July 28, 1925.

1,547,232

R. D. PARKER

MULTIPLEX SIGNALING SYSTEM

Filed Sept. 8, 1919

2 Sheets-Sheet 1

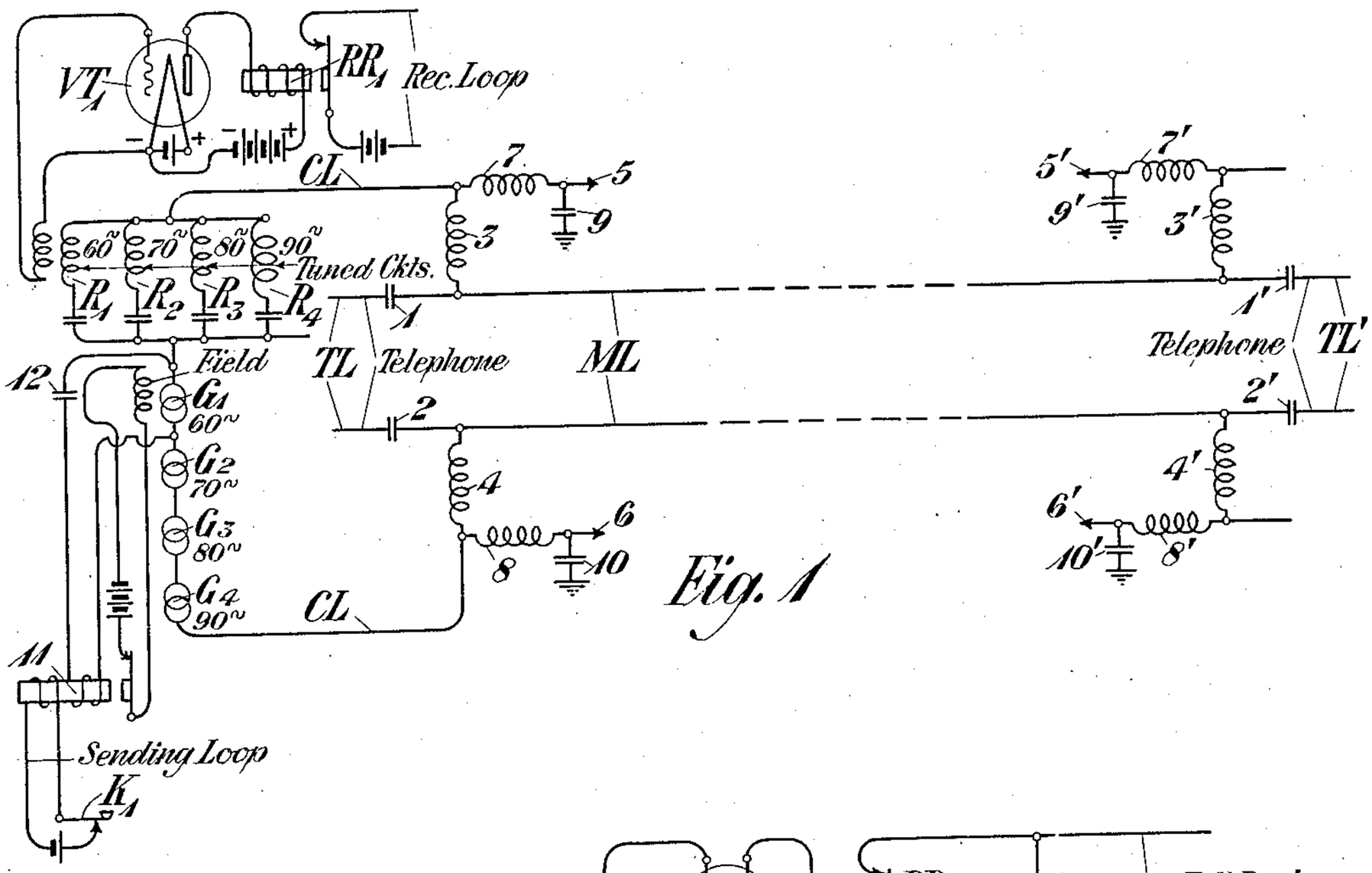

Fig. 1

