for the inductor in a horizontal plane at a height of the order of ten inches above the top of the rails was of the order of five.

According to our discovery, we provide train-carried communication receiving apparatus comprising a pair of inductor coils mounted on a vehicle of the train, one centered over one rail at the height preferably of the order of ten inches and the other centered in like manner over the other rail. Each of the two inductor coils possesses relatively low mutual induction with the rail directly beneath but relatively high mutual induction with the other rail of the same track and with the rails of adjacent tracks. Such inductor coils pick up telephone energy of sufficient magnitude that telephone communication can be satisfactorily accomplished with minimum noise interference. When the caboose or other vehicle of the train on which the communication equipment is located is to be operated over both steam and electrified zones of a railway, the receiving apparatus of our invention is preferably provided with two pairs of inductor coils, one pair mounted above the rails in the manner set forth above for best operation as found to exist in electrified zones and the other pair of inductor coils mounted relatively high (roof) on the vehicle and in a vertical plane for best operation as found to exist in steam territory.

For a better understanding of our invention, reference may be had to the accompanying drawings in which Fig. 1 is a diagrammatic view of a stretch of electrified territory of a four-track railway, the general distribution of the propulsion current in the track rails being illustrated. Fig. 2 is a diagram illustrating the magnetic fields created by the propulsion current for the railway of Fig. 1 and the relationship of such magnetic fields with respect to a pair of train-carried inductor coils embodying our invention. Fig. 3 is a diagrammatic view of the stretch of railway of Fig. 1 with the general distribution

of communication current illustrated when a train occupies a particular one of the tracks. Fig. 4 is a diagram illustrating the inductive relationship of train-carried inductor coils embodying our invention with respect to the magnetic field created by the communication current under the operating conditions of Fig. 3. Fig. 5 is a diagrammatic view of a preferred form of receiving apparatus embodying our invention. Fig. 6 is a diagrammatic view of a modification of the apparatus of Fig. 5 and which apparatus also embodies the invention. Figs. 7, 8 and 9 are diagrammatic views of train-carried apparatus embodying the invention for operation over either electrified territory or over steam territory.

In each of the several views like reference characters designate similar parts.

Referring to Fig. 1, the reference characters 1W, 3W, 2E and 4E represent the tracks of a four-track railway, tracks 1W and 3W being ordinarily used for westbound traffic and tracks 2E and 4E for eastbound traffic as indicated by double pointed arrows. As here shown, the track rails of each track are divided by the usual insulated rail joints to form track sections as required for double rail track circuits for a wayside and/or cab signal system. Taking the eastbound track 2E, for example, three full sections 2E2, 2E3 and 2E4, and the adjacent ends of two sections 2E1 and 2E5 are shown, and it will be understood that the full length of track 2E is formed into similar consecutive track sections. In like manner, the other tracks are formed into consecutive track sections. An impedance bond is provided at each insulated rail joint location in accordance with usual practice for conducting propulsion current around the insulated rail joints but substantially blocking the flow of the track circuit current of the signal system. Again looking at track 2E by way of example, impedance bonds 10, 11, 12 and 13 are provided one at each junction of the track sections.

The track rails of each of the four tracks are included in a common rail return circuit for the propulsion current by means of cross connections or bonds interposed between the mid terminals of the various impedance bonds. The particular arrangement of cross connections is immaterial and is shown in Fig. 1 as that found in present-day use. At location A, the mid terminals of the impedance bonds for the four tracks are all connected by a cross connection 14, which is also connected with a ground electrode 15. At the next insulated rail joint location B to the left, no cross connections are used. At the next location C to the left, a cross connection 16 is connected between the mid terminals of the impedance bonds of tracks 1W and 3W, and a cross connection 17 is connected between the mid terminals of the impedance bonds for the tracks 2E and 4E, the cross connection 17 being further connected with a ground electrode 18. At the next location A1 to the left, the arrangement is similar to that at location A.

It is to be understood that our invention is not limited to a four-track railway or to a railway the track rails of which are formed into insulated track sections. As a matter of fact, the insulated rail joints may be so arranged as to form the rails of each track into sections as required to provide single rail track circuits for the wayside signal system. The track layout of Fig. 1 will serve, however, to illustrate the many places where the invention is useful.

Propulsion current is supplied to the tracks of Fig. 1 by a generator G, one terminal of which is connected through the usual feeder network (not shown) with the trolley wires for the different tracks, only the one trolley wire TW1 associated with track 1W being shown for the sake of simplicity, and it will be understood that each of the other tracks is provided with a similar trolley wire. The other terminal of the generator G is connected with each track rail of the four tracks over a cross connection 19. The propulsion current supplied by the generator G may be either direct current or alternating current, and it is here assumed to be an alternating current of 25 cycles per second.

