Oct. 2, 1934. W. P. PLACE 1,975,371

ELECTRIC SIGNALING SYSTEM

Filed Dec. 10, 1932 3 Sheets-Sheet 1

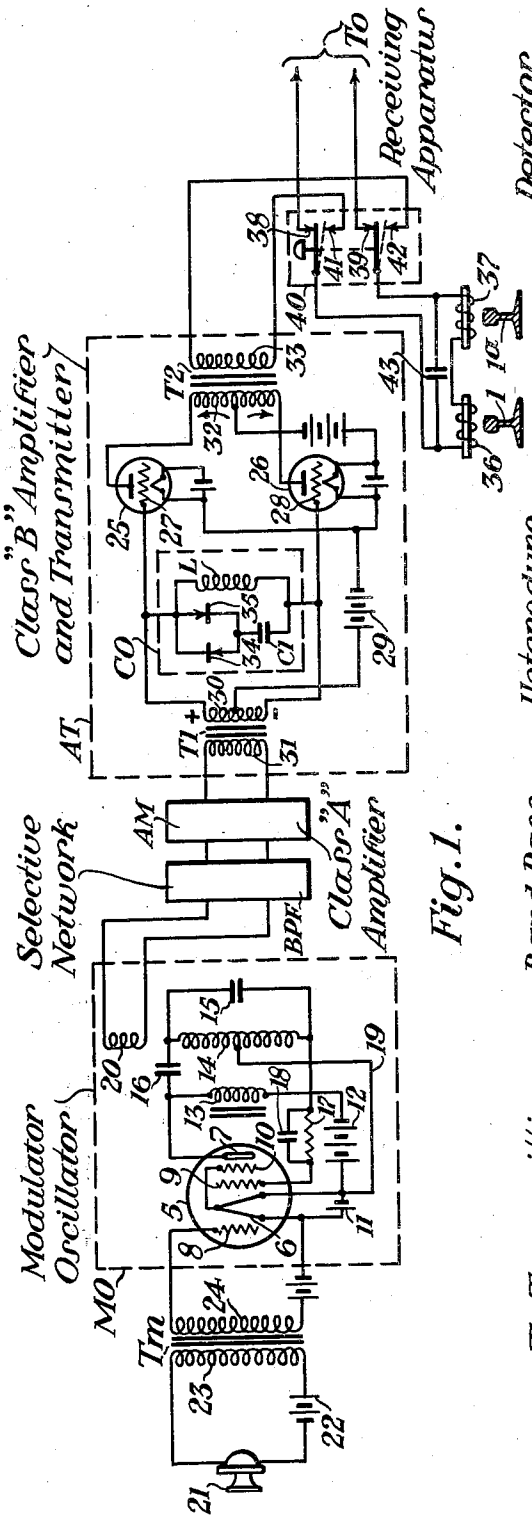


Fig. 1.

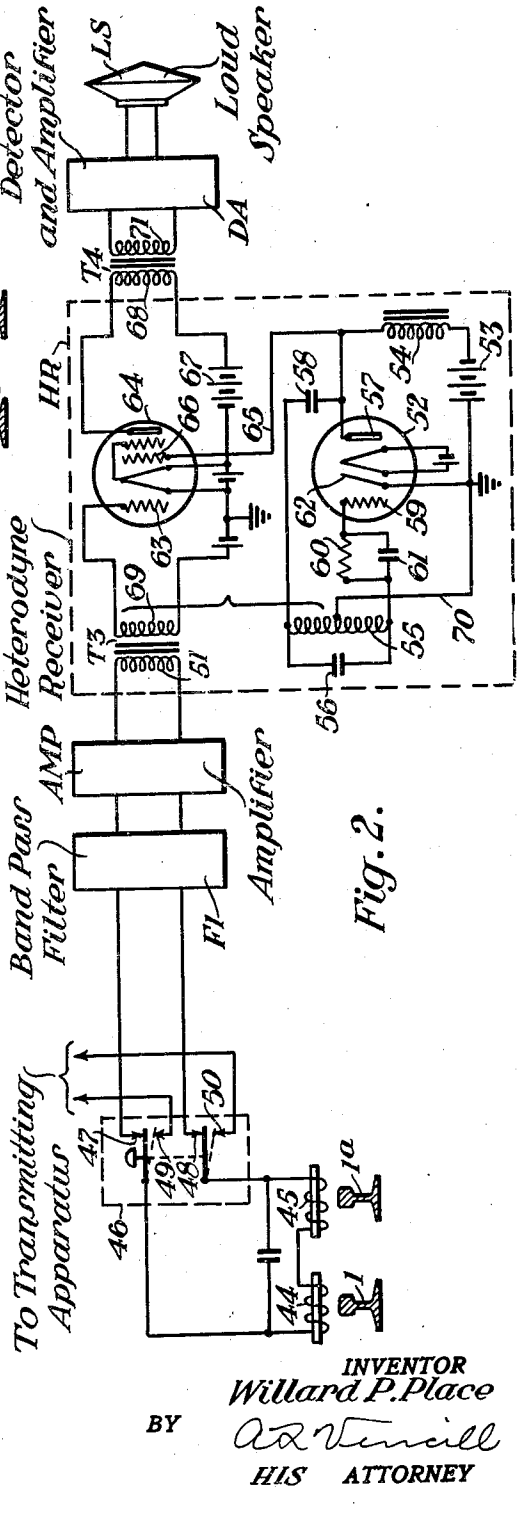


Fig. 2.

