June 19, 1923. 1,459,709

B. W. KENDALL

MULTIPLEX SIGNALING

Filed Oct. 13, 1916 2 Sheets-Sheet 1

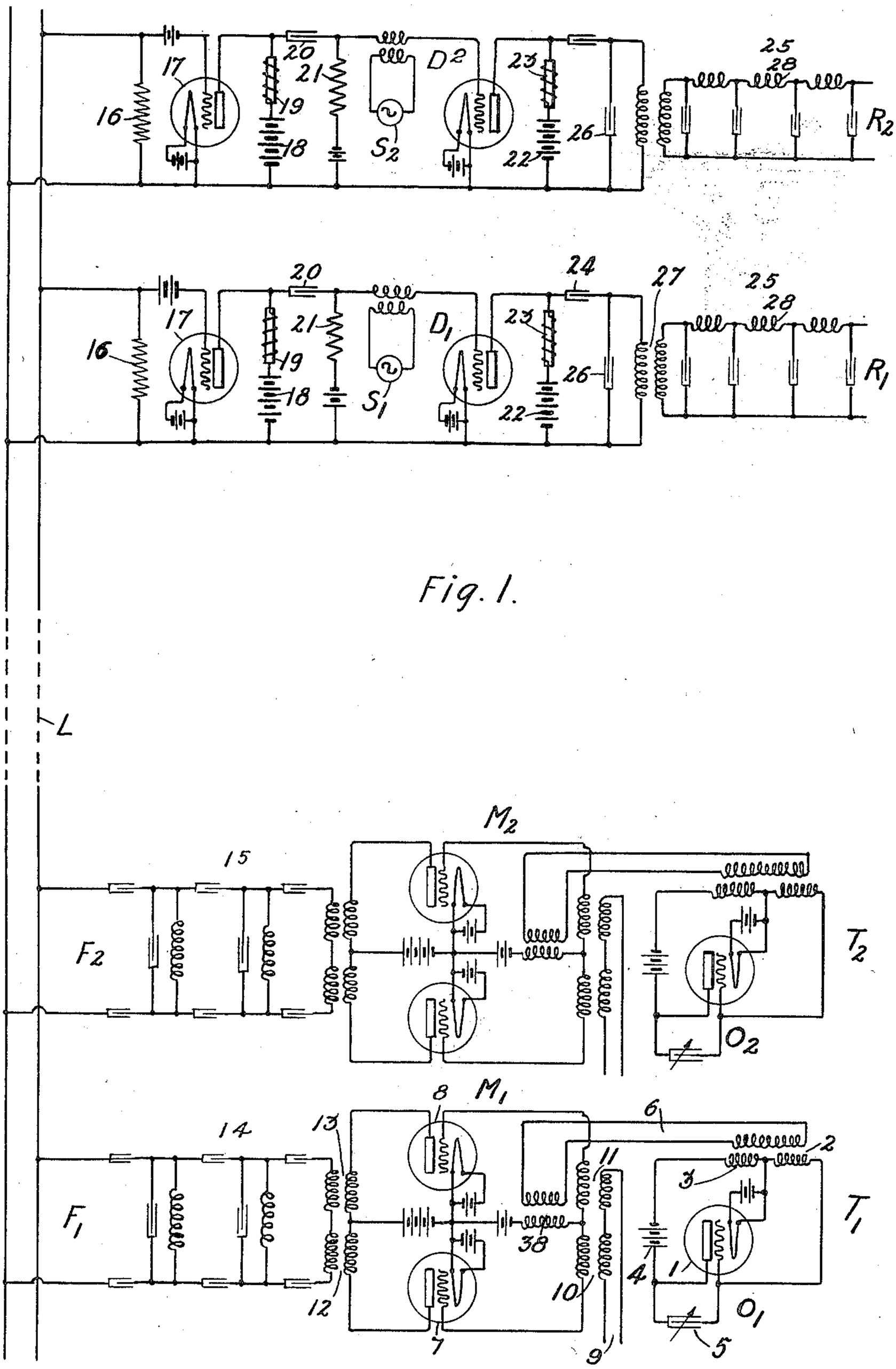

Fig. 1.