A train FT is indicated schematically on track 1W, the two ends of the train occupying the sections 1W3 and 1W4, respectively. The train FT may be of any makeup and, for example, it may be a freight train of which 20 designates the forward vehicle or locomotive and 21 designates the rear vehicle or caboose. The reference character 22 designates the controller mechanism of the locomotive 20 for governing the supply of current from the trolley wire TW1 to the motors 23 for driving the locomotive, current being collected from the trolley wire TW1 by the usual trolley wheel or pantograph collector 24. Propulsion current used to drive the locomotive 20 returns to the generator G over the rail return circuit, equalizing in the rails of the different tracks due to the cross connections. Furthermore, the propulsion current used by other locomotives, not shown, on the other tracks, either within the stretch shown in Fig. 1 or outside of said stretch, returns to the generator G through the rail return circuit. Single pointed arrows have been added to Fig. 1 to indicate the general distribution of the propulsion current, the direction of the arrows indicating the relative direction of the flow of current at a given instant.

Because the propulsion current is strongly inclined to be distributed equally in all the rails of the track, and is also distributed to the different trolley wires through the medium of the usual feeder system, a strong magnetic field is created. Such magnetic field has frequencies equal to the fundamental and harmonic frequencies of the propulsion current and contains other frequencies such as those due to commutation at the locomotive motors. Looking at Fig. 2, the lines 25 illustrate the magnetic flux lines created about each individual rail of the four tracks by the propulsion current, the arrows placed on lines 25 indicating the direction of the flux lines at a given instant. The lines 26 illustrate the magnetic flux lines encompassing the two rails of each of the four tracks due to the propulsion current flowing in both rails of each track in the same direction, and again, the direction of the arrows placed on these lines indicate the direction of the flux at a given instant. The lines 27 illustrate the magnetic flux which encompasses the four tracks as a whole. The lines 38 and 39 indicate the magnetic flux lines created about the trolley wires of the different tracks. It is clear that the magnetic fields created by the propulsion current, as illustrated in Fig. 2, permeate the space occupied by a train on any one of the tracks, and an inductor mounted on a train within the usual clearance limits for railway trains is more or less inductively influenced by these fields, the energy thus induced in such inductor having

components corresponding in frequencies to the fundamental, harmonics and other frequencies of the propulsion current. Certain of these frequency components, particularly those due to commutation, fall within the pass band of the upper side band telephone current referred to hereinbefore, and consequently may cause noise at the loud speaker of such telephone system.

The reference characters C1 and C2 of Fig. 2 designate two inductor coils disposed one over one track rail of the track 1W and the other disposed over the other track rail of track 1W. These inductor coils are disposed with their axes vertical. We have found that inductor coils C1 and C2 disposed in a horizontal plane (axes perpendicular), a few inches above the top of the rails, as shown in Fig. 2, give a minimum response to the influence of the magnetic field created by the propulsion current. The function of the inductor coils C1 and C2 and their relationship to the propulsion current magnetic field will be further discussed hereinafter.

Referring to Fig. 3, the track layout and the freight train FT occupying the westbound track 1W are the same as in Fig. 1. Looking at the train FT, the locomotive 20 and the caboose 21 are provided with communication equipment including transmitting apparatus TA on the locomotive and receiving apparatus RA on the caboose. The transmitting apparatus TA and the receiving apparatus RA may be any one of several well-known forms and each is shown conventionally for the sake of simplicity. It is deemed sufficient for this application to but briefly describe these apparatuses. Assuming telephone communication is to be effected between the locomotive 20 and the caboose 21 by means of the upper side band telephone current referred to hereinbefore, the transmitting apparatus TA includes a source of carrier current of 7000 cycles per second, means for modulating the carrier by voice frequencies, and a filter for selecting the upper side band and substantially suppressing the lower side band and the carrier. The output side of the transmitting apparatus TA is conductively coupled with the track rails over wires 28 and 29 which are connected with the rails by being connected to the journal bearings of the rear and forward pairs of wheels of the locomotive, respectively. In order to effect a more equal distribution of the communication current supplied to the track rails, each of the wires 28 and 29 would be connected in multiple to both journal bearings of the respective pair of wheels. Hence, when the transmitting apparatus TA is made active, communication current flows in that section of the rails between the forward and rear pairs of locomotive wheels. This communication current produces an electromotive force across the section of rails between the forward and rear pairs of locomotive wheels, and as a result of such electromotive force the telephone current flows in the rails both in advance of and to the rear of the locomotive in the well-known manner. The telephone current will also flow in the rails of the other tracks due to the cross connections between the tracks and due to the distributed mutual inductance and conductance between the rails of the track 1W occupied by the train and the rails of the other tracks. Arrows have been added to Fig. 3 to illustrate the general distribution of the telephone current when supplied to the track 1W adjacent the locomotive 20. These arrows would indicate the direction of the

