

C. S. DEMAREST.
VACUUM BULB FOR SIGNALING APPARATUS.
APPLICATION FILED JULY 26, 1918.

1,353,031.

Patented Sept. 14, 1920.

3 SHEETS—SHEET 1.

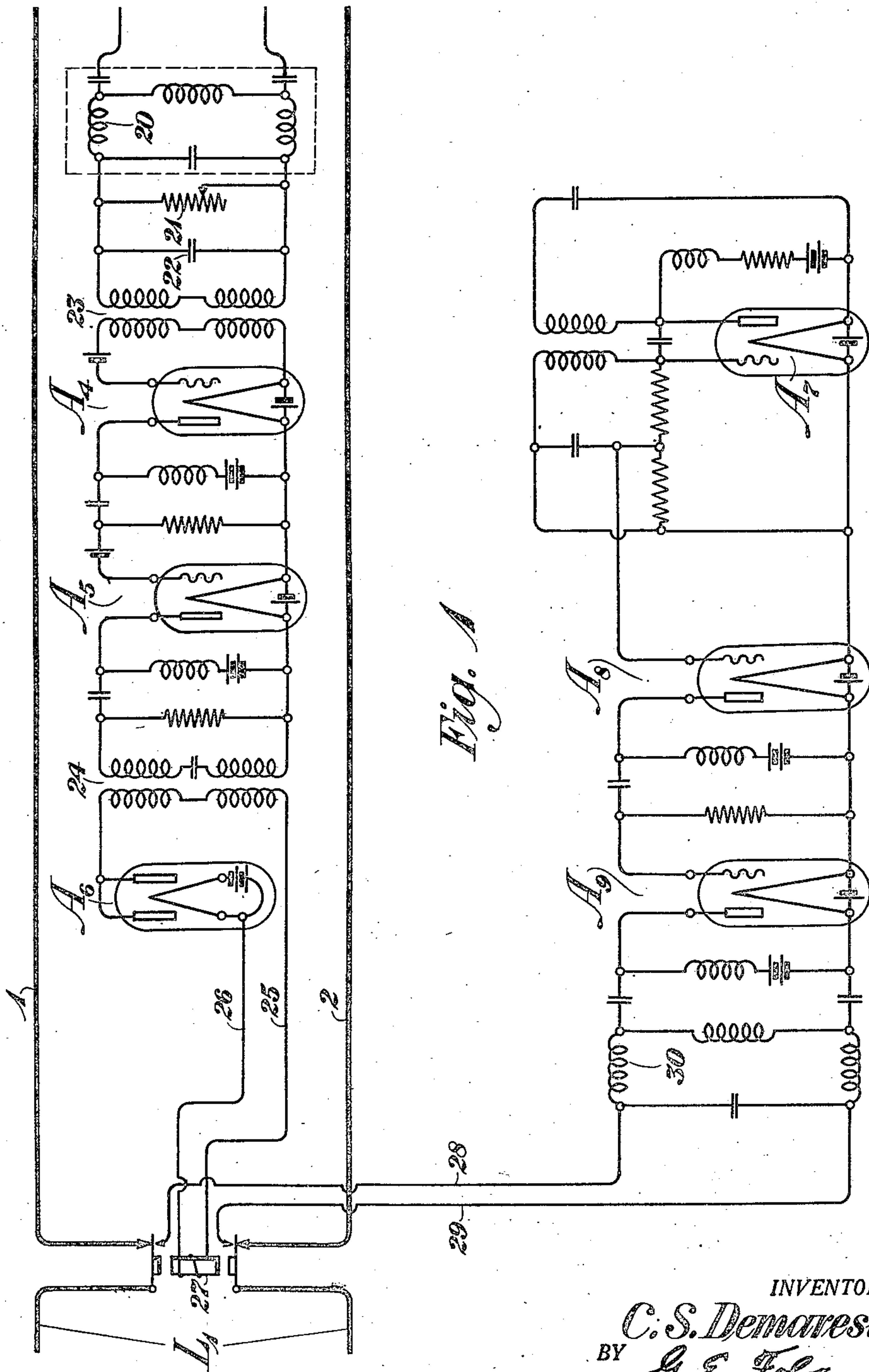


Fig. 1

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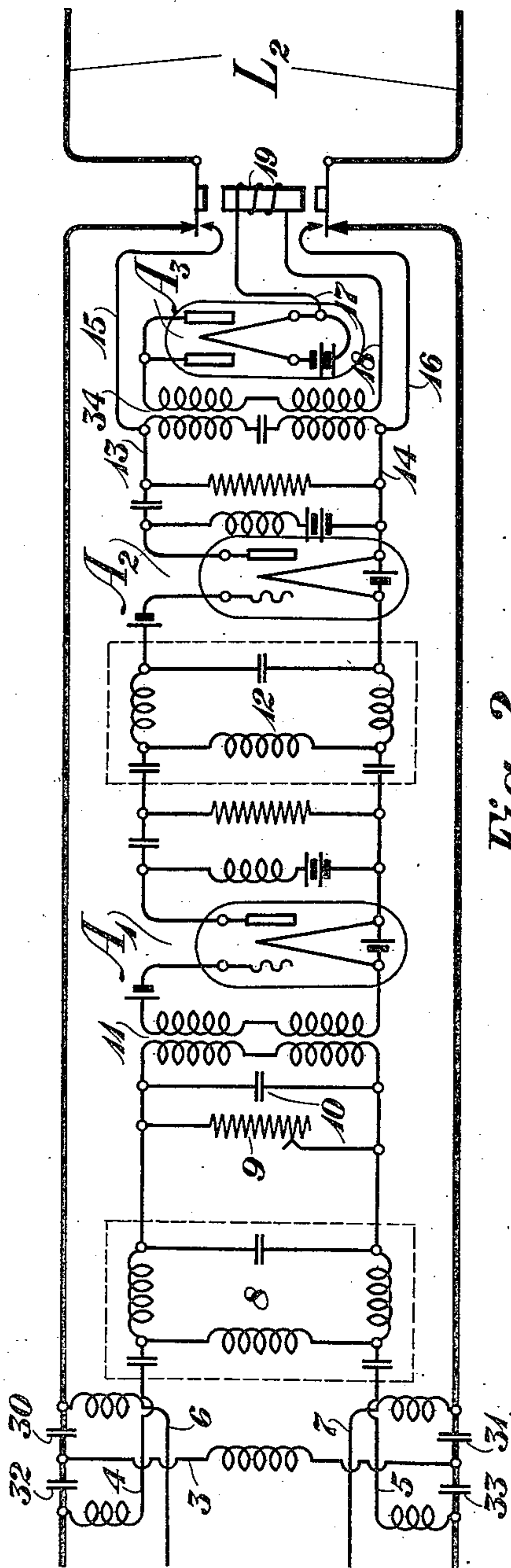