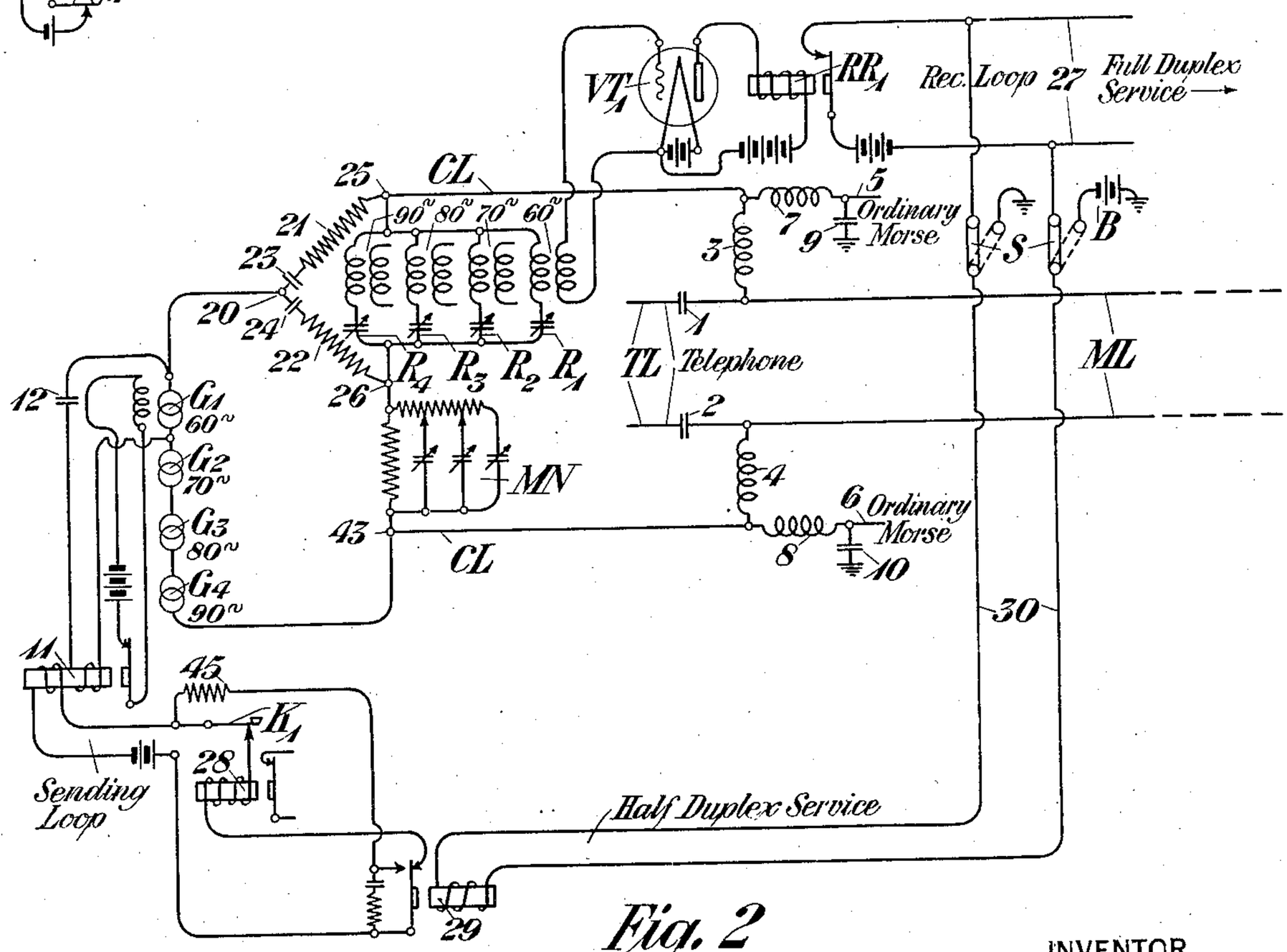

Fig. 2

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2 Sheets-Sheet 2

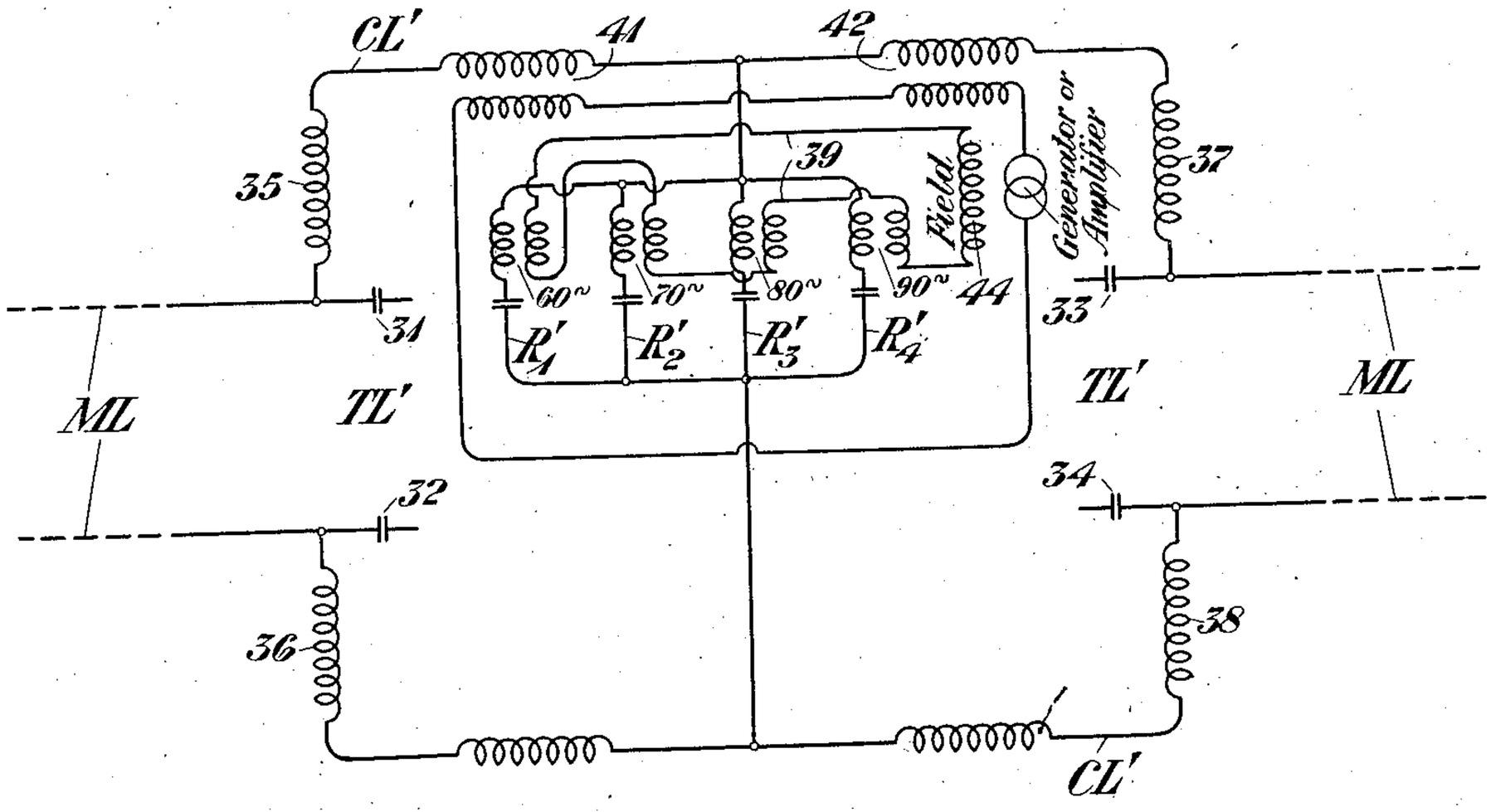

Fig. 3

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UNITED STATES PATENT OFFICE

RALZEMOND D. PARKER, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

MULTIPLEX SIGNALING SYSTEM.