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ELECTRIC SIGNALING SYSTEM

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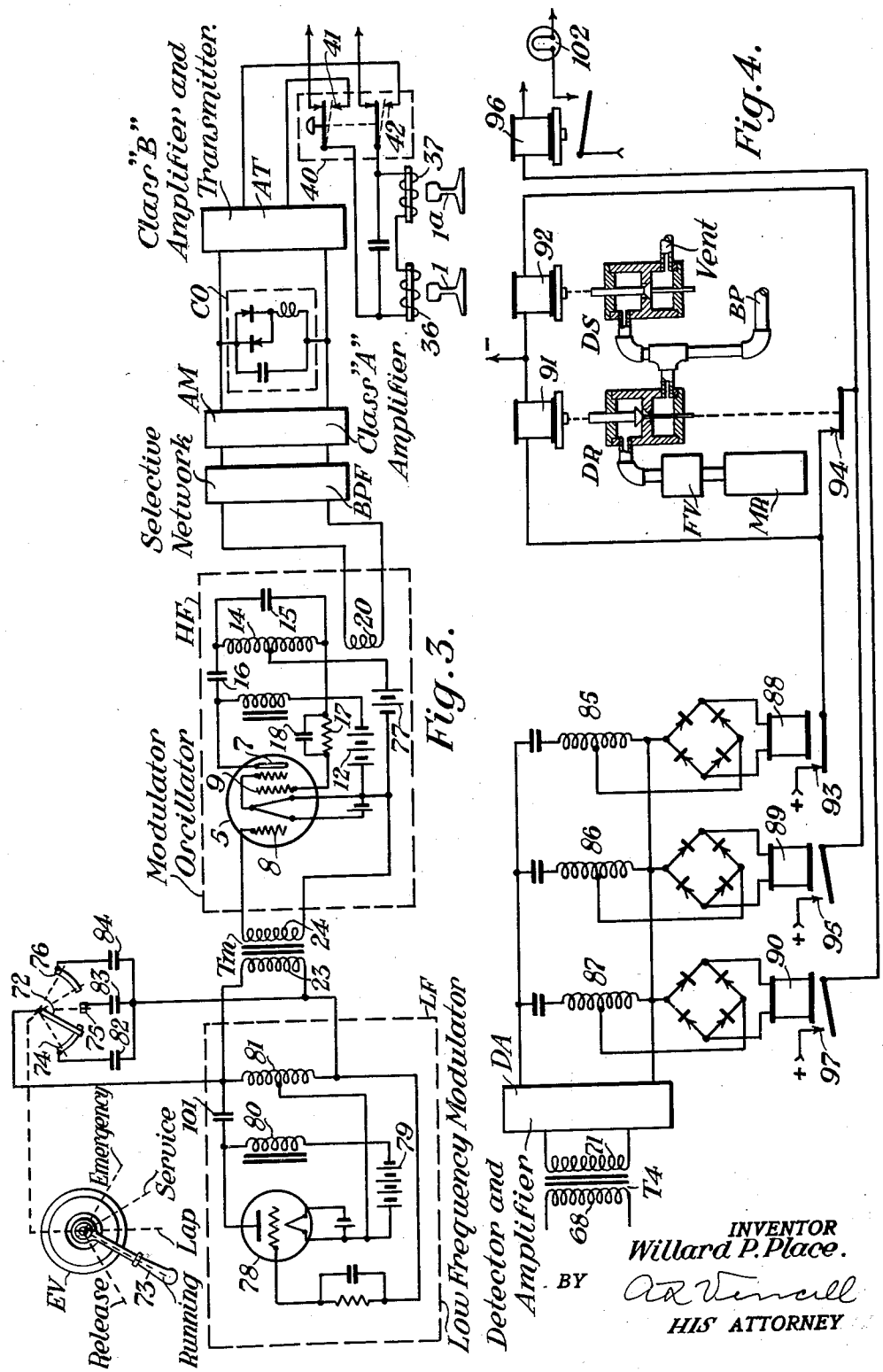


Fig. 3.

Fig. 4.

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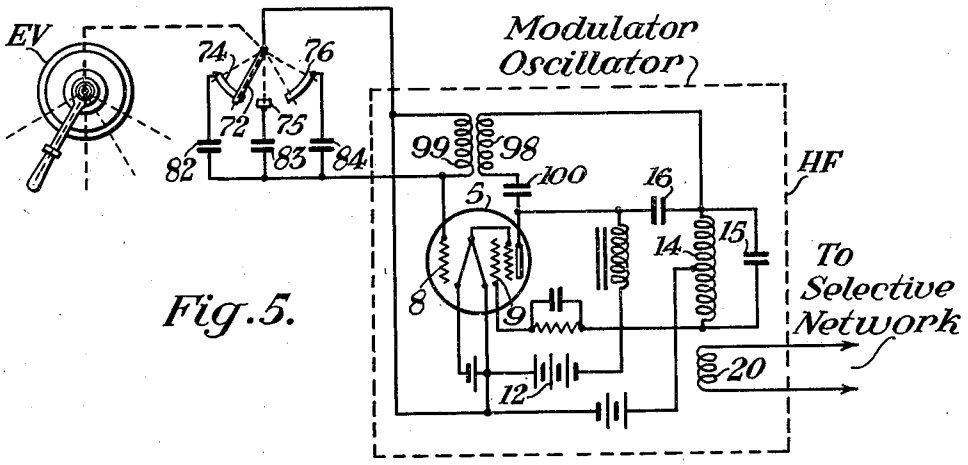


Fig. 5.

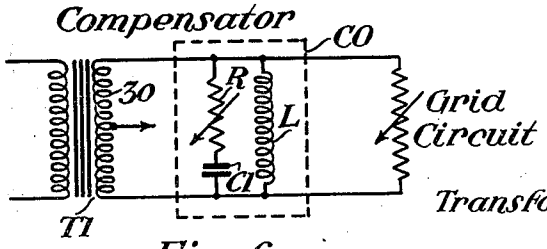


Fig. 6.