flow of current at a given instant. As the train FT advances, distribution of the telephone current not only advances with the train but also changes due to the relative position of the locomotive with respect to the cross connections, etc. A portion of the communication current flowing in the track rails will reach the location of the caboose 21. The magnitude of the current adjacent the caboose depends upon the attenuation of the current due to ballast resistance and other conditions. At a distance of the order of one mile (usual freight train length), the magnitude of the telephone current is sufficient for effective telephone communication. It is clear from Fig. 3 that by the very nature of the circuit involved the telephone current is not distributed in the rails of the several tracks in an orderly fashion. At least, it is not distributed in an orderly fashion to the same extent as the propulsion current. It will be understood, of course, that our invention is not limited to use of a carrier telephone current of frequencies here assumed, and other frequencies can be used.

The receiving apparatus RA includes an amplifier and a demodulator which are operative when carrier telephone current is supplied to its input terminals to produce in its output circuit a current containing the voice frequencies only. Referring to Fig. 5 as well as to Fig. 3, the input circuit for the receiving apparatus RA includes two inductor coils C1 and C2. As viewed in Fig. 5, this input circuit can be traced from the lower left-hand input terminal of the receiving apparatus RA over wire 31, condenser 32, wire 33, coil C1, wire 34, coil C2, wire 35, condenser 36, and wire 37 to the lower right-hand input terminal of the apparatus RA. The output circuit of the receiving apparatus RA is connected through a transformer T1 with the operating winding of a loud speaker LS, as will be readily understood by an inspection of Fig. 5. Hence, telephone current picked up by the inductor coils C1 and C2 is amplified and demodulated at the receiving apparatus RA, and the voice frequencies originally modulating the carrier current at the transmitting apparatus TA are reproduced at the loud speaker LS.

The inductor coils C1 and C2 are preferably air core windings of relatively large central area and are mounted on the caboose, one centered over one track rail and the other centered over the other rail. As shown in Fig. 5, the coils C1 and C2 are disposed in a horizontal plane at a height of d inches which may vary from six to fourteen inches and is preferably of the order of ten inches above the top of the rail. As previously stated, we have discovered that inductor coils C1 and C2 when so constructed and so positioned inductively receive telephone current energy with minimum annoyance due to the magnetic field created by the propulsion current. In Fig. 4 there is illustrated the inductive relationship as it appears to exist between the inductor coils C1 and C2 and the magnetic field created about the rails of the tracks of Fig. 3 by the telephone current supplied to the rails of the track 1W from the transmitting apparatus TA of locomotive 20. It is to be noted from Fig. 4 that the position of each inductor coil is that for minimum mutual induction to the rail directly beneath and for effective mutual induction with the other rail of the same track and with the rails of the adjacent tracks.

It follows from the foregoing discussion that

telephone communication is accomplished between the locomotive and the caboose of the train FT of Fig. 3 through the medium of the apparatuses TA and RA and the track rails, the receiving apparatus being free to a large degree at least from noise energy prevailing in the electrified zone due to the characteristics of the inductor coils. It is clear that by providing transmitting apparatus on the caboose of the train FT and receiving apparatus on the locomotive two-way telephone communication can be accomplished.

In territories such as are shown in Figs. 1 and 3 where double rail track circuits are used, an advantage is obtained in the telephone noise ratio when the inductor coils C1 and C2 are connected to oppose each other in response to a uniform vertical magnetic field. This connection allows the electromotive forces induced in the two coils to aid when the telephone currents in both rails of the track occupied are in phase and in the same direction as is usually the case with a train on the track. In electrified territory where single rail track circuits are used, however, we have found better results to be obtained when the inductor coils are connected to add their effects as produced by a uniform vertical magnetic field. Thus, the preferred connection for the inductor coils depends upon the track characteristics.

Again, we have found some advantage in the telephone noise ratio on the outer track of a four-track road results from a slight tilt of the inductor coils, about 20° from the horizontal toward the outside of the track, as illustrated in Fig. 6. In Fig. 6, the inductor coils are otherwise kept in the same position described hereinbefore. However, good results can be obtained on the outside tracks of a four-track road with the coils exactly horizontal, as illustrated in Fig. 5.