Application filed September 8, 1919. Serial No. 322,269.

To all whom it may concern:

Be it known that I, RALZEMOND D. PARKER, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Multiplex Signaling Systems, of which the following is a specification.

This invention relates to signaling circuits and more particularly to signaling circuits over which signals are transmitted through the agency of carrier currents.

One of the features of this invention resides in the provision of means whereby additional signaling channels may be applied to an ordinary telephone line which is composited for Morse or other operation, such as printing telegraphy, by superposing, simultaneously with the telephone and the Morse, alternating current signaling channels upon such line.

Another feature of the invention resides in the provision of a three-element vacuum tube amplifier or detector for amplifying or detecting signals impressed upon carrier currents.

Another feature of the invention resides in the provision of a source of alternating carrier current, so arranged and controlled by a sending key that the alternating current generated by the generator and supplied to a transmission circuit in response to the action of the key will only be interrupted substantially when the last impulse transmitted passes through zero.

A still further object of the invention is to provide a means whereby the frequency range between the lower limiting telephonic frequency and the extremely low maximum frequency corresponding to Morse signaling, may be utilized for the purpose of obtaining additional signaling channels over a telephone circuit.

Other and further objects of the invention will be clear from the following description when read in connection with the accompanying drawings, Figure 1 of which constitutes a circuit diagram of one embodiment of the invention and Figs. 2 and 3 of which, when taken together, constitute circuit diagrams of other embodiments of the invention.

Referring to Fig. 1, ML designates an ordinary transmission line, such as a telephone line, which terminates at each end in composite apparatus whereby the line may be simultaneously used for the transmission of telephone currents and Morse or other signaling currents. Such composite apparatus comprises a telephone branch TL leading to telephone apparatus not shown, and including condensers such as 1 and 2, adapted to freely transmit telephonic frequencies, while offering a high impedance to the lower frequencies employed for Morse signaling or for low frequency alternating current signals of the character hereinafter described. Branch circuits also extend through inductances 3 and 4, from the terminals of which the Morse leads 5 and 6 extend through inductances 7 and 8. These inductances offer a high impedance to telephonic currents, but readily permit the passage of lower frequencies. Ground taps, including condensers 9 and 10, may be provided for the purpose of shunting to ground any high frequencies which may happen to pass through the inductance elements. Similar composite apparatus is provided at the opposite end of the line, as indicated by the same reference numerals primed.

In order to provide alternating carrier current channels in addition to the telephone and Morse channels above described, a third branch CL is provided in which is included a plurality of alternating current generators G_1, G_2, G_3 and G_4. These generators may be of any type, such as vacuum tube generators or other means for producing alternating currents, but, as illustrated in the drawing, are shown as alternators having their armature windings connected in series with the branch CL. The field winding of the alternator G_1 is controlled by the armature of a relay 11, the circuit of which is in turn controlled by a transmitting key K_1. The relay 11 is provided with two windings, one of which is in circuit with the transmitting key K_1 and the second of which is supplied with alternating current from the generator G_1, through a condenser 12. When the key K_1 is closed the relay 11 maintains the field winding of the generator G_1 active and pulses of alternating current are supplied by the generator to the right hand winding of the relay 11. Should the key K_1 be actuated to open the circuit of the lefthand winding of the relay 11 at any time during the generation of a cycle of alternating cur-

rent, the generator G_1 will remain active until the current supplied thereby substantially passes through zero, since the armature of the relay 11 will not fall off till the amplitude of the pulse of alternating current through the righthand winding of the relay becomes very small. Similar controlling circuits (not shown) are provided for the generators G_2, G_3 and G_4, so that telegraph signals may be impressed by means of the keys, such as K_1, upon the alternating currents supplied by the generators. These generators may be of any frequency outside of the voice range, either above or below, but, as illustrated, frequencies of 60, 70, 80 and 90 cycles are assigned to the generators, so that the range of frequencies between the lower telephone limit and the highest frequency employed in ordinary Morse signaling may be utilized.