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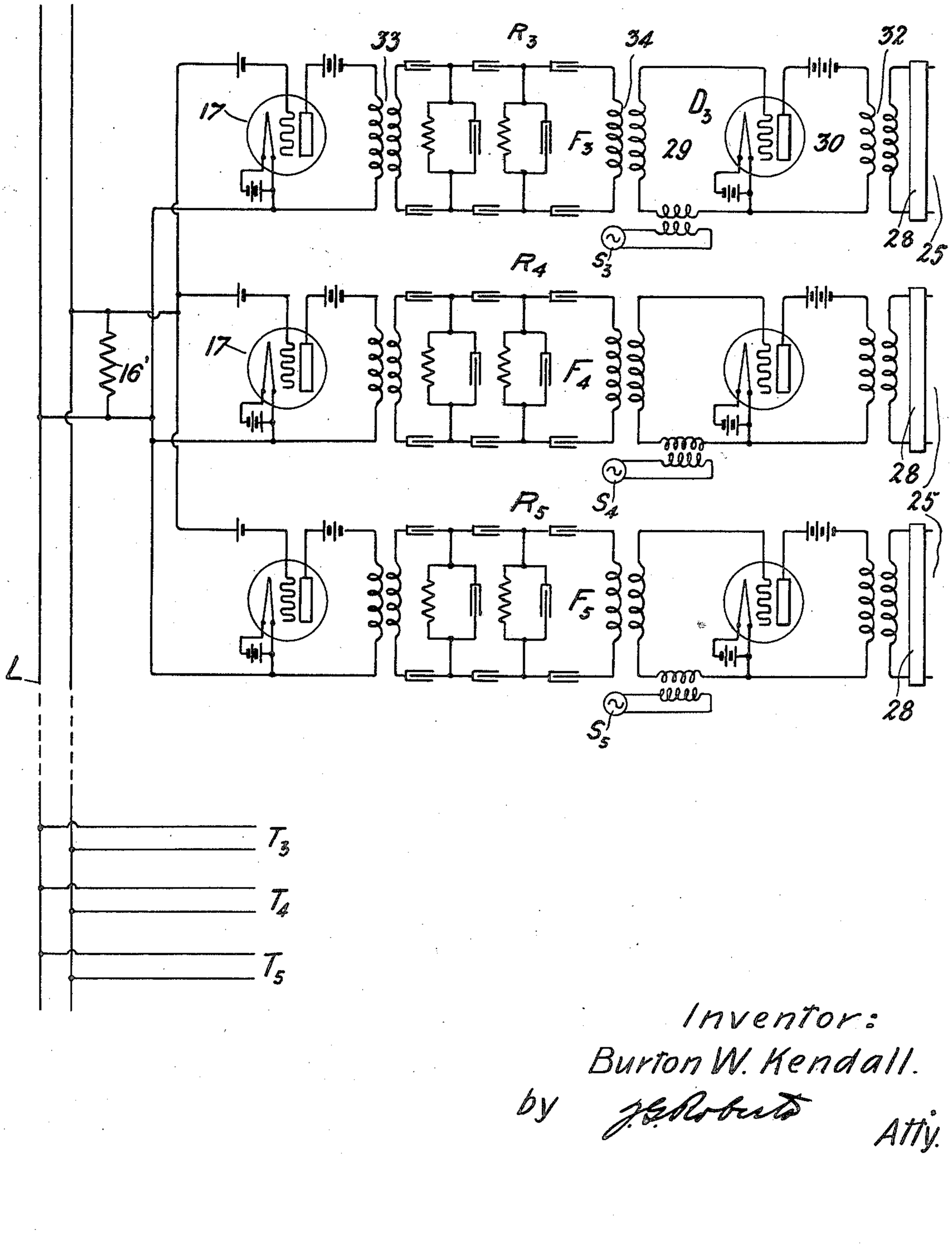
Fig. 2.



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UNITED STATES PATENT OFFICE.

BURTON W. KENDALL, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

MULTIPLEX SIGNALING.

Application filed October 13, 1916. Serial No. 125,349.

To all whom it may concern:

Be it known that I, BURTON W. KENDALL, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Multiplex Signaling, of which the following is a full, clear, concise, and exact description.

This invention relates to a system for multiplex signaling in which signals are transmitted by means of modulated high frequency carrier waves. In such a system, a plurality of transmitter circuits are each in communication with a corresponding receiver circuit. Each of the transmitter circuits comprises a source of carrier oscillations of a frequency different from that supplied to the other transmitter circuits, and each of the receiver circuits is provided with means for selecting the message supplied by its corresponding transmitter circuit.

One of the objects of the invention is to insure that a signal originating in one transmitter circuit shall be received by the corresponding receiver circuit and by no others.

Signals are transmitted as modulations of a high frequency wave and in order that the signal may be received only by the corresponding receiver circuit, it is necessary that the signal currents effect a modulation only of the carrier oscillations generated in the transmitter circuit in which the signal originated.