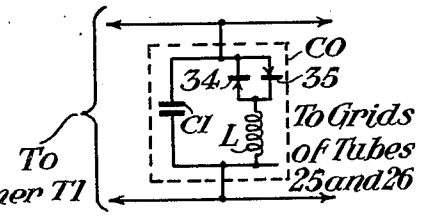


Fig. 7.

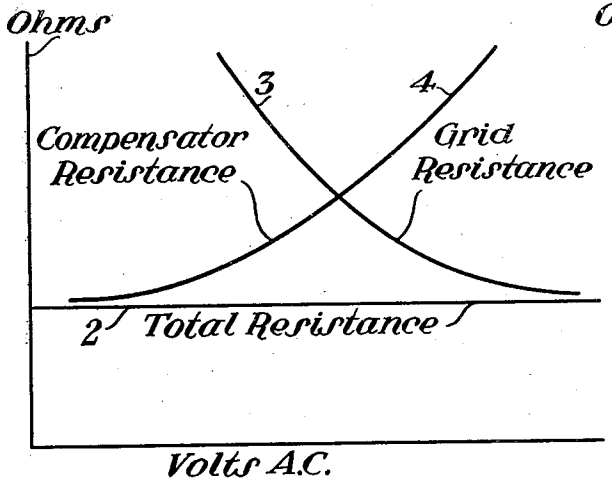


Fig. 8.

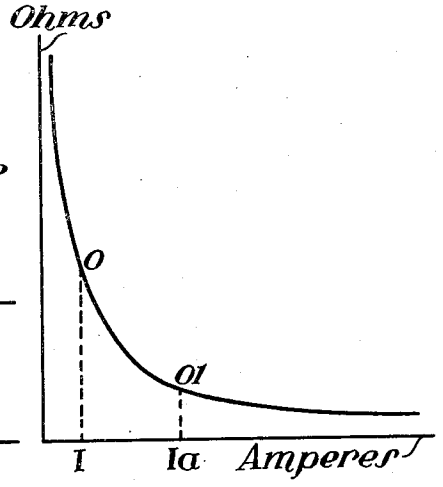


Fig. 9.

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UNITED STATES PATENT OFFICE

1,975,371

ELECTRIC SIGNALING SYSTEM

Willard P. Place, Wilkinsburg, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application December 10, 1932, Serial No. 646,635

4 Claims. (Cl. 179—171)

My invention relates to electric signaling systems, and particularly to signaling systems for railway trains.

I will describe certain forms of apparatus embodying my invention, and will then point out the novel features thereof in claims.

In present day railway practice, a train very frequently is of such length that the customary manner of communicating between the different members of the train crew is ineffective. Signal systems have been proposed whereby a telephone conversation can be carried on between two or more locations on a train. Furthermore, systems have been proposed whereby brake controlling mechanisms located at different points on a train can be simultaneously controlled by the locomotive operator, or whereby control influences can be transmitted from a leading locomotive to a helper locomotive. A feature of my invention is the provision of new and novel apparatus for telephoning between two spaced locations on a train, and, if desired, for conveying control influences between two such locations.

In the accompanying drawings, Figs. 1 and 2, when taken together, constitute a diagrammatic view of one form of apparatus embodying my invention for telephoning between two locations on a train. The apparatus of Fig. 1 is that for transmitting, and the apparatus of Fig. 2 is that for receiving. It will be understood that in practicing my invention both locations will be equipped with the transmitting apparatus of Fig. 1 and the receiving apparatus of Fig. 2 so that a two-way communication may be accomplished. Figs. 3 and 4 are diagrammatic views of modifications of Figs. 1 and 2, respectively, and wherewith control influences for governing a train brake controlling mechanism or other devices are transmitted. Fig. 5 is a diagrammatic view of a self modulated high frequency oscillator which may be used in connection with the transmitting apparatus of Fig. 3. Fig. 6 is a diagrammatic view illustrating the equivalent circuit for the compensator employed between amplifying stages of the transmitting apparatus. Fig. 7 is a diagrammatic view of a second form of the compensator used between the amplifying stages. Fig. 8 is a diagram illustrating the combined resistance of the grid circuit of the amplifier and of the compensator when connected in parallel. Fig. 9 is a diagram illustrating a characteristic of a copper oxide rectifier employed in connection with the compensator.

Although the apparatus of Figs. 1 and 2 may be located at any two points of a train, they will be referred to in the following description as being mounted on the locomotive and in the caboose of a freight train, respectively, in order to clarify the specification. As stated above, in actual practice, both the locomotive and the caboose will be equipped with the apparatus of Figs. 1 and 2 in order to provide a two-way communication. Likewise, in connection with the apparatus of Figs. 3 and 4, the apparatus of Fig. 3 is that installed at the control point, which, in this instance, is on the locomotive; and the apparatus of Fig. 4 is that to be installed at the second location, which, in this instance, is in the caboose.

The communicating circuit from one end of the train to the other may take different forms, but a preferred form is that described and claimed in the L. O. Grondahl application for Letters Patent of the United States, Serial No. 450,135, filed May 6, 1930, for Electric train signaling system, and wherewith communication is maintained between the two ends of a train through the medium of the traffic rails.

Although I am here disclosing a specific application of my invention, it will be understood that I do not wish to limit myself to signaling systems for railway trains. My invention is also equally useful for other signaling systems employing transmitting and receiving apparatus of the type here involved.