For receiving purposes a plurality of tuned branch circuits R_1, R_2, R_3 and R_4 are provided, these branch circuits being tuned by means of inductances and capacities so as to be resonant to 60, 70, 80 and 90 cycles respectively. It will of course be understood that the frequencies herein given are merely illustrative and that in practice other frequencies than those indicated may be employed.

In order to amplify and detect the received carrier currents, a three-element vacuum tube VT_1 is provided, having its input or grid circuit coupled to the tuned branch R_1 and having its output or plate circuit connected to a direct current receiving relay RR_1. Similar apparatus is associated with each of the tuned circuits R_2, R_3 and R_4. Carrier apparatus similar to that described will also be provided at the other end of the main line ML, but in order to simplify the diagram such apparatus is not illustrated.

With reference to the use of the vacuum tube device VT_1, it is recognized that it has heretofore been considered that detectors were only applicable to radio frequencies, that is, frequencies above audibility, for the purpose of translating the radio frequencies into audible signals. It has been discovered, however, that frequencies within the limits of audibility may be translated, by means of detecting devices, into audible signals so that the signaling currents impressed upon the receiving instrument will be the translated currents and not currents of the frequencies existing before the translating operation. An important feature of the present invention, therefore, resides in the use of the vacuum tube device, or other equivalent arrangement, for translating alternating currents having frequencies below the upper limit of audibility into currents corresponding to the signals superposed upon the alternating currents.

The operation is as follows:

Normally the key K_1 is closed, so that the relay 11 is energized, maintaining a current through the field winding of the generator G_1. The generator therefore supplies 60 cycles alternating current to the branch CL, so that carrier current of this frequency is transmitted over the main line M_1 to the distant station. Alternating current of this frequency is also supplied from the generator G_1, through the condenser 12 to the righthand winding of the relay 11. Should the key K_1 be opened for the purpose of transmitting a telegraph signal, the relay 11 will not be deenergized until the amplitude of the alternating current impulse supplied to its righthand winding becomes quite small, so that alternating current supplied by the generator G_1 to the line does not cease until the alternating current wave substantially passes through zero. At the distant station the alternating current thus supplied is selected by a tuned circuit corresponding to R_1 to actuate the receiving apparatus. The operation of the receiving apparatus at the distant station may be understood from a consideration of the operation of the receiving apparatus associated with the branch CL in response to carrier signals from the distant end of the line. The alternating currents corresponding to such carrier signals pass through inductances 3 and 4 into carrier branch CL and are selected in accordance with their frequencies by the tuned circuits R_1, R_2, R_3 and F_4. The alternating currents of 60 cycle frequency pass through the tuned circuit R_1 and are applied to the input of the vacuum tube amplifier and detector VT_1, thereby maintaining the direct current relay RR_1 energized. Upon the interruption of the train of waves by the sending key at the distant station, the relay RR_1 no longer receives sufficient current and is accordingly deenergized, opening the receiving loop to actuate the sounder, not shown.

Messages may be received simultaneously through the receiving apparatus associated with each of the tuned circuits R_1, R_2, etc.; so also messages may be simultaneously transmitted through the agency of each of the generators G_1, G_2, etc. The currents supplied from the several generators pass through the corresponding receiving branch tuned to the generator frequency, so that a certain amount of the sending energy is diverted from the main line through the local receiving apparatus. This permits of recording the transmitted message on a home recorder, but it does not permit of simultaneously sending and receiving over the same channel.