The invention provides for making each transmitter circuit a path of low attenuation to currents originating therein but a path of high attenuation to currents from other transmitter circuits. This is done by connecting in each transmitter circuit a a wave filter which passes the modulated high frequency of that transmitter circuit to the exclusion of modulated oscillations of other high frequencies from other transmitter circuits. Modulated oscillations and amplified low frequency signals from one transmitter circuit cannot circulate in other transmitter circuits to effect a modulation of the carrier oscillations in the latter circuits. Each set of signals is accordingly transmitted on a single carrier wave whereby the signal is received only at the proper receiving station.

In United States patent to Carson, 1,449,382, March 27, 1923, is shown that if a carrier wave of frequency p is modulated by signal oscillations of frequency a, the modulated wave may be considered as having three components of which the frequencies are p, $p+a$, and $p-a$. In said patent it is also shown that the unmodulated component of frequency p may be eliminated at the sending station so that only the side frequencies $p+a$, $p-a$ are transmitted. The unmodulated component of frequency p, which must be combined with $p+a$ or $p-a$ to obtain the speech frequency a, is restored at the receiving station by means of a local generator.

According to the present invention, in each transmitter circuit there is generated a carrier wave of a frequency different from that generated in the other transmitter circuits. The unmodulated component of carrier frequency is eliminated at each sending station and is restored by a local generator at each receiving station, thus the signal is identified in the proper receiver circuit by combining or reinforcing the received oscillations with locally generated oscillations of the frequency of the carrier waves generated in the corresponding transmitter circuit.

Another object of the invention is to prevent the locally generated oscillations in one of the receiver circuits from affecting the other receiver circuits. The oscillations locally generated in a receiver circuit are confined to that circuit by making the same asymmetrically conducting. Each local generator can then supply oscillations only to its own receiver circuit.

In the system herein disclosed each receiver circuit is receptive to currents from all of the transmitter circuits. But the currents from transmitter circuits other than the preferred transmitter circuit, will combine with the locally generated oscillations to produce frequencies higher than those necessary for the transmission of speech. It is necessary to eliminate these higher frequencies. This is accomplished by means of a low pass filter in each receiver circuit, whereby only the low frequency message is transmitted. The term "low pass filter," as used throughout the specification, designates a filter which suppresses currents of frequencies above a given value and which transmits exclusively currents of frequencies below that value.

The message is then received at the proper

receiver circuit, as the local generator supplies oscillations of the carrier frequency whereby the message transmitted on the carrier wave of that frequency will be reproduced in the proper receiver circuit, while the low pass filter serves to eliminate higher frequency oscillations due to the locally generated oscillations combining with different frequency oscillations from circuits other than the corresponding sending circuit.

This will more fully appear in connection with the description of the system disclosed in the drawing, in which:

Fig. 1 shows diagrammatically two receiving circuits in communication with two corresponding sending circuits, and

Fig. 2 discloses a modified form of receiver circuits.

The sending circuit T_1 in Fig. 1 of the drawing is adapted to transmit modulated oscillations to the receiver circuit R_1, and the transmitter circuit T_2 is adapted to communicate messages to the receiver circuit R_2. The oscillation generator O_1 at station T_1 is of the type disclosed in the United States patent to Ralph V. L. Hartley, 1,356,763, patented October 26, 1920, for "oscillation generators." This oscillation generator comprises a vacuum tube 1 of the audion type having coil 2 in its input circuit inductively related to coil 3 in its output circuit. The battery 4 serves as a source of power for the output circuit and the frequency of the oscillations is determined by the adjustment of the variable condenser 5 in shunt to coils 2 and 3. Coils 2 and 3 are adapted to supply high frequency oscillations by means of the circuit 6 to the modulating device M_1.

This modulating device serves to eliminate the unmodulated component of the message wave as described in detail in the Carson patent referred to. As described therein, this modulating system comprises the vacuum tubes 7 and 8 connected in opposition and having divided input and output circuits. The circuit 6 transfers the carrier oscillations from the oscillation generator O_1 to the coil 38 connected between the points of division of the divided input circuits. Signal oscillations are transferred from circuit 9 to the input circuits of tubes 7 and 8 by means of the transformers 10 and 11 respectively. The output circuits of the tubes 7 and 8 are connected by means of the transformers 12 and 13 to the circuit 14 which is adapted to transmit a message wave to the line L. When only carrier oscillations are impressed on the input circuits of the tubes 7 and 8, these oscillations will not be reproduced in the output circuit thereof, as transformers 10 and 11 conduct opposed currents to these tubes. This balanced condition is disturbed, however, when signal currents are present in circuit 9, and the carrier oscillations supplied by circuit 6 are effectively modulated.