Fig. 2

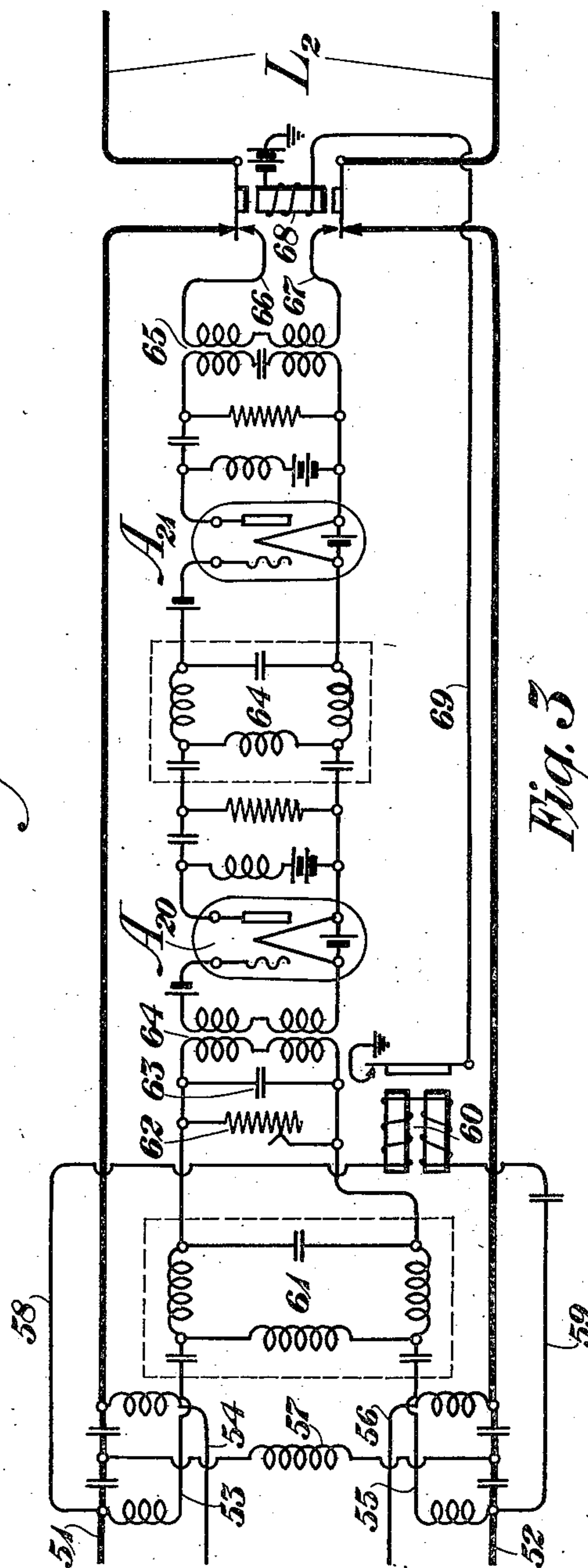


Fig. 3

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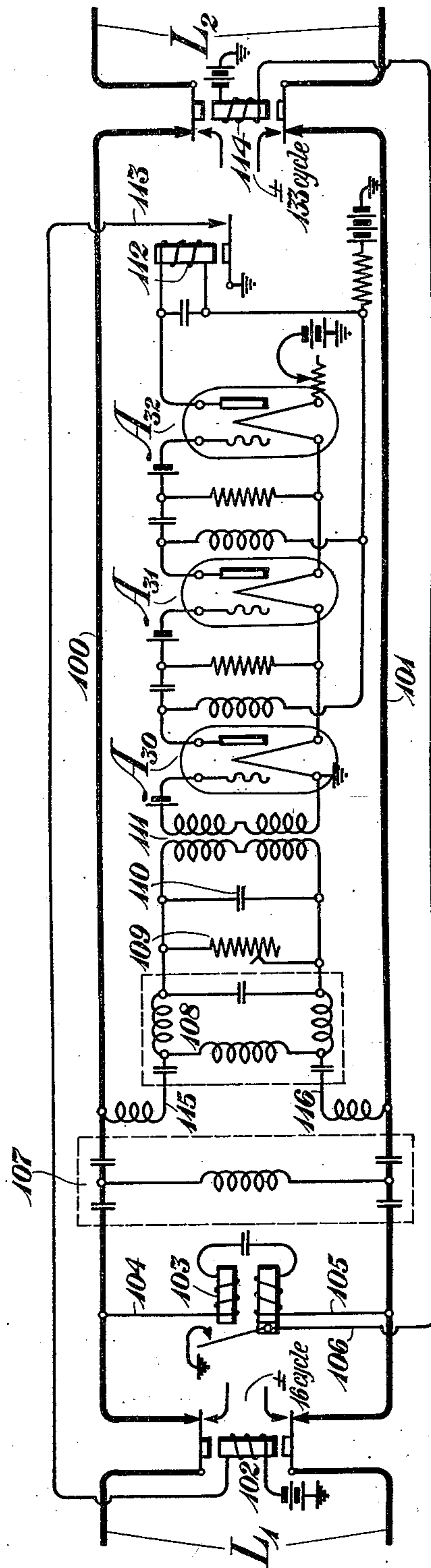


Fig. 4

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UNITED STATES PATENT OFFICE.

CHARLES S. DEMAREST, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

VACUUM-BULB FOR SIGNALING APPARATUS.

1,353,031.

Specification of Letters Patent. Patented Sept. 14, 1920.

Application filed July 26, 1918. Serial No. 246,910.

To all whom it may concern:

Be it known that I, CHARLES S. DEMAREST, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Vacuum-Bulbs for Signaling Apparatus, of which the following is a specification.

This invention relates to signaling apparatus, and particularly to signaling apparatus for use in connection with composited telephone and telegraph lines.

It is one of the objects of the invention to provide signaling apparatus which will translate signaling currents of a frequency suitable for transmission over one section of a line, into signaling currents of a frequency suitable for transmission over another section of the line without the use of a separate source of current of either of said frequencies. Another object of the invention consists in providing signaling apparatus which will operate without the use of ringing or alternating current relays for responding to the attenuated incoming signaling currents received over long distance lines. A further object consists in providing signaling apparatus which will produce signaling currents of a desired frequency in such a manner as to cause no indicative interference on long distance lines and no interference with the operation of a low current telegraph system which may be associated with such lines. When the transmission line is equipped at intermediate points with vacuum bulb telephone repeaters for increasing the range of speech transmission, a further object of the invention is to provide signaling apparatus which will permit the use of signaling currents of such small value as may be transmitted over such a line without being distorted by overloading the vacuum bulbs, and without employing relays to connect a new source of signaling current to the line at each repeater station. Other and further objects of the invention will be clear from the detailed description of its operation.