Referring to Figs. 7, 8 and 9, the caboose 21 is equipped with two pairs of inductor coils. Coils C1 and C2 of one pair are mounted on the caboose in the manner already explained. Inductor coils C3 and C4 of the other pair are mounted on the caboose roof to one side of the cupola. The coils C3 and C4 may be arranged one on one side of the cupola and the other on the other side of the cupola, or both may be placed on the same side, as desired. We have found, however, that in steam territory a preferred arrangement for such roof coils is for the coils to be disposed on the same transverse center line and each an equal distance from the longitudinal center line of the caboose. The entire receiving apparatus on the caboose would preferably be symmetrically disposed about the center line of the caboose, as illustrated in Fig. 9. The coils C3 and C4 are preferably air core windings and are positioned each in a vertical plane and are series tuned by condensers located adjacent each coil.

A double-pole double-throw switch 40 is provided for selectively connecting the two pairs of inductor coils in the input circuit of the receiving apparatus RA. Looking at Fig. 7, the coils C1 and C2 are included in the input circuit when the switch 40 is closed to the left. With the switch 40 closed to the right, the roof coils C3 and C4 are included in the input circuit.

It follows that with the switch 40 closed to the left as viewed in Fig. 7 the receiving apparatus of the caboose 21 is conditioned for best operation when the caboose is to be operated over electrified territory. With the switch 40 closed to

the right, the receiving apparatus is conditioned for best operation when the caboose is to be operated over steam territory.

Although we have herein shown and described only certain forms of apparatus embodying our invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim is:

1. In combination, a railway track, a train, transmitting apparatus located along the track to cause a periodic communication current to flow in the track rails, receiving apparatus responsive to such current mounted on a vehicle of the train, an inductor mounted on said vehicle directly above one of the track rails, said inductor disposed with its axis vertical and positioned at a height of the order of ten inches above the top of the rails for inductively receiving an electromotive force due to the current supplied to the rails by the transmitting apparatus with minimum interference from extraneous magnetic fields, and circuit means to connect said inductor with the receiving apparatus.

2. In combination, a railway track, a train, transmitting apparatus located along the track to cause a periodic communication current to flow in the track rails, receiving apparatus responsive to such current mounted on a vehicle of the train, an inductor mounted on said vehicle comprising two coils of relatively large central areas and one of which is centrally positioned above one rail and the other one of which is centrally positioned above the other rail, said coils disposed in a horizontal plane for minimum induction to the rail directly beneath and for relatively large induction to the other rail of the track and said coils carried at a height of the order of ten inches above the top of the rails for small inductive response to noise energy magnetic fields existing about the rails and effective inductive response to the magnetic field caused by the current flowing in the rails due to the transmitting apparatus, and circuit means to connect said inductor coils with the receiving apparatus.

3. In combination, an electrified zone of a railway track the track rails of which are bonded to serve as a return circuit for propulsion current, a train, transmitting apparatus located along the track to cause a periodic communication current to flow in the track rails, receiving apparatus responsive to such communication current mounted on a vehicle of the train, two inductor coils mounted on said vehicle one directly above one rail and the other directly above the other rail, said coils disposed in a horizontal plane at a height of the order of ten inches above the top of the rail for minimum inductive response to the propulsion current and effective inductive response to the communication current flowing in the rails due to the transmitting apparatus, and circuit means to connect said coils with the receiving apparatus.

4. In combination, an electrified zone of a multi-track railway the track rails of which are bonded and cross connected to serve as a common return circuit for propulsion current, a train occupying one of the tracks, a source of propulsion current for operating the train, communication equipment including transmitting apparatus operative to supply a periodic communication current mounted on one vehicle of the train and

receiving apparatus responsive to such communication current mounted on a second vehicle of the train, means to couple the transmitting apparatus with the rails to cause communication current to flow in the rails of the tracks, two inductor coils mounted on said second vehicle one over one rail and the other over the other rail, said coils disposed in a horizontal plane at a height of the order of ten inches for minimum inductive influence due to the propulsion current and to inductively receiving an electromotive force in response to the communication current flowing in the rails of the different tracks due to the transmitting apparatus, and circuit means to connect said inductor coils with the receiving apparatus.