The transmitter circuit T_2 is similar to the transmitter circuit T_1, the only difference being that the oscillation generators O_1 and O_2 are adapted to supply different frequency oscillations, that is, the former may supply oscillations of frequency f_1, and the latter of frequency f_2. The modulating device M_2, when signals are being sent, will have in its output circuit, currents of the signal frequency. In order to prevent these currents from being impressed by means of circuit 15, line L and circuit 14 on the output circuit of the modulator M_1, the band filter F_1 is provided. The term "band filter" is used to denote a filter which suppresses currents of frequencies both above and below a given range of frequencies and which transmits exclusively a band of frequencies within that range. This band filter F_1 is adapted to transmit a narrow band of frequencies lying between f_1+a_1 and f_1-a_1, where a_1 is the frequency of the signal oscillations. This band filter will correspondingly also prevent a modulated oscillation of frequency f_2 plus or minus a_2 in circuit 15 from being impressed on the output circuit of modulator M_1. If either of the oscillations of low frequency a_2 or the high frequency oscillations f_2 plus or minus a_2 were permitted to be impressed on the output circuit of modulator M_1, these oscillations would effect a modulation of the oscillations of frequency f_1, which would result in the message originating in transmitter circuit T_2 being sent out as modulations of the frequency f_1 as though they had also originated in transmitter T_1. Thus the message of transmitter circuit T_2 would not only be received by the corresponding receiver circuit R_2, but also by the receiver circuit R_1. For a similar reason the filter F_2 is provided between the modulator M_2 and the line L.

The receiver circuit R_1 comprises a resistance 16 through which the currents from the transmitter circuits may circulate. The resistance 16 is connected across the input circuit of an asymmetrically conducting thermionic device 17. The battery 18 in the output circuit of this device serves as a source of power and the impedance coil 19 prevents the variable currents from being short-circuited through this battery. The variable currents are supplied through condenser 20, which isolates battery 18 from detector D_1, to the resistance 21, serving as a source of potential for the detector D_1. Between the unilateral device 17 and the detector D_1 is suitably connected a source S_1 of oscillations of the high frequency f_1. This frequency is the same as that generated in the corresponding transmitter circuit T_1. The output circuit of the detector D_1 comprises the

source of current 22 and the impedance coil 23. The tube serves as a source of variable currents which are supplied through condenser 24 to the primary winding of transformer 27. A path for the high frequency currents is provided by condenser 26. The condenser 24 serves to keep direct current from the battery 22 from circulating through the primary winding of the transformer 27 which serves to couple the output circuit of detector D_1 to the signal circuit 25.

Oscillations from both transmitter circuits T_1 and T_2 may circulate through the resistance 16 but the oscillations supplied by the local generator S_1 combine with the oscillations from transmitter circuit T_1 to reproduce the signal waves which have effected the modulation of the carrier oscillations supplied by the generator O_1. Oscillations from transmitter circuit T_2, on combining with the oscillations supplied by the generator S_1, will produce in the output circuit of the detector D_1 oscillations of a frequency higher than that necessary for the transmission of speech, and to eliminate these high frequency oscillations from a transmitter circuit other than the transmitter circuit T_1, the filter 28 is provided in the signal circuit 25. This filter is adapted to transmit only the low frequency signal oscillations whereby oscillations of higher frequency are suppressed.

In order to prevent the oscillations supplied by generator S_1 from combining with oscillations received in the circuit R_2, the unilateral device 17 is provided. Currents may be transmitted from the line L through the device 17 to the remainder of receiver circuit R_1, but the oscillations from generator S_1 are confined to the receiving circuit R_1 and cannot be impressed on any of the other receiving circuits.

The receiver circuit R_2 is substantially identical with the receiver circuit R_1 just described. The only difference is that the local generator S_2 supplies to detector D_2 oscillations of the high frequency f_2 which is the same frequency as that supplied by the generator O_2 in the transmitter circuit T_2.

In the modification shown in Fig. 2, three receiver circuits R_3, R_4 and R_5 are shown in detail, the transmitter circuits T_3, T_4 and T_5 being similar to the transmitter circuits T_1 and T_2 above described. The oscillations from line L, Fig. 2, are supplied by means of a single resistance element 16′ to the input circuits of the unilateral thermionic elements 17. Each of the receiver circuits is provided with a band filter F_3, F_4, and F_5 respectively, which selectively transmits the pure modulated wave impressed on line L by the corresponding transmitter circuit. Filter F_3, for instance, transmits only the narrow band of frequencies $f_3 \pm a$ where f_3 is the frequency of the carrier oscillations generated in the corresponding sending circuit, and the same frequency f_3 is also supplied by the local generator S_3. Filter F_3 is coupled to the output circuit of unilateral device 17 by means of transformer 33, and is coupled to the input circuit of detector D_3 by transformer 34.