When a transmission line is used solely for telephone purposes the signaling current transmitted thereover for ringing or other

purposes may in practice be of a frequency in the neighborhood of 16 cycles, and the signaling apparatus terminating at the switchboard is usually constructed to generate and respond to currents of approximately this frequency. When, however, the transmission line is composited and used for both telephone and telegraph purposes it has been found that signaling currents having a frequency of the order above mentioned cannot be transmitted out over such a line from the switchboard, nor can they be transmitted over such a line to the switchboard. This is because the frequency of these signaling currents is approximately the same as the frequency of the currents used for telegraph purposes and the filter apparatus devised to keep these telegraphic currents from entering and interfering with the telephone apparatus also serves to attenuate and practically extinguish these signaling currents of similar frequency. Accordingly the signaling current to be well adapted for transmission over a composited transmission line must be of a frequency above the limit suppressed by this filter and it has been found that a signaling current having a frequency in the neighborhood of 133 cycles is well adapted for transmission over such a transmission line, although any frequency above the limit of this filter may be satisfactory. Furthermore, when telephone repeaters are employed at intermediate points in a line it is not practicable to transmit 16 cycle signaling currents through the repeaters unless a special form of repeater suitable for this purpose is employed and it has consequently been the practice to associate relays with the repeaters so as to connect a new source of signaling current to the line at each repeater station. In a long distance line of small gage wire in which several repeaters may be connected in order to secure satisfactory transmission of speech, this method of employing relays is not satisfactory because of the delay in transmitting a signal caused by the successive operation of the ringing relays associated with the repeaters at the several repeater stations. It is, therefore, desirable that the signaling currents should be

transmitted through the telephone repeaters and to permit this it is necessary that these currents should be of smaller magnitude than are ordinarily used in order that in passing through the repeater they will not be distorted by causing overloading of the vacuum bulb. The frequency of the signaling currents must also be suitable for transmission through the telephone repeaters and it is found that the repeaters may be tuned more readily for the transmission of 133 cycle currents or currents of higher frequency than the 16 cycle currents used at the switchboard.

In order to change the low frequency signaling current generated at the switchboard into a higher frequency signaling current suitable for transmission over a transmission line, and vice versa, arrangements have heretofore been associated with the transmission line, known as composite ringer sets. These composite ringer sets customarily included a plurality of tuned relays, one type of which would be adjusted to respond only to the higher frequency signaling current coming in over the transmission line and its actuation would serve to connect to the conductors leading to the switchboard apparatus a local source of lower frequency ringing current suitable to operate said apparatus. The other type of tuned relay would be adjusted to respond only to the lower frequency signaling current impressed on the line at the switchboard and its actuation would serve to connect to the outgoing transmission line a source of higher frequency signaling current suitable for transmission thereover.

In one of the arrangements of this invention one-way vacuum bulb repeaters of different types are employed in place of the tuned or ringing responsive relays and the local sources of signaling current of the composite ringer sets formerly employed. The relatively low frequency signaling current supplied at the switchboard is impressed on a vacuum bulb repeater in the signaling apparatus which is arranged to function as a harmonic producer. The output current therefrom will include harmonics of the original wave and is transmitted over a path arranged to be approximately resonant to the particular frequency or frequencies which are desired for transmission out over the line. The current is then transmitted through a filter whereby undesirable frequencies are eliminated and is amplified by one or more additional vacuum bulbs to the magnitude desired for signaling. It is then impressed on the outgoing line by the operation of a direct current relay and another vacuum bulb which is associated with the circuit and is arranged to act as a rectifier. The ringing current coming in over the line

is transmitted through one or more vacuum bulbs for amplification to the desired magnitude and then passes through a vacuum bulb rectifier to a direct current relay, the operation of which serves to connect the conductors leading to the switchboard signaling apparatus to a vacuum bulb repeater so arranged as to function as an oscillator. By means of proper tuning of the output circuit of the oscillator and the use of a suitable filter the oscillator will impress on the conductors leading to the switchboard a current having a frequency suitable for operating responsive means thereat.

In another arrangement of this invention the relatively low frequency signaling current supplied at the switchboard, which may be of as great a magnitude as desired since it is not attenuated by transmission over a long distance line, is impressed upon a tuned ringing responsive relay arranged to connect a source of signaling current of the frequency and magnitude desired to the outgoing line. This last mentioned source of current may be either an oscillator tuned to give current of the desired frequency, or it may be an interrupter or a generator. The signaling current coming in over the line which may be considerably attenuated is transmitted through one or more vacuum bulbs for amplification to the desired magnitude and then passes through a vacuum bulb rectifier to a direct current relay, the operation of which serves to connect the conductors leading to the switchboard signaling apparatus to a source of low frequency signaling current suitable for operating such apparatus.

The invention may now be more fully understood from the following description when read in reference to the accompanying drawings, in the Figures 1 and 2 of which when taken together is illustrated one form of the invention and in Fig. 3, is illustrated a modification thereof, and in Fig. 4 is illustrated another modification of the invention.