In order to secure the latter result, the modified arrangement shown in Figs. 2 and 3 is provided. In this case the terminal

telephone and Morse apparatus associated with the main line ML is the same as that illustrated in Fig. 1. The carrier branch CL differs from that of Fig. 1, however, in that the transmitting and receiving carrier circuits are arranged in bridged relation. For this purpose bridge arms including resistances 21, 22 and capacities 23, 24 are provided. The tuned receiving circuits R_1, R_2, R_3 and R_4 are connected in parallel across the points 25 and 26 of the bridge, while the generators G_1, G_2, G_3 and G_4 are connected in series between the points 20 and 26 of the bridge. A balancing network or artificial line MN is provided for the purpose of balancing the transmission line ML. The receiving apparatus, as before, consists of a three-element vacuum tube, such as VT_1, associated with each tuned circuit. Direct current relays such as RR_1 are controlled by the vacuum tube and these relays in turn control the receiving loops such as 27.

The generator G_1 is controlled by a transmitting key K_1 through the agency of a relay 11, just as illustrated in Fig. 1. The key K_1 in this instance, however, is serially included in a local sending loop including a sounder or a relay 28.

In order that the apparatus thus far described may be also operated on a half duplex basis, the local sending loop is arranged to be controlled by a relay 29 in a branch 30, which may be connected with the receiving loop 27 by means of a switch S. The function of the relay 29 is to enable a distant receiving operator to "break in" upon the local sending operator when the circuit is being operated on a half duplex basis.

In order to amplify the carrier currents, the repeater arrangement shown in Fig. 3 may be inserted at some intermediate point in the line ML, between the transmitting and receiving station. In order that the repeater apparatus may not interfere with the transmission of telephone currents, telephone branches TL′ are led off from the main line sections through condensers such as 31, 32, 33 and 34. The carrier currents are passed through branches CL′ which include inductance 35, 36, 37 and 38, to suppress currents of voice frequency. Tuned circuits R_1', R_2', R_3' and R_4' are connected in parallel in a bridged circuit across the branch CL′. These branches are tuned respectively to 60, 70, 80 and 90 cycles to correspond to the frequencies generated by the generators G_1, G_2, G_3 and G_4. The amplifier which serves to amplify the carrier frequencies may be of any well-known character but, as herein illustrated, is a generator 44, having its field windings connected in an input circuit 39 inductively associated with the tuned branches R_1', R_2', etc., and its armature or rotor windings included in a local output circuit 40 inductively coupled with the branch CL′ through transformers 41 and 42 symmetrically associated with respect to the bridge connection including the tuned circuits.

The operation of the circuits above described on a full duplex basis is as follows:

Normally the sending loop including the key K_1 and the relay 11 is closed, so that the generator G_1 is operated to generate alternating current having a frequency of 60 cycles. The alternating current thus generated is applied to the mid-point 20 of the bridge, so that the energy divides, one-half flowing through the resistance 21 over the branch CL and the line ML, returning to the point 43, the other half flowing through the resistance 22 and artificial line MN to the point 43. Points 25 and 26 are therefore of equal potential, so that the transmitted energy does not affect the tuned receiving circuits R_1, R_2, R_3, R_4. At the same time alternating current from the other generators G_2, G_3 and G_4 is transmitted to the line in a similar manner. The alternating carrier currents flowing over the line ML at the repeater station pass through the inductances 35 and 36 into the branch CL′ and through the bridge including the tuned circuits R_1', R_2', etc. These tuned circuits select the corresponding frequencies and impress them upon the input circuit 39 of the generator 44, which amplifies them in a well understood manner, so that the corresponding amplified frequencies are impressed through transformers 41 and 42 upon the branch CL′ for the transmission over the line ML to the distant station.

At the same time the carrier currents transmitted from the distant station are amplified by the repeater apparatus and transmitted over the line ML to the station illustrated in Fig. 2. At this station they pass through the inductances 3 and 4 to the branch CL and flow through the bridge, including the tuned circuits R_1, R_2, R_3 and R_4. The received alternating current of 60 cycle frequency is transmitted from the tuned circuit R_1 to the vacuum tube VT_1, thereby operating the receiving relay R′, which maintains the receiving loop 27 closed. The switch S during full duplex operation is thrown to the right in order to disconnect the relay 29 from the receiving loop 27, said relay 29 being maintained energized by current from the battery B. Relay 29 is maintained energized during this operation for the purpose of holding the sending loop in its normally closed condition through the key K_1.