The filter F_3 and the generator S_3 supply oscillations which are combined in the input circuit of detector D_3. The generator S_3 restores the component that was suppressed in the sending circuit T_3. The output circuit 30 of detector D_3 is coupled by means of transformer 32 to the signal circuit 25, which may include a filter 28 similar to that shown in Fig. 1. The filter F_3 serves to selectively transmit the modulated wave of the proper frequency to the detector D_3. The unilateral device 17 confines the oscillations supplied by generator S_3 to the receiver circuit R_3 as described in connection with Fig. 1. In Fig. 2 the unilateral device 17 performs an additional function in that it prevents any interaction between the filters in the various circuits. If the devices 17 were not provided, transients in one of the filters would serve to impress voltages on the other filters and also the efficiency of tranmission would be reduced. But the unilateral devices 17 prevent any interaction of the filters.

It is obvious that any number of the transmitter and receiver circuits may be provided, and as long as each pair generates carrier oscillations of the same frequency, the signals will be identified in the proper receiving circuits.

In case the unmodulated component is not suppressed at the sending station and restored at the receiving station, in which case the generators S_3, S_4, S_5 are not used, the unilateral devices 17 are still useful in preventing any interaction of the filters.

While the invention has been described in connection with a wired system, it is not necessarily restricted to such use, and the component parts of this invention are just as applicable to a wireless system. Moreover, the system is adapted for selective electrical transmission of any kind as well as for signaling.

What is claimed is:

1. The method of multiplex signaling, which consists in modulating each of a plurality of different frequency carrier oscillations in accordance with a signal, eliminating the unmodulated components, transmitting pure modulated waves to distant receiving circuits, and selecting said signals at the proper receiving circuits by restoring in each circuit an unmodulated component similar to that suppressed at the corresponding sending circuit.

2. The method of multiplex signaling, which consists in modulating each of a plu-

rality of different frequency carrier oscillations in accordance with a signal, eliminating the unmodulated components, transmitting pure modulated waves to distant receiving circuits, and selecting each of said signals at the proper receiving circuit by restoring at each receiving circuit a locally generated unmodulated component similar to that suppressed at the corresponding sending circuit.

3. In a transmission system, the combination of a plurality of high frequency transmitting circuits and a plurality of high frequency receiver circuits associated therewith, each of said transmitter circuits comprising a source of modulated carrier oscillations, each of said receiver circuits comprising a source of reinforcing oscillations, and means for confining said reinforcing oscillations to their respective receiving cirsuits.

4. In a transmission system, the combination of a plurality of high frequency transmitter circuits and a plurality of high frequency receiver circuits therefor, each of said transmitter circuits comprising a source of modulated carrier oscillations, each of said receiver circuits comprising a source of reinforcing oscillations, and an asymmetrically conducting device in each of said receiver circuits for preventing the reinforcing oscillations in one of said receiver circuits from combining with modulated oscillations in another of said receiver circuits.

5. A high frequency signaling system comprising the combination of a line wire, a plurality of transmitter circuits and a plurality of receiver circuits associated with said line wire; each of said transmitter circuits comprising a source of signal oscillations, a source of carrier oscillations, and means for modulating the latter in accordance with the former; each of said receiver circuits comprising a source of reinforcing oscillations of the same frequency as that of the carrier oscillations supplied by one of said transmitter circuits, a detector and means for asymmetrically conducting the transmitted modulated oscillations to said source of reinforcing oscillations and to said detector, and a circuit adapted to transmit the detected signal oscillations; the carrier oscillations supplied by one of said carrier oscillation sources being of a frequency different from that of the carrier oscillations supplied by the others of said carrier oscillation sources.

6. In a multiplex signaling system, the combination of a line wire, a plurality of transmitter circuits, and a plurality of receiver circuits associated with said line wire, each of said transmitter circuits comprising a source of modulated carrier oscillations; each of said receiver circuits comprising a thermionic device having an input circuit and an output circuit, means for supplying modulated oscillations from said line wire to the input circuit of said thermionic device, a source of high frequency oscillations and a detector associated with the output circuit of said device, and a circuit for said detector adapted to transmit the detected signal oscillations.