In the Figs. 1 and 2 is shown a transmission line, the two sections L_1 and L_2 of which are interconnected by the conductors 1 and 2. Section L_1 is connected to switchboard apparatus and section L_2 is a portion of a long distance line. Included in conductors 1 and 2 are the condensers 32 and 30, and 33 and 31, respectively. Bridged across conductors 1 and 2 between condensers 32 and 30 is conductor 3. Conductor 3, together with condensers 30 and 31, serves to form a low frequency filter which readily allows the transmission of high frequency voice currents but prevents currents of lower frequencies, such as below 200 cycles, from being transmitted from the switchboard apparatus and thence over conductors 6 and 7,

and to the signaling arrangements associated with section L_1 as will be pointed out later. Condensers 32 and 33 serve to prevent conductor 3 from being a direct current bridge with respect to apparatus at the switchboard. Connected to conductors 1 and 2 are conductors 4 and 5, and 6 and 7, which include windings which are constructed to be of high impedance in order to decrease the transmission loss caused by the association of the signaling apparatus with the transmission line. Associated with conductors 4 and 5 is the filter 8 which readily allows the transmission of the low frequency signaling currents generated at the switchboard and serves to attenuate and extinguish currents of all other frequencies. Associated with the filter 8 is the vacuum bulb A_1 which is arranged to function as a harmonic producer. Associated with the vacuum bulb A_1 is the variable resistance shunt 9 which is adjusted to the desired value to prevent interference due to "Morse thump" and switchhook impulses. Associated with vacuum bulb A_1 is the condenser 10 which is designed to give a parallel resonant circuit at the desired low frequency, such as 16 cycles, in conjunction with the input windings 11 of the vacuum bulb A_1 . Associated with the output circuit of vacuum bulb A_1 is the filter 12 which is designed readily to transmit currents of the desired frequency for signaling purposes over the line L_2 , such as currents of a frequency of 133 cycles, but which will attenuate and extinguish currents of all other frequencies. A_2 is a vacuum bulb amplifier designed to amplify these last mentioned currents. A_3 is a vacuum bulb designed to function as a rectifier, the output circuit of which controls relay 19 and serves to connect the sides of section L_2 of the line to conductors leading to the output circuit of the harmonic producer A_1 .

Associated with conductors 6 and 7 is the filter 20 which is designed readily to transmit signaling currents of a frequency suitable for use over the section L_2 of the line, and which in practice may have a frequency of 133 cycles, but which will attenuate and extinguish currents of all other frequencies. Associated with the filter 20 are the vacuum bulbs A_4 and A_5 designed to amplify the signaling currents which are transmitted through filter 20. Associated with the vacuum bulb A_4 is the condenser 22 designed to form a parallel resonant circuit at 133 cycles in conjunction with the input windings 23 of vacuum bulb A_4 . Associated with the vacuum bulb A_4 is the variable resistance 21 which serves as a noninductive shunt resistance in parallel with the transformer 23 and is designed to shunt irregular current impulses such as "Morse thump" or switchhook impulses which may pass through the

filter 20 and would otherwise interfere with the signaling apparatus. Associated with vacuum bulb A_5 is the vacuum bulb A_6 which is designed to function as a rectifier. The output circuit of vacuum bulb A_6 controls the relay 27 which serves to connect the sides of line L_1 to a source of signaling current suitable for use with the switchboard apparatus. This source of current includes the vacuum bulb A_7 which is designed to function as an oscillator tuned to generate currents of the desired frequency. The oscillations generated by vacuum bulb A_7 are transmitted through a number of vacuum bulbs such as A_8 and A_9 and are amplified to the desired degree. Associated with the output circuit of the vacuum bulb A_9 is the filter 30 which is designed readily to transmit currents of a frequency suitable for use at the switchboard apparatus, such as currents of a frequency of 16 cycles, but which attenuates and practically extinguishes currents of all other frequencies.

In the Fig. 3 is shown a modification of the invention which is adapted to be substituted for the arrangements illustrated in Fig. 2. The vacuum bulb A_3 of Fig. 2 which operated as a rectifier is replaced in Fig. 3 by the relay 60 which is tuned to respond to currents of a frequency generated by apparatus at the switchboard, such as a frequency of 16 cycles. The relay 60 is connected to the conductors 51 and 52 by the conductors 58 and 59 and its operation serves to control the relay 68 which connects the sides of the line L_2 to the vacuum bulbs A_{20} and A_{21} which are substantially similar to the vacuum bulb arrangements A_1 and A_2 of Fig. 2.