In the present system, speech picked up through the medium of a microphone, or a control influence established through the medium of a control device is applied to a relatively high frequency carrier current in such a way that the carrier current is modulated by the voice frequencies or by the frequency of the control influence. This signaling current, which comprises the carrier frequency and two sideband frequencies, is applied to a selective network of balanced circuits and filters, and the carrier and one sideband are substantially suppressed. For functions to appear later, a small portion of the carrier frequency is passed by the selective network. The remaining sideband, preferably, the upper sideband, is amplified and then applied to an amplifying transmitter, a compensator to be fully described later, being inserted in the circuit for compensating the variable resistance of the transmitter. A function of the compensator is to prevent the introducing of harmful distortion that may render the speech sound unintelligible, or the control influences ineffective.

At the second location, this energy is picked up from the communicating circuit and first applied

to a selective band pass filter tuned to select that band of frequencies to the exclusion of all other frequencies. After proper filtering and amplification has been accomplished, the phantom carrier is then supplied by a local oscillator, and the combined currents detected, amplified and delivered to a loud speaker. In the case of control influences, the energy is delivered to sharply tuned circuit networks selectively responsive to the modulation frequencies.

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

Referring to Fig. 1, the reference character MO designates apparatus for generating a carrier frequency current which is to be modulated by voice frequencies. Although the apparatus for generating the carrier frequency may take different forms, preferably, it includes an electron tube having two grid elements such, for example, as the conventional screen grid tube or pentode. In Fig. 1, the electron tube 5 contains a filament 6, a plate 7, and two grids 8 and 9. The filament 6 is provided with a cathode grid 10 interposed between the screen grid 9 and the plate 7 to shield the screen grid from the secondary electrons emitted from the plate 7. The filament 6 is heated by current from a battery 11, and the plate 7 is provided with a circuit including a battery 12 and a customary iron core choke coil 13. The plate 7 and the screen grid 9 are coupled through a tuned circuit including an inductor coil 14 and a condenser 15 to form the conventional Hartley oscillator circuit. A blocking condenser 16 is inserted in the connection of the oscillating circuit with the plate 7; and a biasing element including a resistor 17 and a condenser 18 in parallel, is inserted in the connection to the grid 9, while a center tap of the coil 14 is connected to the filament 6 by a wire 19. These parts are so proportioned and adjusted that oscillations of carrier frequency of, say, 7000 cycles per second are generated in the oscillating circuit, which are induced in an output coil 20. It will be understood, however, that my invention is not limited to any particular carrier frequency, and the frequency of 7000 cycles is given by way of illustration only.

The amplitude of the oscillations is controlled by the voltage applied to the control grid 8, which, in this instance, is determined by a microphone 21 and an associated modulating transformer T*m*. Vibrations produced by speaking into the microphone 21 cause variations in the current flowing in the circuit which includes a battery 22, primary winding 23 of the transformer T*m*, and the microphone 21, and these variations induce corresponding voltages in the secondary winding 24 of transformer T*m*. The voltages induced in the secondary winding 24 are applied to the control grid 8 by a simple circuit, and thus it follows that the carrier frequency current delivered to the output coil 20 will be modulated in accordance with the voice frequencies developed in the microphone 21. The speech modulated carrier current induced in the output coil 20 is thus made up of the carrier frequency of 7000 cycles per second and two sideband groups of frequencies, one having the frequency range of the carrier frequency plus the voice frequency range; and the other having the frequency range of the carrier frequency minus the voice frequency range. This modulated carrier current is applied to a selective circuit network indicated by the reference character BPF and the carrier frequency and one sideband are suppressed, leaving only one sideband, preferably the upper sideband, to be supplied to an amplifier AM. As previously stated, a small portion of the carrier frequency is to be also passed by this selective network BPF. The selective network BPF may be of the band pass filter type which is well known; and as the specific structure of this network forms no part of my invention, it is shown conventionally only in order to simplify the drawings as much as possible.

The output of this selective network BPF is applied to the input of an amplifying device AM, and the amplified output of amplifier AM is used to energize the grids of two power tubes of a type of amplifier known as the class "B" amplifier; and which is indicated as a whole in Fig. 1 by the reference character AT. The amplifier AM may be of any one of several types, but, preferably, it is of the vacuum tube class "A" type. As the specific structure of the amplifier AM forms no part of my invention, it is also shown conventionally only. Electron tubes 25 and 26 of the amplifier AT are of the three-element type, and preferably are matched tubes, that is, they are alike in characteristics. The filaments of the tubes 25 and 26 are each heated by a simple circuit as will be readily understood by an inspection of Fig. 1. The grids 27 and 28 of tubes 25 and 26, respectively, are connected to the opposite terminals of the secondary winding 30 of a repeater transformer T1, the primary winding 31 of which is included in the output of the amplifier AM. The grids 27 and 28 are each negatively biased by a battery 29 connected between a center tap of the secondary winding 30 and the filaments of the tubes.

The amplified voltage induced in the secondary winding 30 of transformer T1 will be relatively high, sufficiently so, as to cause the grids 27 and 28 to become positive during a portion of each cycle. During the portion of the cycle that a grid of a tube is negative with respect to its filament substantially no current flows in the grid circuit, and the grid-filament resistance of the tube is very high. During the part of the cycle that the grid is made positive with respect to the filament, a current flows in the grid circuit, and consequently the grid-filament resistance is lowered to some finite value. If the source of the driving alternating voltage, which, in this instance, is the output of the amplifier AM, has poor voltage regulation this changing in the resistance of the grid circuits for tubes 25 and 26 will cause a sufficient change in the load that distortion of the voltage wave form will take place. In other words, if the electron tube of amplifier AM is not one of relatively large capacity, distortion of the wave form applied to the amplifier transmitter results. The output circuit of tubes 25 and 26 include the opposite halves of the primary winding 32 of an output transformer T2. The two halves of the primary winding 32 are so arranged that variations in current flowing in opposite directions, as indicated by the arrows, have an additive effect in the secondary winding 33. It follows that any distortion of the wave form of the voltage applied to the grids of tubes 25 and 26 will be reproduced in the current supplied by the secondary winding 33 of the output transformer T2.