7. A multiplex signaling system comprising a plurality of communicating transmitter and receiver circuits, each of said transmitter circuits comprising a source of pure modulated oscillations, each of said receiver circuits comprising a source of reinforcing oscillations, and means for preventing the reinforcing oscillations in one of said receiver circuits from combining with the modulated oscillations transmitted to another of said receiver circuits.

8. In a multiplex signaling system, the combination of a plurality of communicating transmitter and receiver circuits, each of said transmitter circuits comprising means adapted to supply modulated oscillations; each of said receiver circuits comprising a detector, means for supplying reinforcing oscillations to said detector, and means for selectively transmitting the detected signal oscillations.

9. In a multiplex signaling system, the combination of a plurality of communicating transmitter and receiver circuits, each of said transmitter circuits comprising means adapted to supply modulated oscillations, each of said receiver circuits comprising a detector, means for supplying reinforcing oscillations to said detector, and a filter for selectively transmitting the detected signal oscillations.

10. A receiving system for multiplex signaling, comprising a source of modulated oscillations, an impedance device in circuit with said source, and a plurality of receiver circuits conductively connected to said device.

11. A receiving system for multiplex transmission comprising a source of modulated oscillations, a resistance in circuit with said source, and a plurality of receiver circuits connected across said resistance.

12. In a transmission system, the combination of a plurality of transmitter circuits, each comprising a source of modulated oscillations, a resistance, means for supplying modulated oscillations from said transmitter circuits to said resistance, and a plurality of receiver circuits conductively connected to said resistance.

13. In a high frequency system, the combination of a line wire, a resistance in circuit therewith, a plurality of receiver circuits each comprising a thermionic device having an input circuit and an output circuit, said resistance being in circuit with each of said

input circuits, and a signal translating circuit associated with each of said output circuits.

14. In a multiplex transmission system, the combination of a line wire, a plurality of transmitter circuits and a plurality of receiver circuits associated with said line wire, each of said transmitter circuits comprising a source of pure modulated waves, each of said receiver circuits comprising a source of reinforcing oscillations, and a resistance for supplying said receiver circuits in parallel.

15. In a multiplex signaling system, the combination of a plurality of receiver circuits each comprising a thermionic device having an input circuit and an output circuit, means for supplying oscillations varied in accordance with signals to said input circuit, a filter adapted to be supplied by said output circuit, a source of oscillations, a detector, means for coupling said filter to said detector, means for supplying oscillations from said source to said detector, and a signal circuit associated with said detector.

16. In a high frequency signaling system, the combination of a plurality of communicating transmitter and receiver circuits, each of said transmitter circuits comprising a source of carrier oscillations of a frequency different from that supplied by the remainder of said transmitter circuits; each of said transmitter circuits also comprising a source of signal oscillations, means for modulating said carrier oscillations in accordance with said signal oscillations and for preventing transmission of unmodulated carrier oscillations, and a band filter adapted to selectively transmit modulated oscillations from its respective transmitter circuit to the exclusion of different frequency oscillations from other of said transmitter circuits.

17. A multiplex signaling system comprising a plurality of transmitter circuits and a plurality of corresponding receiver circuits, each of said transmitter circuits comprising a source of pure modulated oscillations; each of said receiver circuits comprising a detector, means for supplying reinforcing oscillations to said detector, means for confining the reinforcing oscillations from said supplying means to their respective receiver circuits, and means for selectively transmitting the signal to be received; and means for preventing one of said transmitter circuits from supplying current to another of said transmitter circuits.

18. In a multiplex signaling system, the combination of a plurality of transmitter circuits each comprising a source of carrier oscillations of a frequency different from that supplied by the other of said transmitter circuits, and a plurality of receiver circuits each in communication with one of said transmitter circuits; each of said transmitter circuits comprising a source of signal oscillations, means for modulating said carrier oscillations in accordance with said signal oscillations and a band filter for selectively transmitting the modulated oscillations; each of said receiver circuits comprising an asymmetrically conducting thermionic device having an input circuit and an output circuit, a circuit for supplying the transmitted oscillations to said input circuit, a source of carrier frequency reinforcing oscillations and a detector associated with said output circuit, and a band filter for selectively receiving the detected signal oscillations.

19. A multiplex receiving system having a plurality of receiving channels each including a high frequency amplifier having an output circuit and a detector connected to said output circuit, and means for supplying locally generated oscillations between each respective amplifier and the associated detector.