In the modification of the invention illustrated in Fig. 4 the two sections L_1 and L_2 of the transmission line are interconnected by conductors 100 and 101. Associated with conductors 100 and 101 is the filter apparatus 107 which readily allows voice currents to be transmitted over conductors 100 and 101 but which prevents the transmission of low frequency signaling currents such as currents of a frequency below 200 cycles, which are generated at the switchboard apparatus associated with line L_1 , and such as come in over the line L_2 . Bridged across conductors 100 and 101 is the relay 103 which is tuned to respond to the low frequency signaling currents generated at the switchboard apparatus. The relay 103 controls the relay 114 whereby the sides of line L_2 are connected to a source of signaling current suitable for use over the transmission line, which current may, in practice, have a frequency of 133 cycles. Associated with conductors 100 and 101 by means of a bridge including windings of high impedance are the vacuum bulb ar-

rangements A_{30} , A_{31} , and A_{32} . Associated with the input circuit of vacuum bulb A_{30} is the filter apparatus 108 which is designed to permit efficient transmission of signaling currents suitable for use over the line L_2 , such as 133 cycle current, and which attenuates and practically extinguishes currents of other frequencies. The resistance element 109 is variable and acts as a shunt to prevent interference due to "Morse thump" and switchhook operation. The condenser 110 is designed to give a parallel resonant circuit at 133 cycles in conjunction with the input windings of transformer 111. The vacuum bulbs A_{30} and A_{31} are designed to amplify the signaling current to the desired degree and are connected to the vacuum bulb A_{32} which serves to operate as a rectifier and to control the relay 112. The relay 112 controls the relay 102 whereby the sides of the line L_1 are connected to a source of signaling current suitable for operating signaling apparatus at the switchboard which current may, in practice, have a frequency of 16 cycles.

The operation of the form of the invention illustrated in Figs. 1 and 2 is as follows: As the signaling current generated by apparatus at the switchboard for ringing purposes may in practice have a frequency in the neighborhood of 16 cycles, such ringing current will hereinafter be referred to as 16 cycle current. The low frequency 16 cycle ringing current generated at the switchboard will be transmitted over the line L_1 and over conductors 1 and 2 and thence over conductors 4 and 5 to the filter apparatus 8. The filter apparatus 8 readily allows the transmission of these low frequency 16 cycle currents but attenuates and practically extinguishes currents of other frequencies. Accordingly, these 16 cycle ringing currents will be transmitted through the filter apparatus and through the left hand winding of transformer 11. Connected in parallel with the left hand winding of transformer 11 is the non-inductive shunt resistance 9, which is so designed as to shunt any irregular current impulses, such as switchhook impulses, which may pass through the filter apparatus 8 and would otherwise interfere with the signaling apparatus. Associated with the left hand winding of transformer 11 is the condenser 10, which is so designed as to form an oscillating circuit at 16 cycles with the transformer 11, so that the potential impressed on the left hand winding of transformer 11 will cause the maximum current flow through the transformer at this frequency. The ringing current transmitted through the left hand winding of transformer 11 will induce a current in the right hand winding of transformer 11 and over the input circuit of vacuum bulb apparatus A_1 , which is

designed to function as a harmonic producer. Sufficient energy at the low frequency is supplied to overload the vacuum bulb of the harmonic producer with the result that the input wave is distorted and the output current of the vacuum bulb includes harmonics of the original wave. As the input current might in practice have a frequency in the neighborhood of 16 cycles, it will be seen that one of the harmonics thereof would be a frequency in the neighborhood of 133 cycles. A current of the latter frequency is in practice suitable for transmission out over the line L_2 . Accordingly, there is associated with the output circuit of vacuum bulb A_1 a filter apparatus 12, which is designed readily to transmit currents having a frequency in the neighborhood of 133 cycles, while at the same time attenuating and practically extinguishing currents of other frequencies. Accordingly 133 cycle ringing current will be transmitted through the filter apparatus 12 to the input circuit of the vacuum bulb A_2 . Vacuum bulb A_2 is designed to function as an amplifier and will increase the 133 cycle current to the desired magnitude. This current will then be transmitted over conductors 13 and 15 and 14 and 16. A portion of the current transmitted over conductors 13 and 14 will be transmitted through the transformer 34 and to the vacuum bulb apparatus A_3 , which is designed to function as a rectifier. The alternating ringing current is accordingly rectified and is transmitted over conductors leading to the direct current relay 19, thereby operating relay 19. The operation of relay 19 serves to connect the sides of the transmission line L_2 to conductors 15 and 16 which in turn are connected to conductors 13 and 14 as formerly pointed out. Ringing current of a suitable frequency and magnitude will now be transmitted over these conductors and out over the line L_2 .