If a device having low resistance when the voltage impressed on it is low and a high resistance when a high voltage is impressed on it, be placed in parallel with the grid circuits of tubes 25 and 26, the combined load of this device with that of the grid circuits can be made to remain substan-

tially constant throughout the full voltage range of a complete cycle of the wave form of the voltage delivered by the amplifier AM. Such an arrangement will overcome the distortion due to a change in the resistance of the grid circuits. Hence, with such a device or compensator a much lower and more economical amplifier AM can be employed as the driving stage to the amplifier transmitter without distortion resulting from poor voltage regulation. Furthermore, with such a compensator, the amplification factor for the electron tube employed in the amplifier AM will remain substantially constant over the full range of voltages, and distortion due to a variable amplification is avoided.

To this end, I provide a compensator indicated by the reference character CO; and which includes an inductance L, half-wave rectifiers 34 and 35, and a condenser C1. The inductance L constitutes one branch of the compensator, and the rectifiers 34 and 35 in parallel and in series with the condenser C1 constitute a second branch of the compensator. As indicated in the drawings, the rectifiers 34 and 35 are arranged with their low resistance or forward directions reverse to each other. This compensator CO is connected across the terminals of the secondary winding 30 as will be readily understood by an inspection of Fig. 1, and thus forms a load in parallel with the grid circuits of tubes 25 and 26. The parts of the compensator CO are so proportioned as to substantially form parallel resonance at the frequency range of the upper sideband being transmitted.

It is well known that the effective alternating current resistance of a circuit network made up of inductance, capacity and resistance and tuned to parallel resonance, is inversely proportional to the series resistance in the capacity branch or in the inductive branch, or both. Hence, in the equivalent circuit diagram for the compensator CO, as shown in Fig. 6, the effective alternating current resistance of the compensator as a unit for alternating current of the resonant frequency is inversely proportional to the resistance R located in the capacity branch. Assuming the ohmic resistance of the inductance coil L to be negligible, if the resistance of resistor R is high, the effective alternating current resistance of the compensator CO is low; and if the resistance of resistor R is lowered, then the effective alternating current resistance of the compensator is proportionally increased for alternating current of the resonant frequency.

It is also well known that the metal oxide rectifier, such, for example, as the copper oxide rectifier disclosed and claimed in Letters Patent of the United States, No. 1,640,335, granted August 23, 1927, to L. O. Grondahl, has a resistance in its forward direction which decreases with increasing current flow. Referring to Fig. 9, which is a typical characteristic curve for a copper oxide rectifier, an increase in the current flow from the point indicated by the reference character I to that indicated by the reference character Iα is accompanied by a very sharp decrease in the ohmic resistance of the rectifier. In other words, the copper oxide rectifier, when operated in its forward direction and on that portion of its characteristic curve indicated by the points O and O1 of Fig. 9, is a device having a relatively high resistance for low voltages that cause a low current flow and a relatively low resistance for high voltages that cause a high current flow. Thus, if the resistor R of Fig. 6 be made a copper oxide rectifier arranged to operate in its forward direction, the compensator CO will have an effective alternating current resistance for current of resonant frequency, that varies directly with the voltage applied. Therefore, as the instantaneous values of the voltage wave form increase for that half of the cycle corresponding to the forward direction of the rectifier, the current flowing through the resistor R will be increased, causing its ohmic resistance to decrease, and the effective alternating current resistance of the compensator as a unit will be increased. The result is that the load consumed by the compensator will decrease for the higher voltage values.

Referring again to Fig. 1, during the half cycle when the upper terminal of the secondary winding 30 is positive and the lower terminal is negative, and the instantaneous voltage values are high enough to render the grid 27 of tube 25 positive with respect to its filament, these higher voltages cause the current flowing through the rectifier 35 to increase, lowering its ohmic resistance. Hence, the effective alternating current resistance of the compensator CO is increased, and the load consumed by the compensator is decreased. Consequently, the decrease in the load consumed by the compensator will offset the increase in the load resulting from current flowing in the grid circuit during the higher voltages. During the opposite half-cycle, when the lower terminal of secondary 30 is positive and its upper terminal is negative the increase in the current flowing through the rectifier 34 will cause the load consumed by the compensator CO to be decreased with the result that this decrease in the load taken by the compensator CO offsets the increase in the load caused by rendering the grid 28 of tube 26 positive with respect to its filament. It follows that by proper proportioning of the parts of the compensator CO, the load it consumes can be made to so vary as to offset the change in the load taken by the grid circuits of tubes 25 and 26, and the combined load on the amplifier AM will be maintained substantially constant throughout the entire range of voltages. In Fig. 8, there is illustrated the effect produced by the compensator. As the alternating current voltages increase, the grid resistance for the tubes 25 and 26 will decrease substantially in accordance with the curve 3 of Fig. 8, and the effective resistance of the compensator will increase substantially in accordance with the curve 4, with the result that the total load resistance remains substantially constant as indicated by the curve 2 for all voltages of a complete cycle.

36 and 37 are inductor coils mounted on the locomotive in inductive relation with the traffic rails 1 and 1^a, respectively. Normally these inductor coils will be connected to the receiving apparatus on the locomotive to be described later. Reversing a circuit controlling device 40 to the position indicated by dotted lines in Fig. 1, the coils 36 and 37 are transferred from the receiving apparatus to the secondary winding 33 of the output transformer T2, the circuit being completed at the contacts 41 and 42 of the circuit controller 40. A condenser 43 may be connected across the coils 36 and 37 to tune this circuit to the frequency range of the upper sideband. That is to say, at such time as the circuit controller 40 is in its normal position and contacts 38 and 39 closed, the receiving apparatus on the locomotive is coupled to the communicat-

ing circuit, but at such time as the circuit controller 40 is reversed, the transmitting apparatus on the locomotive is coupled to the communicating circuit.