5. In combination, an electrified zone of a multi-track railway the track rails of which are bonded and cross connected to serve as a return circuit for propulsion current and each track provided with a trolley wire, a generator connected with said trolley wires and said return rail circuit to supply an alternating current for operating trains over said zone and which current tends to equalize in the rails of the different tracks, a train on one of said tracks, communication equipment including transmitting apparatus mounted on one vehicle of the train and receiving apparatus mounted on a second vehicle of the train, said transmitting apparatus operative to supply a carrier telephone current and said receiving apparatus operative to demodulate and reproduce the voice frequencies of such telephone current, means to couple the transmitting apparatus to the track rails to cause the telephone current to be distributed in the rails of the different tracks by virtue of the distributed rail-to-ground conductance and the cross connections, and an input circuit for said receiving apparatus including two inductor coils mounted on said second vehicle one centered over one rail and the other centered over the other rail for inductively receiving an electro-motive force due to the distribution of the telephone current in the rails of the different tracks, and said coils disposed in a horizontal plane at a height of six to fourteen inches above the top of the rails to effect best telephone to propulsion current noise energy ratio.

6. In combination, an electrified zone of a multi-track railway the track rails of which are bonded and cross connected to serve as a return circuit for propulsion current and each track provided with a trolley wire, a generator connected with said trolley wires and said return rail circuit to supply an alternating current for operating trains over said zone and which current tends to equalize in the rails of the different tracks, a train on one of said tracks, communication equipment including transmitting apparatus located along the tracks and receiving apparatus mounted on a vehicle of the train, said transmitting apparatus operative to supply a carrier telephone current and said receiving apparatus operative to demodulate and reproduce the voice frequencies of such telephone current, means to couple the transmitting apparatus to the track rails to cause the telephone current to be distributed in the rails of the different tracks, and an input circuit for said receiving apparatus including an inductor comprising two air core windings of relatively large central areas, said windings mounted on said vehicle one centered over one rail with its axis vertical and the other centered over the other rail with its axis vertical and each winding carried at a height of the order of ten inches for

receiving an electromotive force due to the telephone current distributed over the rails of the different tracks with a minimum amount of noise energy due to the distribution of the propulsion current over the rails.

7. In combination, an electrified zone of a multi-track railway the track rails of which are bonded and cross connected to serve as a return circuit for propulsion current and each track provided with a trolley wire, a generator connected with said trolley wires and said return rail circuit to supply an alternating current for operating trains over said zone and which current tends to equalize in the rails of the different tracks, a train on one of the outside tracks of said tracks, communication equipment including transmitting apparatus mounted on one vehicle of the train and receiving apparatus mounted on a vehicle of the train, said transmitting apparatus operative to supply a carrier telephone current and said receiving apparatus operative to demodulate and reproduce the voice frequencies of such telephone current, means to couple the transmitting apparatus to the track rails to cause the telephone current to be distributed in the rails of the different tracks by virtue of the distributed rail-to-ground conductance and the cross connections, and an input circuit for said receiving apparatus including two air core coils of relatively large central areas mounted on said vehicle one centered over one rail and the other centered over the other rail, and said coils positioned at a height of the order of ten inches above the top of the rails and tilted about 20° from the horizontal toward the outside of the track for inductively receiving an electromotive force due to the distribution of the telephone current in the rails of the different tracks with best telephone to propulsion current noise energy ratio.

8. In combination, a railway vehicle adaptable

of operation over either steam or electrified territories of a railway, receiving apparatus mounted on said vehicle operative to reproduce the voice frequencies of a telephone current, a first and a second inductor mounted on said vehicle, said first inductor mounted relatively high on the vehicle and in a vertical plane for inductively receiving an electromotive force due to such telephone current flowing in the track rails in steam territory, said second inductor mounted in a horizontal plane directly over a track rail at the height of six to fourteen inches above the top of the rail for inductively receiving an electromotive force due to telephone current flowing in the track rails in electrified territory, and means to connect either said first or said second inductor with the receiving apparatus.

9. In combination, a railway vehicle adaptable of operation over either steam or electrified territories of a railway, receiving apparatus mounted on said vehicle operative to reproduce the voice frequencies of a telephone current, a first and a second pair of inductor coils mounted on said vehicle, said first pair of coils mounted relatively high on the vehicle and in a vertical plane for inductively receiving an electromotive force due to such telephone current flowing in the rails in steam territory, said second pair of coils mounted one over one rail and the other over the other rail and each disposed in a horizontal plane at a height of the order of ten inches for inductively receiving an electromotive force due to the telephone current flowing in the rails in electrified territory with minimum interference due to the propulsion current, and means for connecting either the coils of the first pair in series or the coils of the second pair in series with said receiving apparatus.

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