Aug. 4, 1931. **R. V. MORGENSTERN** **1,817,702**

COMBINING ALTERNATING CURRENT CHANNELS WITH SUPERPOSED TELEGRAPH CIRCUITS

Filed May 14, 1930 2 Sheets-Sheet 1

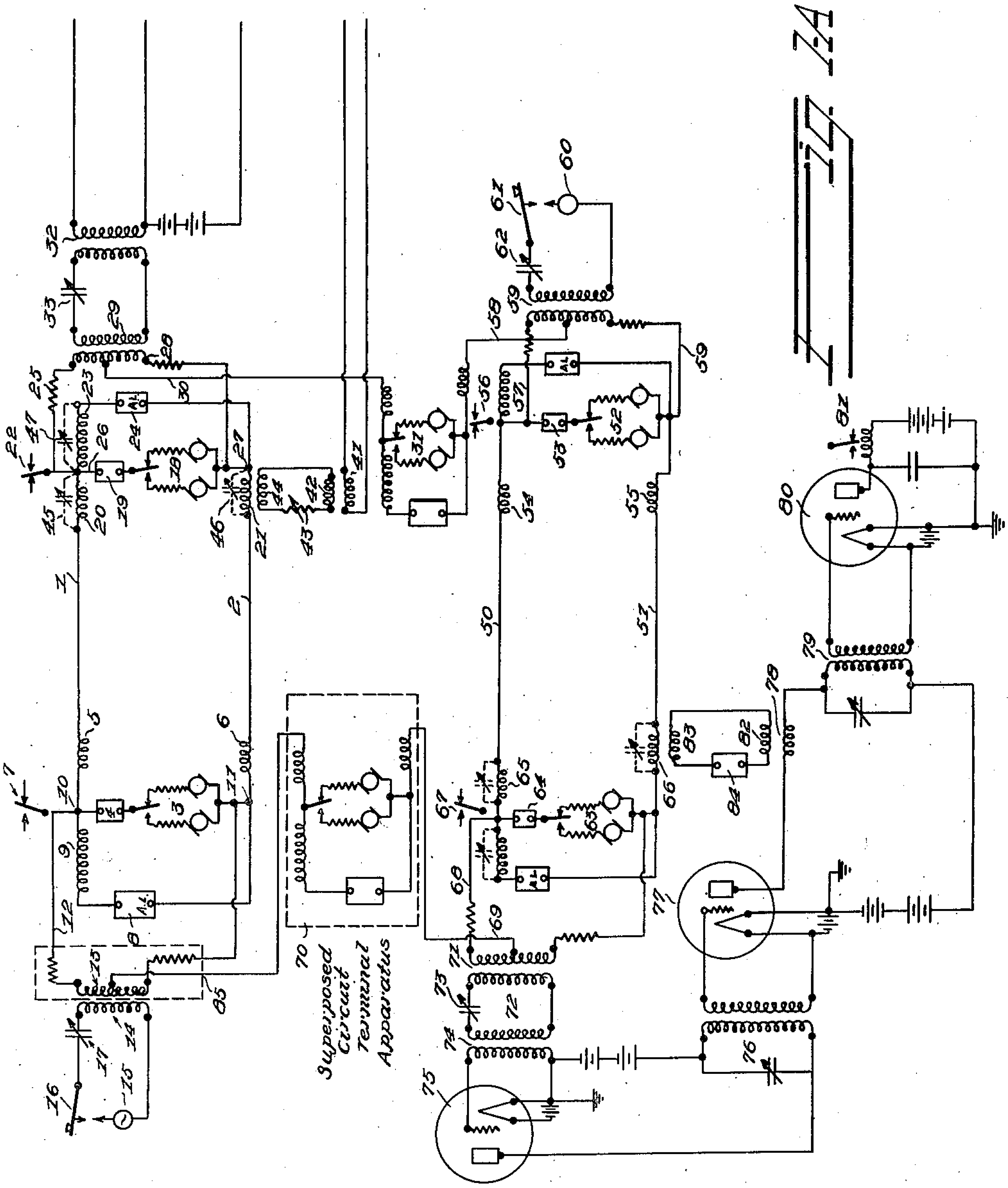

Fig. 1A

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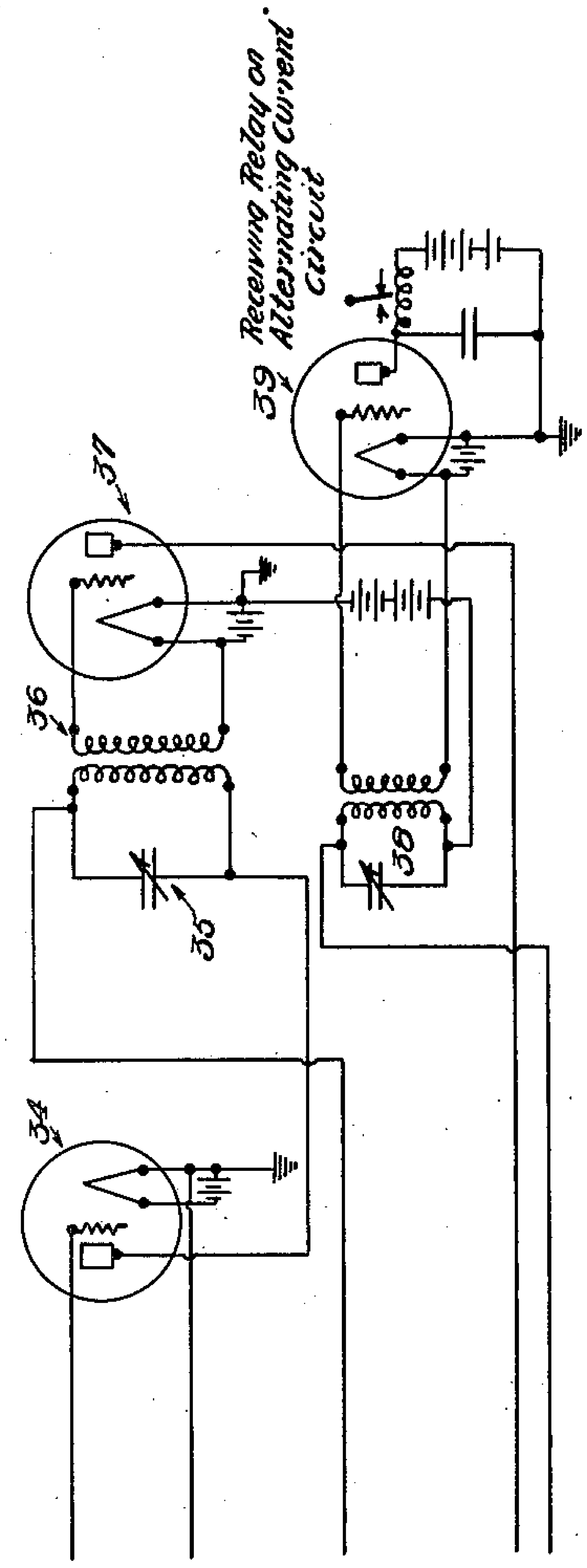