Referring to Fig. 2, the inductor coils 44 and 45 are mounted in inductive relation to the traffic rails 1 and 1a at the caboose. The normal position of a circuit controller 46 connects these coils 44 and 45 to a band pass filter F1 over the contacts 47 and 48. Reversing the circuit controller 46 to a position to close the contacts 49 and 50, the inductor coils 44 and 45 will be transferred to the transmitting apparatus in the caboose and which apparatus will be preferably similar to that described in connection with Fig. 1. The energy picked up from the traffic rails by the coils 44 and 45 is applied to the band pass filter F1 which is so proportioned and adjusted as to select the frequencies of the upper sideband to the exclusion of all other frequencies. The energy selected by filter F1 is applied to an amplifying device AMP which amplifies it and supplies the amplified energy to a primary winding 51 of a coupling transformer T3 associated with a heterodyne receiver indicated as a whole in Fig. 2 by the reference character HR. The filter F1 and amplifier AMP may be any one of several types for such devices and for clarity, they are shown conventionally only as their specific structure forms no part of my invention.

After the received energy has been filtered and properly amplified, the carrier frequency is replaced. The mechanism for supplying the carrier frequency preferably consists of a separate oscillator coupled to a broadly tuned amplifier in such a manner that the energy of the carrier current predominates over the energy of the sideband, and the combination as a whole is then delivered to a detector. In Fig. 2, a local oscillating tube 52 is provided with a plate circuit that includes a battery 53 and a choke coil 54 in the usual manner. The oscillating circuit associated with tube 52 includes an inductance coil 55 and a condenser 56, and this circuit is connected to the plate 57 through a blocking condenser 58 and to the grid 59 through a biasing element comprising a resistance 60 and a condenser 61 in parallel, a center tap of the coil 55 being connected to the cathode element 62 by a wire 70. The parts associated with the oscillator tube 52 are so proportioned that oscillations of the carrier frequency of 7000 cycles per second are generated. The coupling transformer T3 applies the received upper sideband frequencies to the control grid 63 of an amplifying tube 64, preferably of the screen grid or pentode type. The local carrier frequency generated by the tube 52 is applied to the screen grid 66 of tube 64 over wire 65. Hence, there is produced in the plate circuit of tube 64, which includes a battery 67 and the primary winding 68 of a transformer T4, a carrier current modulated in accordance with the voice frequencies produced in the microphone 21 of the transmitting apparatus.

As indicated by a bracket in Fig. 2, the coil 55 is loosely coupled to the secondary winding 69 of transformer T3, and consequently, the small portion of the carrier frequency transmitted along with the upper sideband by the transmitting apparatus of Fig. 1, will function to cause the local oscillator 52 to fall into synchronism, providing, of course, that the local oscillating circuit is not too stable and its resonant frequency is not too far different from the frequency of the incoming carrier. It follows that the small amount of the carrier transmitted along with the upper sideband synchronizes the local oscillator with the transmitted carrier.

As previously stated, the coupling and the manner of supplying the upper sideband to the amplifying tube 64 are such that the energy of the local carrier predominates over the energy of the incoming sideband so that the current supplied by the secondary winding 71 of a transformer T4 is a carrier current of 7000 cycles modulated at the voice frequencies, the effective modulation of which is low. The current supplied by the secondary winding 71 is delivered to a detecting and amplifying device indicated by the reference character DA. The device DA may be any one of several forms of apparatus used for detecting the modulation frequency of a carrier current and cause to appear in its output variations corresponding to the modulation frequencies only. As the type of detector and amplifier forms no part of my invention, this device is also shown conventionally only in order to simplify the drawings. The output of the detector and amplifier DA is supplied to a loud speaker LS, and hence the loud speaker LS will reproduce the message spoken into the microphone 21.

To transmit a spoken message from the caboose to the locomotive, the circuit controller 46 will be reversed to transfer the inductor coils 44 and 45 to the transmitting apparatus in the caboose, and the circuit controller 40 on the locomotive will be set in its normal position to connect its inductor coils 36 and 37 to its receiving apparatus.

In transmitting control influences from the locomotive to another location on the train in accordance with my invention, the transmitting apparatus will preferably take the form disclosed in Figs. 3 and 5, and the receiving apparatus of Fig. 2 will be modified as shown in Fig. 4. Referring to Fig. 3, the reference character EV indicates the usual engineer's brake valve of the standard type, and which is adapted to establish the release, running, lap, service and emergency conditions of the train brakes. As shown schematically, a contact member 72 is actuated by the handle 73 of the brake valve EV. The contact 72 is adapted to engage a contact segment 74 in both the release and running positions to engage a contact segment 75 in the lap position, and to engage a contact segment 76 in both the service and emergency positions. The function of this contact assembly associated with the brake valve EV will shortly appear.

The high frequency oscillator designated in Fig. 3 by the reference character HF includes the oscillating circuit comprising the inductance coil 14 and the condenser 15 which is connected to the plate 7 and the grid 9 of the pentode 5, the same as in Fig. 1 except for the fact that a biasing battery 77 is inserted in the connection from the center tap of coil 14 to the filament of the tube. The parts of this circuit are so proportioned and adjusted that the carrier frequency generated is, preferably, of 3000 cycles per second instead of being of 7000 cycles per second referred to in connection with Fig. 1. I have found that after the parts of this oscillating circuit are once selected and adjusted the desired carrier frequency will be maintained to a high degree of stability if the parts are not subject to further adjustment.