Ringling current coming in over the line L_2 may in practice have a frequency in the neighborhood of 133 cycles and such incoming ringing currents will hereinafter be referred to as 133 cycle current. The 133 cycle ringing current coming in over the line L_2 will be transmitted over conductors 1 and 2 and thence over conductors 6 and 7 to the filter apparatus 20. The filter apparatus 20 is designed readily to transmit currents having a frequency in the neighborhood of 133 cycles but will attenuate and practically extinguish currents of other frequencies. Accordingly, the 133 cycle ringing current will be transmitted through the filter 20 and through the right hand winding of transformer 23. Connected in parallel with the transformer 23 is the noninductive shunt resistance 21 which is so designed as to shunt any irregular current impulses, such as

switchhook or "Morse thump" impulses, which may pass through the filter 20 and would otherwise interfere with the signaling apparatus. Associated with the right hand winding of transformer 23 is the condenser 22, which is designed to form an oscillating circuit at 133 cycles with the transformer 23, so that the potential impressed on the right hand winding of the transformer 23 will cause the maximum current flow through the transformer at this frequency. The 133 cycle ringing current transmitted through the right hand winding of transformer 23 will induce a current in the left hand winding of transformer 23 which current will be transmitted through the vacuum bulbs A_4 and A_5 , which are designed to function as amplifiers and will increase the current to the desired magnitude. While only two vacuum bulb amplifiers have been illustrated, it will be understood that a greater or lesser number may be employed if desired, as the ringing currents coming in over line L_2 may be very weak and may be substantially attenuated by the high impedance windings which are included in conductors 6 and 7. This ringing current will now be transmitted over the output circuit of vacuum bulb A_5 and through the right hand winding of transformer 24. Ringing current will then be transmitted through the transformer 24 to the vacuum bulb A_6 , which is designed to function as a rectifier and accordingly will translate the ringing current into direct current and will transmit it over conductors 25 and 26 to the direct current relay 27, thereby operating relay 27. The operation of relay 27 disconnects the sides of the line L_1 from conductors 1 and 2 and connects the line L_1 to conductors 28 and 29 which lead to the vacuum bulb arrangements A_7 , A_8 and A_9 . The input circuit of vacuum bulb apparatus A_7 is inductively coupled with the output circuit thereof and accordingly the vacuum bulb A_7 will function as an oscillator and generate alternating currents. These alternating currents will be transmitted through the vacuum bulbs A_8 and A_9 , which function as amplifiers and will be increased to the desired magnitude. These currents will then be transmitted to the filter apparatus 30 which is designed readily to transmit currents having a frequency in the neighborhood of 16 cycles but which attenuates and practically extinguishes currents of other frequencies. Accordingly 16 cycle ringing current will now be transmitted over conductors 28 and 29 and over the sides of line L_1 to the switchboard apparatus.

The operation of the arrangements illustrated in Fig. 3 is as follows: The 16 cycle ringing current generated at the switchboard will be transmitted over conductors 51 and 52 and thence over conductors 53 and

55 to the filter apparatus 61. The filter apparatus 61, the vacuum bulb apparatus A_{20} , the filter apparatus 64 and the vacuum bulb apparatus A_{21} are substantially similar, respectively, to the filter apparatus 8, the vacuum bulb A_1 , the filter apparatus 12 and the vacuum bulb A_2 of the Fig. 2. Accordingly, the 16 cycle ringing currents transmitted over conductors 53 and 55 will be transmitted through the filter 61 and to the harmonic producer A_{20} . 133 cycle ringing current will then be transmitted through the filter 64 and the amplifier A_{21} and through the left hand winding of transformer 65, substantially in the same manner as described with respect to Fig. 2. Accordingly, 133 cycle current will be induced in the right hand winding of transformer 65 and will be transmitted over conductors 66 and 67. The 16 cycle ringing current generated at the switchboard will also be transmitted over conductors 51 and 52 and thence over conductors 58 and 59 and through the windings of relay 60, which is tuned to respond to currents having a frequency in the neighborhood of 16 cycles. Accordingly, when 16 cycle ringing current is transmitted over the line, the relay 60 will operate and close the following circuit: from ground, contact and armature of relay 60, over conductor 69, winding of relay 68 to battery and ground. The closing of this last mentioned circuit will operate relay 68 and will connect the sides of line L_2 to conductors 66 and 67, whereby 133 cycle ringing current will be transmitted out over the line L_2 .