Fig. 1B

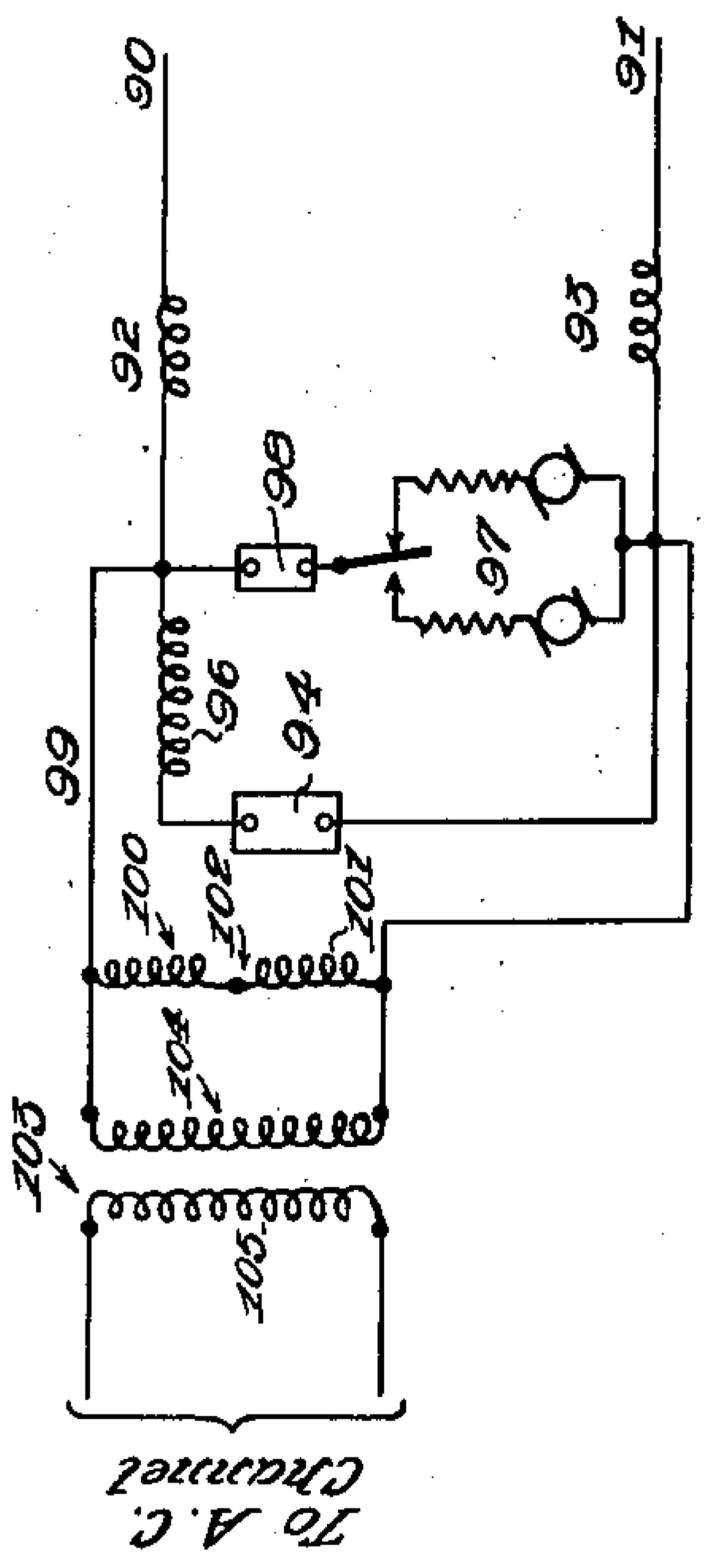

Fig. 2

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UNITED STATES PATENT OFFICE

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COMBINING ALTERNATING CURRENT CHANNELS WITH SUPERPOSED TELEGRAPH CIRCUITS

Application filed May 14, 1930. Serial No. 452,481.

This invention relates to telegraph systems, and in particular to the combination of an alternating current system with superposed telegraph circuits.

The object of the invention is to superpose an alternating current channel upon a direct current telegraph circuit in such a way as to prevent the alternating current channel from interfering with the direct current channel. Specifically an alternating current carrier telegraph circuit channel is superposed upon the side circuits of a superposed telegraph system without interference to either of the side circuits or to the superposed circuit.

An object of the invention is to neutralize directly the alternating current interference to the physical or direct current telegraph circuits.

A further object is to introduce the alternating current signaling channel on to the line wires of a superposed group by means of the inductive shunt connected across the two points at which battery is applied to the side circuits.

In a superposed A. C. carrier system according to this invention, the system can be made fairly rugged as compared with the ordinary carrier system inasmuch as the frequencies which need to be employed will be comparatively low, and the amounts of power which can be employed fairly large. This is made possible because of the provision of means for neutralizing A. C. interference to the D. C. circuit by superposing upon the D. C. circuit a portion of the A. C. signal just large enough to neutralize the disturbing A. C. currents which leak into the direct current apparatus.