The carrier current is modulated by applying different frequencies to the control grid 8 through the medium of the modulated transformer Tm. The electron tube 78 of the modulator LF is of the usual three-element type, the plate circuit for which includes a battery 79 and the usual

choke coil 80. The oscillating circuit for tube 78 includes a coil 81 and the condensers 82, 83 and 84, and is connected to the plate circuit through the usual blocking condenser 101. Positioning the handle 73 so as to bring the contact member 72 into engagement with the contact segment 74, connects the condenser 82 with the oscillating circuit and the frequency of the oscillations will be, say, 120 cycles per second. Moving the handle 73 to the lap position, causes the condenser 83 to be connected into the oscillating circuit, and the frequency of the oscillations will then be, say, 140 cycles per second. Moving the handle 73 to the service or emergency position causes the condenser 84 to be included in the oscillating circuit, and the frequency will be, say, 160 cycles per second. It will be understood, of course, that my invention is not limited to these specific modulating frequencies, and other frequencies could be selected if found desirable. It follows that when the brake valve EV is at either the release or the running position, the carrier current is modulated at the low frequency of 120 cycles and produces an upper sideband of 3120 cycles. The lap position of the valve EV will be identified by an upper sideband frequency of 3140 cycles, and the service and the emergency positions of the valve EV will be identified by an upper sideband frequency of 3160 cycles.

It is apparent that a frequency variation of the high frequency carrier current of as much as three or four per cent will produce a variation in the frequency of the upper sideband equal to or greater than the modulation frequency, but a frequency variation of the modulation frequencies of even as great as ten per cent. will not vary the upper sideband frequency beyond that which can be tolerated. As previously stated, I have found that a much more stable and reliable condition will result if the adjustment of the high frequency carrier circuit is not molested and the necessary frequency variations are obtained by adjusting the oscillating circuit of the low frequency modulator, than will result if the frequency variations are obtained by adjusting the carrier circuit.

The frequencies induced in the output coil 20 of Fig. 3 are passed to the selective network BPF where the carrier frequency and one sideband are suppressed, and the remaining sideband, preferably the upper sideband, is then applied to the amplifier AM. The amplified upper sideband frequency is passed to the input of the amplifier transmitter AT, a compensator CO being connected in parallel with the amplifier AT to eliminate harmful distortion of the wave form as described hereinbefore. The compensator CO disclosed in Fig. 3 is shown in the form illustrated in Fig. 7, that is, the rectifiers are placed in series with the inductance L. Hence, at such time as the circuit controller 40 is reversed, the inductor coils 36 and 37 are connected to the output of the amplifier AT, and the traffic rails are supplied with the upper sideband frequency corresponding to the position of the brake valve EV, the fidelity of the wave form being maintained by the compensator CO. The current thus supplied to traffic rails will be picked up through the medium of the inductor coils 44 and 45 of Fig. 2 and applied to the filter F1 which, in this instance will be so proportioned and adjusted as to select the frequencies of the range of the locomotive apparatus of Fig. 3. After the energy has been amplified by the amplifier AMP, it is applied to the heterodyne receiver HR through the medium of the coupling transformer T3 and is combined with a local carrier in the manner described hereinbefore. The combined current consisting of the local carrier and the received upper sideband is detected and amplified by the device DA and applied to sharply tuned circuit networks 85, 86 and 87, as shown in Fig. 4. The network 85 is tuned to resonance at the frequency of 120 cycles per second, the network 86 is tuned to resonance at the frequency of 140 cycles per second, and network 87 is tuned to resonance at the frequency of 160 cycles per second, and thus it follows that the relays 88, 89 and 90, controlled by the circuit networks 85, 86 and 87, respectively, will selectively respond to the different positions of the engineer's brake valve EV on the locomotive.

The caboose is equipped with an auxiliary brake controlling mechanism including a main reservoir MR, a feed valve FV, two electropneumatic valves DR and DS and a control magnet 96. The caboose will also be equipped with a compressor, air gages and all other equipment necessary to insure ample air pressure in the main reservoir MR independently of the usual air pressure on the locomotive. The valve DR is biased to the closed position and is held open by the energizing of a magnet 91. The valve DS is biased to the open position and is held closed by the energizing of a magnet 92. When the valve DR is open and the valve DS is closed, the brake pipe BP is connected to the feed valve FV and the auxiliary brake controlling mechanism reproduces the running condition of the engineer's brake valve on the locomotive. When both valves DR and DS are closed both the supply and the exhaust to the brake pipe BP are blanked, and the auxiliary brake controlling mechanism reproduces the lap condition of the engineer's brake valve. When the valve DR is closed and the valve DS is open, the brake pipe BP is connected to the atmosphere through a vent of such characteristic as to produce the usual service rate of reduction of brake pipe pressure, and a service application of the train brakes.

When the relay 88 is energized in response to the modulation frequency of 120 cycles, the magnet 91 is supplied with current by a simple circuit that includes the front contact 93 of relay 88. With the valve DR opened, a contact 94 is closed, and the magnet 92 is supplied with current by the circuit that includes the front contact 93 and the contact 94, and the valve DS is closed. Hence energizing relay 88 causes the auxiliary brake controlling mechanism to establish the running condition of the train brakes. When relay 89 is picked up in response to the modulating frequency of 140 cycles, the magnet 92 will be supplied with current over the front contact 95 of relay 89, and valve DS is held closed. The valve DR will also be closed as its magnet 91 is now without current, and hence the auxiliary brake mechanism establishes the lap condition of the train brakes in response to lap position of valve EV. At such time as both relays 88 and 89 are deenergized, the two magnets 91 and 92 are also deenergized, and the auxiliary brake mechanism establishes a service application of the train brakes. The energizing of relay 90 in response to the modulation frequency of 160 cycles per second, supplies current to the magnet 96 over the front contact 97 of relay 90. The magnet 96 is used to control an indicating device 102 to indicate the brake applying positions of the engineer's brake valve.