20. A multiplex receiving system including a transmission line and a plurality of receiving channels connected thereto, each of said channels comprising a unilaterally conducting device arranged to transmit high frequency oscillations, a vacuum tube device, and means supplying locally generated oscillations between said unilateral device and said vacuum tube.

21. A multiplex receiving system having a plurality of receiving channels each comprising a unilaterally conducting amplifier having an output circuit and a detector of the audion type having an input circuit connected to said output circuit, and means associated with each channel for supplying oscillations between the respective amplifier and detector.

22. A multiplex receiving system comprising a high frequency line adapted to receive modulated high frequency oscillations, means comprising a local generator for reinforcing the received modulated oscillations, and means for substantially preventing said local generator from supplying oscillations to said high frequency line.

23. A signaling system comprising a transmitter circuit and a receiver circuit, said transmitter circuit comprising a source of pure modulated oscillations; said receiver circuit comprising a high frequency line, a detector, means for supplying oscillations to be combined with the received modulated wave to said detector, and means for preventing said supplying means from supplying oscillations to said line.

24. A signaling system comprising a transmitter circuit and a receiver circuit, said

transmitter circuit comprising a source of pure modulated oscillations; said receiver circuit comprising a high frequency line, a detector, means for supplying oscillations to be combined with the received modulated wave to said detector, and a thermionic device between said supplying means and said line.

25. The method of multiplex signaling which comprises modulating each of a plurality of different frequency carrier oscillations in accordance with a signal, eliminating a component of the oscillations after modulation, transmitting the resulting energy to receiving circuits and selecting said signals at the proper receiving circuits by restoring in each circuit a component similar to that suppressed at the corresponding sending circuit.

26. A transmission system comprising a transmitter, a receiving station and a conductive line connecting said transmitter to said station, an alternating current source at said station for reinforcing varying currents received over said line from said transmitter, and means for substantially preventing transmission of energy from said source to said line.

27. A transmission system comprising a transmitter, a receiving station and a high frequency line adapted to transmit modulated high frequency oscillations connecting said transmitter to said station, means comprising a local generator for reinforcing the received modulated oscillations, means for detecting said reinforced modulated oscillations, and means for substantially preventing said local generator from supplying oscillations to said high frequency line.

28. A signaling system comprising a line, a plurality of high frequency current sources connected to said line to supply high frequency currents thereto, means for modulating each of said high frequency currents in accordance with low frequency signals individual thereto before transmission to said line, and means for preventing the transmission of unmodulated currents to said line.

29. The method of multiplex transmission which consists in modulating each of a plurality of different frequency carrier oscillations in accordance with low frequency impulses individual thereto, eliminating the resulting unmodulated components to enable the transmission of pure modulated waves, and selecting said low frequency impulses at the proper receiving circuits by restoring in each circuit an unmodulated component similar to that suppressed at the corresponding sending circuit.

30. The method of multiplex transmission which consists in modulating each of a plurality of different frequency carrier oscillations in accordance with low frequency impulses individual thereto, eliminating the resulting unmodulated components to enable the transmission of pure modulated waves, and selecting said low frequency impulses at the proper receiving circuits by restoring at each receiving circuit a locally generated unmodulated component similar to that suppressed at the corresponding sending circuit.

31. A multiplex transmission system comprising a plurality of corresponding transmitter and receiver circuits, each of said transmitter circuits comprising means for supplying oscillations varied at a low frequency rate, each of said receiver circuits comprising a source of reinforcing oscillations, and means for preventing the reinforcing oscillations in one of said receiver circuits from combining with the varied oscillations transmitted to another of said receiver circuits.

32. In a multiplex transmission system, the combination of a plurality of corresponding transmitter and receiver circuits, each of said transmitter circuits comprising means for supplying oscillations varied at a low frequency rate, each of said receiver circuits comprising a detector, means for supplying reinforcing oscillations to said detector, and a filter for selectively transmitting the detected oscillations.

33. A signaling system comprising a transmitter circuit and a receiver circuit, said transmitter circuit comprising a source of pure modulated oscillations, a high frequency line connecting said circuits, said receiver circuit comprising a detector, means for supplying to said detector oscillations to be combined with the received modulated oscillations, and means including an amplifier for connecting said line to said detector.

34. A multiplex transmission line, a receiving circuit connected thereto, said circuit comprising a detector, an alternating current generator associated with the input circuit of said detector, and means for preventing transmission of oscillations from said generator to said line.