In certain superposed systems the superposed circuit is placed on the physical or side circuits by means of a tap at the midpoint of a shunt across two points at which battery is applied to the side circuits. In accordance with one method disclosed hereinafter, this shunt is converted into a transformer the secondary of which is tapped to provide connection of the superposed circuit thereto. The primary is connected through a code making device, illustrated as a key, to a source of alternating current of the desired frequency. As shown, a condenser is placed in series with the primary to tune the primary circuit to resonate at the desired frequency.

At the receiving end of the alternating current channel the shunt to which the superposed circuit is connected is changed to a transformer, connection of the superposed circuit being made to the electrical midpoint of the primary of the transformer. The tuned secondary circuit of this transformer is used to feed the input circuit of a vacuum tube, either directly or through the medium of a second transformer. As illustrated, in the drawing, an amplifier is employed. In the output circuit of the last tube of the amplifier circuit,—that is, the tube preceding the detector tube,—is inserted a transformer which is coupled through a circuit of variable resistance to a coil of the side circuit receiving relay properly poled with respect to its other coils. The purpose of the resistance is to regulate or limit the strength of the amplified signal current which is supplied to the neutralizing relay coil.

Details of the invention will be disclosed more fully in connection with the drawings in which:—

Figures 1—A and 1—B, which when placed together form a complete continuous figure, show a superposed telegraph system in which one of the side circuits is used to transmit alternating current signals in one direction and the other side circuit to transmit alternating current signals in the opposite direction.

Figure 2 is a fragmentary view showing an alternative method of coupling the alternating current channel to the metallic side circuit.

In Figures 1—A and 1—B the line conductors are represented at 1 and 2, the side circuit transmitter 3 being connected thereto by way of a filter circuit diagrammatically represented at 4 and the line coils 5 and 6 of a D. C. receiving relay 7. The side circuit transmitter is diagrammatically represented as comprising a pair of generators connected through resistance, in the usual manner, to the contacts and tongue of a code making device. The receiving relay 7 is connected in neutral relation to transmitter 3 by means of an artificial line 8 and comprises the line coils 5 and 6 and an additional coil 9, the latter connected in series in the artificial line. Points of the receiving relay which are neutral with respect to the transmitter 3 are indicated at 10 and 11. To these neutral points is connected an inductive shunt 12 at the electrical midpoint of which is tapped a conductor 85 by way of which superposed circuit terminal apparatus is conductively connected to the side circuit.

The principles in accordance with which this shunt circuit may be designed are disclosed in an application of R. V. Morgenstern Serial No. 258,948, entitled Superposed telegraph circuits, filed March 3, 1928. The resistance and inductance of the shunt circuit are adjusted to give the least distortion of the received signals at the distant end of the circuit. The shunt circuit has no harmful effect upon the signal currents from transmitter 3 and yet provides means for connecting the superposed circuit to the two points to which battery is applied on the side circuit.

In accordance with the principles of this invention, the inductive portion of shunt 12 comprises a transformer secondary 13, the primary 14 of which is connected to the alternating current source 15 through a code making device schematically represented by the key and contacts 16. An adjustable condenser 17 in series with the primary 14 tunes the circuit to the frequency of the alternating current source 15.

At the receiving end of the line 1—2 is found direct current apparatus corresponding to that already described. A transmitter 18 is schematically represented by a tongue having alternate contacts through which current impulses of opposite polarity are supplied from a pair of generators and their associated resistances. The D. C. signal current is supplied to line through a filter 19 and the coils 20 and 21 of a receiving relay 22. A third coil 23 of the relay is connected in series with the artificial line 24. A shunt circuit 25 is connected to neutral points 26 and 27 of the receiving relay, the inductive portion of which comprises a transformer having a primary 28 and secondary 29. A conductor 30, connected to the electrical midpoint of the primary 28 leads to superposed circuit terminal apparatus indicated generally at 31.

Secondary 29 of the shunt circuit transformer leads to a coupling transformer 32 by way of a series condenser 33. The condenser 33 may be adjusted to tune the circuit to the frequency of the alternating current source 15.