The operation of the arrangements illustrated in Fig. 4 is as follows: the 16 cycle ringing current generated at the switchboard will be transmitted over the sides of line L_1 and over conductors 100 and 101 and thence over conductors 104 and 105 and through the windings of relay 103. The relay 103 is tuned to respond to currents of approximately this frequency and accordingly will operate and close the following circuit: from ground, contact and armature of relay 103, conductor 106, winding of relay 114 to battery and ground. The closing of this circuit will operate relay 114, which will pull up its armatures and connect the sides of line L_2 to conductors leading to a source of current suitable for use over the line L_2 and which in practice may be current having a frequency in the neighborhood of 133 cycles. The 133 cycle ringing current coming in over the line L_2 will be transmitted over conductors 100 and 101 and thence over conductors 115 and 116, which include high impedance windings, to the filter apparatus 108. The filter apparatus 108 is designed readily to transmit currents of a frequency of 133 cycles but attenuates and practically extinguishes currents of all other frequencies. Accordingly,

133 cycle ringing current will be transmitted through the filter 108 and through the left hand winding of transformer 111. Connected in parallel with the transformer 111 is the non-inductive shunt resistance 109 which is so designed as to shunt out any irregular current impulses, such as switch-hook or "Morse thump" impulses, which may be transmitted through the filter 108 and would otherwise interfere with the ringing apparatus. Associated with the left hand windings of transformer 111 is the condenser 110, which is designed to form an oscillating circuit with the transformer 111 at 133 cycles so that the potential impressed on the left hand winding of the transformer by the ringing current will cause the maximum current flow through the transformer at this frequency. The induced current will now be transmitted through the right hand windings of transformer 111 and through the vacuum bulb arrangements A_{30} and A_{31} , which are designed to function as amplifiers and which will increase the weak incoming ringing current to the desired magnitude. The ringing current will then be transmitted to the vacuum bulb A_{32} which is designed to function as a rectifier and which translates the alternating ringing current into direct current. This latter current will then be transmitted through the winding of the direct current relay 112, thereby operating relay 112. The operation of relay 112 closes the following circuit: from ground, armature and contact of relay 112, conductor 113, winding of relay 102 to battery and ground. The closing of this circuit operates relay 102, whereby the sides of line L_1 are connected to conductors leading to a source of current suitable for operating the ringing apparatus at the switchboard, which current may in practice have a frequency in the neighborhood of 16 cycles.

While for purposes of illustration the signaling current suitable for operating responsive means at the switchboard has been referred to as current having a frequency in the neighborhood of 16 cycles, and while the signaling current suitable for transmission over line L_2 has been referred to as having a frequency in the neighborhood of 133 cycles, it will be understood that the arrangements of this invention are not limited in operation to currents of approximately these frequencies but may be arranged to operate with currents of any desirable frequencies. While the invention has been disclosed as embodied in certain specific arrangements which are deemed desirable, it will be understood that it is capable of embodiment in many and widely varied forms without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. A transmission line, a bridge across

said line adapted to transmit current of a frequency suitable for transmission over one section of said line, a vacuum bulb apparatus associated with said bridge and adapted to translate said first mentioned current into currents having frequencies which would be harmonics of the frequencies of said first mentioned current, and means to select one of said last mentioned currents and to impress said current on another section of said line.

2. A transmission line, a bridge across said line including a filter adapted to transmit current of a frequency suitable for transmission over one section of said line and to attenuate and practically extinguish current of other frequencies, a vacuum bulb apparatus associated with said filter and adapted to translate said first mentioned current into currents having frequencies which would be harmonics of the frequency of said first mentioned current, means to select one of said last mentioned currents and to impress said selected current on another section of said line, and means to prevent currents of other frequencies from being impressed thereon.

3. A transmission line, a bridge across said line including a filter adapted to transmit current of a frequency suitable for transmission over one section of said line and to attenuate and practically extinguish currents of other frequencies, a vacuum bulb apparatus associated with said filter and adapted to translate said first mentioned currents into currents having frequencies which would be harmonics of the frequency of said first mentioned currents, means to select one of said last mentioned currents, means to amplify said selected current, and means to impress said selected current on one section of said transmission line, said selecting means operating to prevent currents of other frequencies from being impressed thereon.

4. A transmission line, a bridge across said line adapted to transmit currents of a desired frequency, means in said bridge for attenuating and extinguishing currents of other frequencies, a vacuum bulb apparatus associated with said bridge and adapted to translate said first mentioned currents into currents having frequencies which would be harmonics of the frequency of said first mentioned currents, means to select one of said last mentioned currents, means to rectify a part of said selected current, and means responsive to said rectified current whereby the other portion of said selected current is impressed on one section of said transmission line.

5. A transmission line, means responsive to current transmitted over one section of said line for generating current suitable for transmission over another section of said

line, means to rectify a portion of said generated current, and means controlled by said rectified current for applying the other portion of said generated current to the last
5 mentioned section of said line.

6. A transmission line, a vacuum bulb apparatus associated therewith adapted to rectify alternating current transmitted over

one section of said line, a relay controlled by said rectified current, and means controlled by said relay for connecting the other
10 section of said line to a source of current.

In testimony whereof, I have signed my name to this specification this 22 day of July, 1918.

CHARLES S. DEMAREST.