35. In combination, a line, means for simultaneously receiving a plurality of different messages transmitted thereover as modified currents of different frequencies, said means comprising a receiving channel for each different frequency current message, each of said channels comprising a filter the selectivity of which is substantially independent of the characteristics of said line for transmitting its respective message currents to the exclusion of currents of other frequencies, means for rendering the selectivity of said channel substantially independent of the characteristics of said line, means for detecting the current selected by said filter and a second filter connected to said detecting means for transmitting the detected signal current and suppressing undesired currents.

36. In combination, a line for transmitting a plurality of different frequency carrier currents each modified in accordance with signals individual thereto, a plurality of receiving channels connected to said line, each of said channels including a filter the selectivity of which is substantially independent of the characteristics of said line for transmitting a limited range of currents of the frequencies corresponding to one of said individual signals, means for rendering the selectivity of said channel substantially independent of the characteristics of said line, a detector connected to said filter to detect the currents passed thereby, and a second filter connected to said detector to transmit the detected signal current and suppress other undesired currents.

37. In combination, a line for transmitting a plurality of different bands of high frequency currents, a plurality of receiving channels connected thereto each comprising a band filter for selecting one of said bands of currents from the others, a detector for detecting said selected band to produce signal currents, and a filter connected to said detector for filtering said detected signal currents from other currents in said receiving channel.

38. In combination, a line for transmitting a plurality of different bands of high frequency currents, a plurality of receiving channels connected thereto each comprising a band filter for selecting one of said bands of currents from the others, a detector for detecting said selected band to produce signal currents, a filter connected to said detector for filtering said detected signal currents from other currents in said receiving channel and means for supplying high frequency reinforcing oscillations to said detector.

39. In a transmission system, a line, means for supplying thereto a modulated carrier wave substantially free from any unmodulated component of the carrier frequency, means connected to said line for receiving said modulated carrier wave and combining therewith a reinforcing component of the carrier frequency and means for preventing said reinforcing component from being transmitted to said line.

40. In a transmission system, a line, a source of carrier oscillations, means for modulating the oscillations produced by said source in accordance with a signal wave, means for suppressing one side band of the modulated carrier oscillations and transmitting the resulting oscillations to said line, a receiving channel connected to said line including a detector whereby oscillations of the unsuppressed side band may be combined with unmodulated oscillations of the original carrier frequency to reproduce said signal wave, means for supplying to said detector unmodulated oscillations of carrier frequency, and a receiving element connected to said detector to respond to said reproduced signal wave.

41. In a multiplex transmission system, a line, means for producing carrier waves of a plurality of different frequencies, means for simultaneously modulating each of said different frequency carrier waves in accordance with a signal wave individual thereto, means for suppressing one side band of each of said modulated carrier waves and for transmitting the resulting oscillations to said line, a plurality of receiving channels connected to said line, each of said channels having means for selecting a particular one of said transmitted carrier waves, each of said receiving channels including a detector whereby transmitted oscillations of the unsuppressed side band may be combined with unmodulated oscillations of the carrier wave frequency corresponding thereto to reproduce said signal wave, means for supplying to said detector unmodulated oscillations of carrier frequency, and a receiving element connected to said detector to respond to said reproduced signal wave.

42. In a signaling system, a high frequency line, a low frequency line, a repeater for repeating signals from said low frequency line to said high frequency line including a high frequency wave generator, means controlled over said low frequency line for causing modulation of the output waves of said generator, and a band filter between said generator and said high frequency line for transmitting the modulated waves to said high frequency line.

43. In a signaling system, a high frequency line, means for transmitting currents of different high frequencies over said line and for modulating the current of each high frequency in accordance with signals to produce a range of high frequency currents, a plurality of low frequency lines, and repeating means for repeating signals from said high frequency line to each of said low frequency lines, each of said repeating means including a band filter adapted to pass one of said ranges of high frequency currents but to prevent the passage of currents of other frequencies.

44. In a signaling system, a high frequency line, a plurality of low frequency lines, an individual repeater for repeating signals from said high frequency line to each of said low frequency lines including means for detecting high frequency currents received over said high frequency line and transmitting the detected currents to said low frequency line, and band filters connected between each of said detecting means and said high frequency line.

45. In a signaling system, a carrier line, a plurality of low frequency lines, means

connected to said carrier line for receiving signal modified currents of different carrier frequencies transmitted over said carrier line, said means including a plurality of band filters each designed to pass a modified carrier current of a frequency individual to said filter, a detector connected to each band filter to detect the modified carrier current passed thereby and an individual one of said low frequency lines connected to said detector to transmit the low frequency detected current.

In witness whereof, I hereunto subscribe my name this 11th day of October, A. D., 1916.

BURTON W. KENDALL.