The secondary 32 of the coupling transformer is connected to the input of a three-electrode thermionic vacuum tube 34. The output circuit of vacuum tube 34 is tuned to the frequency of the received A. C. signals and is inductively connected by another coupling transformer 36 to a second amplifier stage comprising amplifying tube 37. The output circuit of vacuum tube 37 includes a tuned circuit 38 coupled to the input of a detector tube 39. Tube 39 supplies rectified signal current to a receiving relay for the A. C. carrier circuit.

The coils 20, 21 and 23 of the receiving relay 22 are shown provided with by-pass condensers 45, 46 and 47 respectively, but these by-pass condensers may be omitted if desired.

The other side circuit comprises conductors 50 and 51 arranged for duplex operation in the usual manner. The duplex terminal apparatus at one end of the line comprises a transmitter 52 connected to conductors 50 and 51 through a filter 53 and the line windings 54 and 55 of a D. C. receiving relay 56. To neutral points of the relay is connected a shunt circuit 57 tapped at its electrical midpoint by a conductor 58 which leads to the superposed circuit terminal apparatus 31 hereinbefore referred to. The transformer 59 in shunt 57 supplies alternating current signals to the shunt and thence to the side circuit from an alternating current generator 60. A key 61 in series with tuning condenser 62 completes the circuit of the A. C. generator.

At the other terminal of the side circuit 50, 51, D. C. terminal apparatus comprises a transmitter 63 connected to the line through a filter 64 and the line windings 65 and 66 of a D. C. receiving relay 67. The line windings of the relay and its artificial line winding are shown shunted by by-pass condensers, but this feature is optional. One purpose of the by-pass condensers is to cut down the amount of A. C. signaling current which passes through the windings of the D. C. relay.

To neutral points of the receiving relay 67 is connected the shunt 68 at the electrical center of which a conductor 69 leads to superposed circuit terminal apparatus 70. The transformer 71 in shunt circuit 68 forms part of an intermediate circuit 72 tuned to the frequency of the alternating current of the transmitting generator 60. The tuned intermediate circuit supplies received alternating current signals to the grid circuit of a vacuum tube 75 by way of the coupling transformer 74.

The tuned output circuit 76 of tube 75 is coupled inductively to the grid circuit of a second amplifier tube 77. The output circuit of amplifier tube 77 includes the transformer 78 and a loop tuned circuit 79. Tuned circuit 79 is coupled to the grid circuit of detector tube 80 in the output circuit of which is connected a receiving relay 81 for the alternating current circuit.

In Figure 2 is shown an alternative method for connecting the alternating current channel to the inductive resistance shunt. In this figure the conductors of the side circuit are represented as 90 and 91, the line windings of the D. C. relay at 92 and 93, the artificial line at 94, and the artificial line winding of the D. C. relay at 96. Transmitter 97 is connected through a filter 98 to neutral points of the relay. To these same neutral points is connected a shunt circuit 99. In this case the shunt circuit 99 comprises two portions in parallel. One portion includes the two electrically equal halves 100 and 101 of an inductive resistance shunt, at the electrical midpoint 102 of which connection may be made to a superposed circuit. The other portion comprises a coupling transformer 103 including two windings 104 and 105. The winding 104 is in parallel to the inductive resistance shunt. The winding 105 is connected to the apparatus of the alternating current channel.

An arrangement according to Figure 2 may be employed where the resistance and inductance of the shunt are such that the shunt cannot readily be converted into a suitable transformer. It may also be used in the case of superposed systems such as that disclosed in the application of Morgenstern & Teter, Serial No. 422,194 filed January 20, 1930, entitled Superposed telegraph system, in which the superposed circuit is taken out of the center of the armature of a generator forming the signaling source on the side circuit.

It is to be understood that the alternative connection illustrated in Fig. 2 may be used at either end of either side circuit; that is, it may be used in place of the shunt circuits indicated at 12, 25, 57 and 68, or at any one or more of these. If the circuit of Fig. 2 replaced the shunt 12 or the shunt 57, then the coil 105 of Fig. 2 would be connected to alternating current transmitting apparatus. If the shunt circuit of Fig. 2 replaced the shunt 25 or 68, the coil 105 of Fig. 2 would be connected to alternating current receiving apparatus.