When signals are being transmitted from the distant station the alternating currents are interrupted by the transmitting keys and the relay RR_1 is deenergized each time the alternating current of 60 cycles frequency is interrupted, thereby causing the ac-

tuation of the sounder. The operation of the transmitting key K_1 may simultaneously interrupt the transmission of alternating current from the generator G_1 to the distant station, in accordance with the signaling code, so that for each carrier frequency, signals may be simultaneously received and transmitted.

When the circuit is to be operated on a half-duplex basis, so that signaling takes place in but one direction at a time, the key K_1 may be operated to open the sending loop intermittently, in accordance with the signaling code, so that groups of oscillations from the generator G_1 are transmitted to the main line ML and are amplified by the ampifier shown in Fig. 3, as described in connection with the full duplex operation. During half-duplex operation the switch S is thrown to the left, thereby connecting the loop 30 including the relay 29, to the receiving loop 27. The distant station, which is receiving the signals transmitted from the station of Fig. 2, maintains an uninterrupted flow of alternating current upon the line, so that the receiving relay RR_1 is maintained energized and the receiving loop 27 is closed. The relay 29 therefore is held in its operated condition, so as to maintain the integrity of the sending loop. Should the operator at the distant station, who is receiving at 60 cycles frequency, desire to "break in" or interrupt the operator at the station of Fig. 2, who is transmitting at 60 cycles frequency, such distant operator will open a transmitting key at that station, corresponding to the key K_1, thereby interrupting the train of 60 cycles oscillations. Relay RR_1 is therefore deenergized and opens the receiving loop, thereby permitting the relay 29 to be deenergized. This opens the circuit through the sounder 28 and the key K_1 and completes an alternative circuit for the relay 11 through the resistance 45 and the back contact of the relay 29. Consequently, when the operator at the station of Fig. 2 manipulates the key K_1 the sounder 28 will not respond thereto, so that the operator is apprised of the fact that the distant operator desires, for some reason, to "break in" and transmit signals. The operator will therefore cease attempting to transmit and the distant operator will proceed to signal. The relay 29 which is controlled by the receiving relay RR_1, will respond to these signals, thereby opening and closing the sending loop through the sounder 28. The local operator may therefore read the signal from the actuation of said sounder.

It will be understood, of course, that similar operations may take place simultaneously with regard to each of the carrier frequencies, and that the system may be operated on a full duplex basis with regard to one or more frequencies at the same time, and operated on a half duplex basis with regard to other frequencies. It will also be understood that the number of alternating channels may be varied as desired and may be either above or below the telephonic range, the frequencies indicated on the drawing and herein described being merely illustrative.

It will also be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a signaling system, a telephone line, composite apparatus associated therewith for superposing Morse signals upon said telephone line, means for superposing alternating carrier currents of a plurality of frequencies upon said telephone line, and controlling means for impressing telegraph signals upon said alternating currents.

2. In a signaling system, a telephone line, composite apparatus associated therewith for superposing Morse signals upon said telephone line, means for superposing alternating carrier currents of a plurality of frequencies upon said telephone line, controlling means for impressing telegraph signals upon said alternating currents, selective receiving circuits corresponding to each carrier current frequency, and receiving devices associated with said selective circuits.

3. In a signaling system, a telephone line, composite apparatus associated therewith for superposing Morse signals upon said telephone line, means for superposing alternating carrier currents of a plurality of frequencies upon said telephone line, controlling means for impressing telegraph signals upon said alternating currents, selective receiving circuits corresponding to each carrier frequency, means associated with said receiving circuits for translating the carrier frequencies into signals, and receiving devices responsive to the translated signals.

4. In a signaling system, a transmission circuit, means for impressing an alternating carrier current upon said transmission circuit, means for controlling said carrier current in accordance with signals, a receiving circuit responsive to said carrier current, a three-element vacuum tube associated with said receiving circuit, and signal responsive means in the output circuit of said vacuum tube.