In describing the operation of the brake control system disclosed by Figs. 3 and 4, I shall first assume that the engineer's brake valve EV occupies the running position, and the circuit controller 40 is reversed to connect the inductor coils 36 and 37 to the output of the amplifier AT. The running position of valve EV causes the carrier frequency to be modulated at 120 cycles. The upper sideband of 3120 cycles passed by the selective network BPF is amplified and supplied to the traffic rails. At the caboose, the filter F1 selects this upper sideband which is then amplified by the amplifying device AMP. At the heterodyne receiver HR, the local carrier of 3000 cycles is combined with the upper sideband and the combination applied to the detector and amplifier DA. In the output, the circuit network 85 responds to the modulation frequency of 120 cycles, and the relay 88 is selected to effect a running condition of the train brakes at the auxiliary brake controlling mechanism. In the event, the brake valve EV is moved to the lap position, and the modulation frequency of 140 cycles is applied to the carrier frequency, the upper sideband passed by the selective network is of 3140 cycles per second. This upper sideband when received at the caboose and combined with the local carrier causes a current of 140 cycles to appear in the output of amplifier DA and relay 89 is selected with the result that the auxiliary brake controlling mechanism reproduces the lap condition of the valve EV. In the event the valve EV is set at a brake applying position, the modulation frequency applied to the carrier current is 160 cycles per second and the upper sideband has a frequency of 3160 cycles. This upper sideband when received at the caboose and combined with the local carrier causes a current of 160 cycles to appear in the output of amplifier DA and relay 90 is selected. Both relays 88 and 89 are now down and relay 90 is picked up with the result that the auxiliary mechanism establishes a service application of the train brakes, and the magnet 90 is energized to complete a circuit to the indicating device 102.

It is clear that by providing the caboose with transmitting apparatus and the locomotive with receiving apparatus and then operating the circuit controllers 40 and 46 alternately, a return indication can be transmitted from the caboose to the locomotive for controlling indicating or signaling devices whereby the condition of the caboose apparatus will be indicated to the locomotive operator.

In the brake control system, the pentode tube 5 may be arranged as a self modulating high frequency oscillator. Referring to Fig. 5, a high frequency or carrier current is generated by the tube 5 in conjunction with the oscillating circuit including the inductance coil 14 and the condenser 15 the same as in Fig. 3, and at the same time the low frequency or modulating current is generated by the tube 5 in conjunction with the inductances 98 and 99 and the condensers 82, 83 and 84 associated with its control grid 8. Once established, the parts used in connection with the generating of the high frequency carrier current remain fixed to insure a substantially constant frequency therefor. The modulating frequency is varied by selecting the condensers 82, 83 or 84 in accordance with the position of the brake valve EV. The modulated carrier current is then supplied to the selective network through the medium of the output coil 20 the same as in Fig. 3. The form of apparatus disclosed in Fig. 5 possesses the advantage in that one electron tube, namely, the low frequency oscillator, is eliminated.

It is clear that the operation of the system when using the self modulated oscillator of Fig. 5 will be the same as described in connection with the apparatus of Fig. 3.

Signaling systems such as here disclosed, provide a high degree of modulation of a carrier current by using a single electron tube of the pentode type. By using the positive voltage characteristic of the copper oxide rectifier in a compensating resistance, it is possible to energize the amplifier transmitter with substantially no distortion of the wave form. A compensator such as here employed further obtains a substantially constant amplification. When control influences are to be transmitted, suppressing the carrier frequency and one sideband results in a material saving of power. Accurately determining the carrier frequency within permissible limits of variation are readily obtained when the adjustment of the carrier frequency oscillator remains fixed. A self modulating high frequency oscillator possesses the additional advantage in that one electron tube is eliminated.

Although I have herein shown and described only certain forms of apparatus embodying my 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 my invention.

Having thus described my invention, what I claim is:

1. In a signaling system, means to generate a signaling current of a predetermined frequency and having a distinctive wave form, an electron tube amplifying device for amplifying such current; a compensator comprising an inductance branch and a capacity branch arranged for parallel resonance at the frequency of said signaling current, and a copper oxide rectifier inserted in one of said branches; and said compensator connected across the input of the electron tube for eliminating distortion of the wave form of said signaling current.

2. In combination, a source of periodic current having a distinctive wave form, an electron tube amplifying device, means for applying such current across the input circuit of said tube for amplifying the current; a compensating device comprising an inductance path and a capacity path tuned to parallel resonance at the frequency of said current, and a resistance unit having an ohmic resistance which varies inversely with the current flowing therethrough inserted in one of said paths; and said compensating device connected across the input circuit of said tube for compensating the varying impedance of said tube to the periodic current.

3. In combination, a source of alternating current of a given frequency, a push-pull electron tube type amplifier, circuit means for applying the alternating current to the grids of the electron tubes of said amplifier; a circuit network comprising an inductance branch and a capacity branch, and tuned to resonance at the frequency of the alternating current, and said network connected across the grids of said electron tubes; and two copper oxide rectifiers connected in parallel and arranged with their forward direction reverse to each other, and inserted in the capacity branch of said circuit network, whereby the load consumed by said circuit network will decrease

substantially in proportion to the increase in the load taken by the electron tubes.

4. In combination, a source of alternating current, two electron tubes arranged as a push-pull amplifier, circuit means for applying the alternating current to the grids of the electron tubes; a circuit network comprising an inductance branch and a capacity branch, tuned to parallel resonance at the frequency of the alternating current and connected to said circuit means in parallel with the electron tubes; a resistance unit having an ohmic resistance which varies inversely with the current flowing therethrough, and said unit inserted in a branch of the circuit network whereby the said circuit network will compensate the varying impedance of the electron tubes to said alternating current.

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