The filter circuits represented diagrammatically at 4, 19, 53 and 64 may be parallel resonant circuits tuned to the frequency of the corresponding alternating current generator or they may be low-pass filters designed to transmit alternating current of the signaling frequency and to exclude undesired components of the direct current signal. Any other form of filter accomplishing the desired purpose may be used.

By selecting the frequency of the alternating current channel in proper relation to the frequency components of the transmitted signal from the direct current sources of the side circuit, the interference between circuits can be minimized and the effect of the added filter apparatus on the side circuits can also be minimized.

The condensers in parallel with the coil of the receiving relay 22 (e. g. 45, 46 and 47) at the receiving end of the A. C. channel may be proportioned with relation to the inductance of the relay coils and the frequency of the alternating current channel to reduce both the amount of interference current to be neutralized and the impedance of the D. C. relay to the alternating current. This current from the alternating current channel which passes through the relay coils tends to cause it to operate. By passing the correct amount of current through the neutralizing relay coil in the amplifier circuit, this current from the alternating current channel may be neutralized.

Although but one alternating current channel is shown on the drawing, additional channels may be employed if proper apparatus be provided to separate them.

The frequency supplied from the alternating current source 15 and that supplied from the alternating current source 16 need not be the same. As has been pointed out above, the frequencies may be comparatively low and the amounts of power employed may be fairly large since interference to the physical or direct current telegraph circuit can be neutralized directly intsead of depending upon filters to separate the direct current and alternating current channel. In this connection it will be noted that the alternating current channel is applied to the side circuits at the same point as the D. C. signaling potential from these side circuits.

It is apparent that the alternating current chanel may be superposed on a side circuit operating in one direction only instead of duplex.

The parallel resonant tuned circuit or low pass filter inserted in the battery supply circuit of the side circuits serves to minimize the shunting effect of the direct current battery supply of the side circuits on the alternating current channel, as well as to minimize the interference from the direct current channels into the alternating current channels.

The alternating current porton of the system is prevented from interfering with the direct current portion as follows. Closing the key 16 connects the source of alternating current 15 to the tuned circuit composed of condenser 17 and transformer primary 14. The alternating current then passes via transformer secondary 13 which forms a part of shunt circuit 12 to points 10 and 11 of the receiving relay 7 on the direct current circuit connected to line wires 1 and 2. The alternating signaling current has two paths between points 10 and 11. One path is via artificial line coil 19 of relay 7 and the artificial line 8. The other is via coil 5 of relay 7 line wire 1, the transformer primary 23 (which forms a part of shunt circuit 28) coil 21 of relay 22, line wire 2 and coil 6 of relay 7. A small portion of the current will pass between points 26 and 27 of relay 22 via relay coil 23 and artificial line 24. The filter 19 stops the alternating current from flowing via the transmitter 18.

Now consider the effects of the alternating current from source 15 on the receiving relays 7 and 22 of the direct current circuit. Coils 5 and 6 are connected to line wires 1 and 2 in series aiding and are connected in opposition to relay coil 19 in series with the artificial line 8. Coils 5 and 6 together have the same number of turns as relay coil 19.

If, then, the artificial line circuit has the same effective impedance as the real line at the frequency of the alternating current channel, the same current will pass through coil 19 of relay 7 as through coils 5 and 6 and in opposite directions, and relay 7 will not be affected by outgoing alternating current, just as it is not affected by current from the direct current transmitter 3.

Current from the alternating current channel passes through coils 20, 21 and 23 of relay 22 in a direction to cause relay 22 to tend to operate.

Relay 22 is, however, equipped with coil 44 which is connected through adjustable resistance 44 and transformer windings 42 and 41 to the output circuit of vacuum tube 37. The alternating current in the relay coil 44 is adjusted in amount and phase relationship to neutralize the effect of that coming over line wires 1 and 2 and passing through the coils 20, 21 and 26 of relay 22. If necessary to get the proper phase relationship, a variable condenser can be placed in the circuit containing neutralizing coil 44.