5. In a signaling system, a transmission circuit, means to apply a plurality of alternating carrier currents of differing frequencies to said transmission circuit, means to control each of said carrier frequencies in accordance with the signals, selective receiving circuits corresponding to each carrier frequency, a three-element vacuum tube

associated with each selecting circuit and signal responsive means associated with the output circuit of each vacuum tube.

6. In a signaling system, a telephone transmission line, composite apparatus associated with said line for superposing Morse signals thereon, means for applying alternating carrier currents of a plurality of frequencies to said line, means for controlling said carrier currents in accordance with the signals, selective receiving circuits corresponding to each carrier frequency, three-element vacuum tubes associated with each receiving circuit, and signal responsive means in the output circuit of each vacuum tube.

7. In a signaling system, two distant signaling stations, a transmission circuit extending between said stations, a continuously operative means at one station for generating alternating carrier currents to be supplied to said transmission circuit, a transmitting key, means responsive to said transmitting key for at times preventing generation of said alternating currents and for controlling the application of alternating carrier currents of the frequency of said generating means to said transmission circuit for transmission to the distant station, said last mentioned means being so arranged that a train of alternating current waves supplied by said generating means to said transmission circuit will only be interrupted substantially when the alternating current wave supplied to said transmission circuit passes through zero.

8. In a signaling system, a transmission circuit, a source of alternating carrier current associated with said circuit, a transmitting key, means responsive to said transmitting key for controlling the generation of alternating carrier currents by said source, said means including means so connected to the generator that it will permit said generator to continuously generate current during the actuation of said key, and when the actuation of said key ceases, said second means will cause said generator to continue to generate current until the wave then being generated passes through zero.

9. In a signaling system, a transmission circuit, an alternating current generator for supplying alternating carrier current thereto, a transmitting key, a relay responsive to said transmitting key, said relay controlling the field of said generator, and a locking winding upon said relay, said locking winding being supplied with current from said generator, when the generator is active, so that said relay will not be deenergized to open the field of the generator, except when the alternating current wave passes substantially through zero.

10. In a signaling system, a transmission circuit, means for impressing carrier currents of a plurality of frequencies upon said transmission circuit, means to modify each of said carrier currents in accordance with signals, repeater apparatus in said transmission circuit, said repeater apparatus comprising amplifying means, a plurality of selecting circuits associated with said amplifying means and responsive to said carrier frequencies, and means for so connecting the said amplifying means with all of said selecting circuits that currents therefrom will be applied to said amplifier.

11. In a signaling system, a transmission circuit, means for applying carrier currents of a plurality of frequencies to said transmission circuit, means to modify each of said carrier currents in accordance with signals, repeating apparatus associated with said transmission circuit, said repeating apparatus comprising an amplifier for amplifying all of the carrier frequencies impressed upon said circuit, a plurality of selecting circuits, one corresponding to each carrier frequency, an input circuit for said amplifier so associated with all of said selecting circuits that currents therefrom will be applied to said amplifier, and an output circuit associated with said amplifier for impressing the amplified carrier frequencies upon the transmission circuit.

12. In a signaling system, a transmission line, stations at each end of said line, means at each station for supplying alternating carrier current to the line, a transmitting key at each station for controlling the supply of alternating carrier current, receiving means at each station responsive to the alternating carrier current transmitted from the other station and means at each station whereby, when the carrier current transmitted from the other station is interrupted, the control exercised by the key over the supply of alternating current at the first station will be defeated.

13. In a signaling system, a transmission line, stations at each end of said line, means at each station for supplying alternating carrier current to the line, a transmitting key at each station for controlling the supply of alternating carrier current, receiving means at each station responsive to the alternating carrier current transmitted from the other station and means whereby, when the key at one station is operated to transmit signals by means of said carrier currents, the transmission of signaling currents from the other station is prevented.

In testimony whereof, I have signed my name to this specification this 5th day of September, 1919.

RALZEMOND D. PARKER.