Alternating current from source 60 is prevented from interfering with relays 56 and 67 connected to wires 50 and 51 in the same manner. That is, the effect on relay 56 is balanced out by the artificial line and its associated relay coil. The effect on relay 67 is balanced out by means of the neutralizing coil 83 and its associated circuit.

I claim:

1. In a signaling system, a line circuit comprising a pair of conductors, a source of D. C. voltage connected across terminals of said line to apply direct current signals thereto, an inductive shunt connected across said terminals with a superposed circuit connected to the electrical midpoint of said shunt and a source of A. C. voltage connected to apply A. C. signal currents to said line circuit at said terminals.

2. In a signaling system a line and a balancing line arranged for duplex operation, a transmitter, relay windings in said line and balancing line connected so that the relay is in neutral relation with respect to said transmitter, a circuit in shunt to said transmitter, a superposed circuit connected to said line by way of said shunt circuit, an alternating current signal receiving circuit connected to said shunt and means for applying a portion of the signal energy in said receiving circuit to an additional relay winding whereby said relay is neutral wth respect to said alternating current signals.

3. A signaling circuit comprising a line, a D. C. signal transmitter and a D. C. receiving relay connected to said line so that the relay is neutral with respect to D. C. signals from said transmitter, an inductive shunt circuit connected across said D. C. transmitter, a superposed circuit connected to said line at an intermediate point in said shunt circuit, an alternating current receiving circuit connected effectively in parallel to said shunt and means interconnecting said receiving circuit and said D. C. relay for neutralizing the effect of alternating current signals on said D. C. relay.

4. A signaling circuit comprising a line, D. C. transmitting and receiving apparatus connected to said line to provide duplex operation thereover, inductive shunt circuits in parallel to said line across said D. C. transmitting apparatus, an alternating current source coupled to one of said shunt circuits for applying A. C. signals to said line, an alternating current receiving circuit coupled to the other shunt circuit and means interconnecting said alternating receiving circuit and its associated D. C. receiving apparatus for applying a portion of the A. C. signal current to said D. C. receiving apparatus.

5. A signaling circuit comprising a line, D. C. transmitting and receiving apparatus connected across the line at both terminals thereof to provide duplex operation thereover, inductive shunt circuits in parallel to said line across said D. C. transmitting apparatus, an alternating current source coupled to one of said shunt circuits for applying A. C. signals to said line, a tuned alternating current receiving circuit coupled to the other shunt circuit, by-pass condensers in shunt to said D. C. receiving apparatus and means interconnecting said alternating current receiving circuit and the D. C. receiving apparatus at the same terminal for applying an adjustable portion of the received A. C. signal current to said D. C. receiving apparatus.

6. A signaling circuit comprising a line, D. C. transmitting and receiving apparatus connected across the line at each terminal thereof to provide duplex operation thereover, inductive shunt circuits in parallel to said line across said D. C. transmitting apparatus, an alternating current source coupled to one of said shunt circuits for applying A. C. signals to said line, a tuned alternating

current receiving circuit coupled to the other shunt circuit and filtering means in series with said D. C. transmitting apparatus across the line having a frequency characteristic designed to exclude currents of the frequency of the alternating current source, whereby the shunting action of said D. C. transmitter to A. C. signal currents and interference from said D. C. transmitter in the A. C. receiving channel are suppressed.

7. A signaling circuit comprising a line, a D. C. telegraph transmitter connected across said line, an inductive shunt circuit connected to the line terminals of said transmitter having electrical constants such that the shunting action of the inductive circuit to signal currents of opposite polarities from said transmitter are practically suppressed at the beginning of a signal, and a tuned alternating current signal receiving circuit coupled to said shunt effectively in parallel to the terminals thereof.

8. A signaling circuit comprising a line, a D. C. telegraph transmitter connected across said line, a D. C. receiving relay having windings in series in said line, an inductive shunt circuit connected to the line terminals of said transmitter, a tuned alternating current signal receiving circuit coupled to said shunt and means for applying a portion of the received A. C. signal current from said tuned circuit to a winding of said D. C. receiving relay.

9. A signaling circuit comprising a line, a D. C. telegraph transmitter connected across said line, a D. C. receiving relay having windings in series in said line, an inductive shunt circuit connected to the line terminals of said transmitter, a tuned alternating current signal receiving circuit coupled to said shunt comprising means for amplifying the received alternating current and means for applying an adjustable portion of the amplified current to a winding of said D. C. receiving relay.

10. A signaling circuit comprising a line, a D. C. telegraph transmitter connected across said line, a D. C. receiving relay having windings in series in said line, said transmitter being connected to neutral points of said relay through a filter designed to suppress A. C. components of the D. C. signal having a given frequency, an alternating current receiving circuit tuned to signal currents of said given frequency, means for receiving alternating currents of said given frequency in said tuned circuit through the line windings of the D. C. relay in series and means for applying a neutralizing alternating current of said given frequency to said D. C. relay.

11. In a superposed telegraph system, a pair of line conductors and an artificial balancing line therefor, transmitting and receiving apparatus connected to said line and artificial line for the two way transmission of direct current signals thereover, an alternating current channel superposed thereon comprising a transmitter at one end of the line and a receiver at the other, the impedance of said artificial line at the frequency of said alternating current being substantially the same as the line impedance at said A. C. frequency and means comprising said artificial line for neutralizing the effect of signals from said A. C. transmitter upon said direct current receiving apparatus.

12. In a combined direct and alternating current telegraph system, a line and an artificial line therefor adapted to balance said line for direct and alternating current signal frequencies, a direct current receiving relay, a direct current transmitter connected to the line and balancing line through opposed windings of said relay whereby the effects of currents from the D. C. transmitter on said relay neutralize one another, an alternating current channel superposed upon said line comprising an A. C. transmitter connected to said line and artificial line in balancing relation through said opposed windings of the D. C. relay.

13. In a combined direct and alternating current telegraph system, a line, an artificial line therefor having an impedance characteristic simulating that of the line at the frequencies of the direct and alternating current signals, a direct current transmitter, a direct current receiving relay having windings in said line and other windings in said artificial line connected in opposition to said line windings with respect to currents from said direct current transmitter and an alternating current transmitter connected to send A. C. signal currents through the line and artificial line windings of said direct current relay in opposition.

14. In a combined direct and alternating current telegraph system, a line, an artificial line therefor having an impedance characteristic simulating that of the line at the frequencies of the direct and alternating current signals, a direct current transmitter connected across said line, an inductive shunt circuit connected to the terminals of said transmitter, a direct current receiving relay having windings in said line and other windings in said artificial line connected in opposition to said line windings with respect to currents from said direct current transmitter, an alternating current channel superposed on said line comprising an alternating current transmitter coupled to said shunt circuit, whereby A. C. signal currents from said A. C. transmitter pass through the line and artificial line windings of said direct current relay in opposition.

15. In a combined direct and alternating current telegraph system, a line, an artificial line therefor having an impedance charac-

teristic simulating that of the line at the frequencies of the direct and alternating current signals, a direct current transmitter connected to said line through filtering means designed to exclude currents of the alternating current signal frequency, an inductive shunt circuit connected to the terminals of said transmitter, an alternating current signal transmitter coupled to said shunt, a direct current receiving relay having windings in said line and other windings in said artificial line connected in opposition to said line windings with respect to currents from said direct and alternating current transmitters.

16. In a combined direct and alternating current telegraph system, a line, an artificial line therefor having an impedance characteristic simulating that of the line at the frequencies of the direct and alternating current signals, a direct current transmitter connected across said line, an inductive shunt circuit connected to the terminals of said transmitter, a direct current receiving relay having windings in said line and windings in said artificial line connected in opposition to said line windings with respect to current from said direct current transmitter, capacitive shunts about the windings of said line and artificial line relay windings, and an alternating current signal transmitter coupled to said shunt circuit, whereby signals from said A. C. transmitter are prevented from causing operation of said direct current relay.

In testimony whereof I affix my signature.

RONALD V. MORGENSTERN.