Jan. 5, 1926.

1,568,861

H. A. AFFEL

REPEATER CIRCUIT

Filed July 2, 1921

2 Sheets-Sheet 1

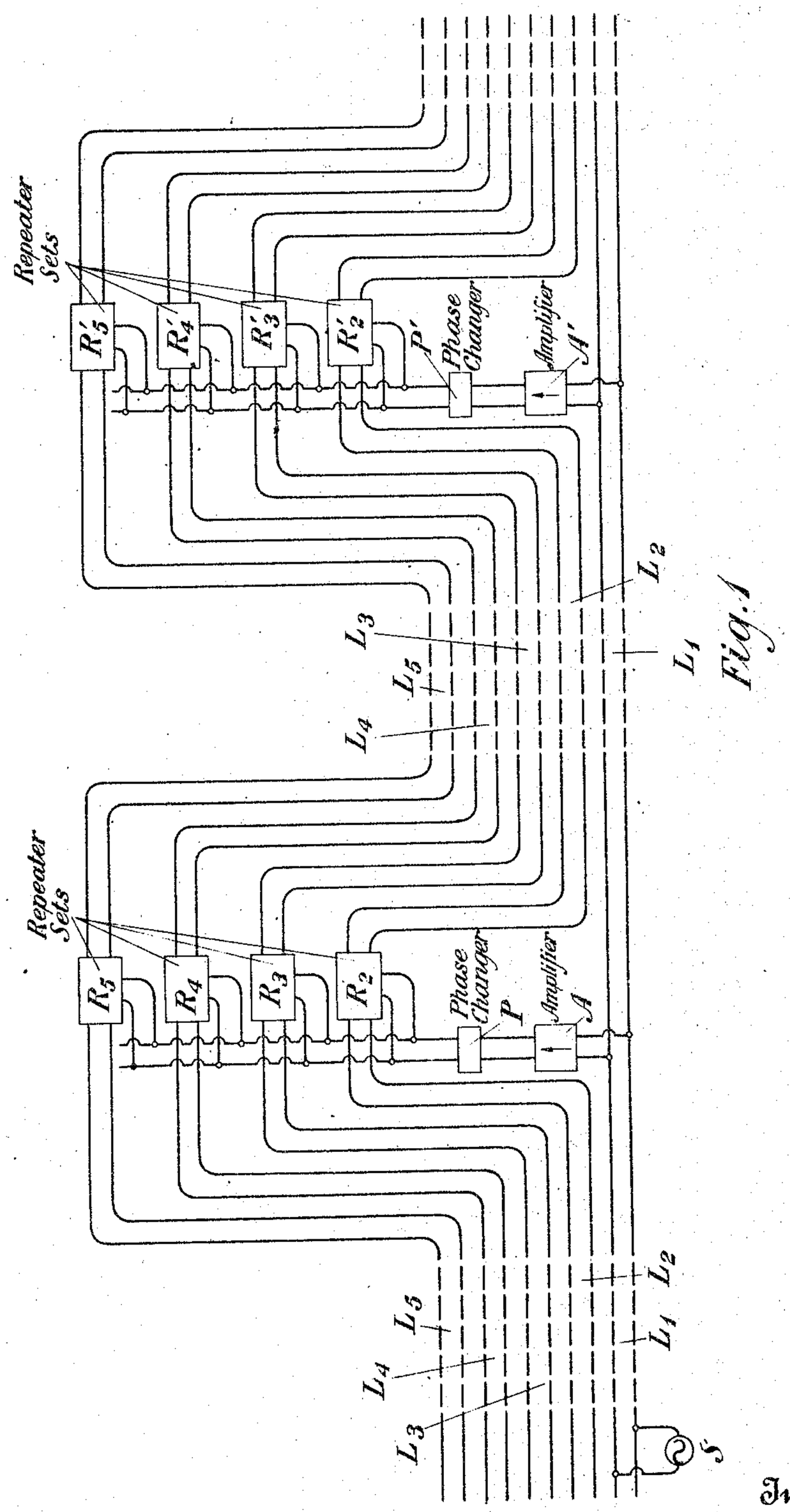

Fig. 1

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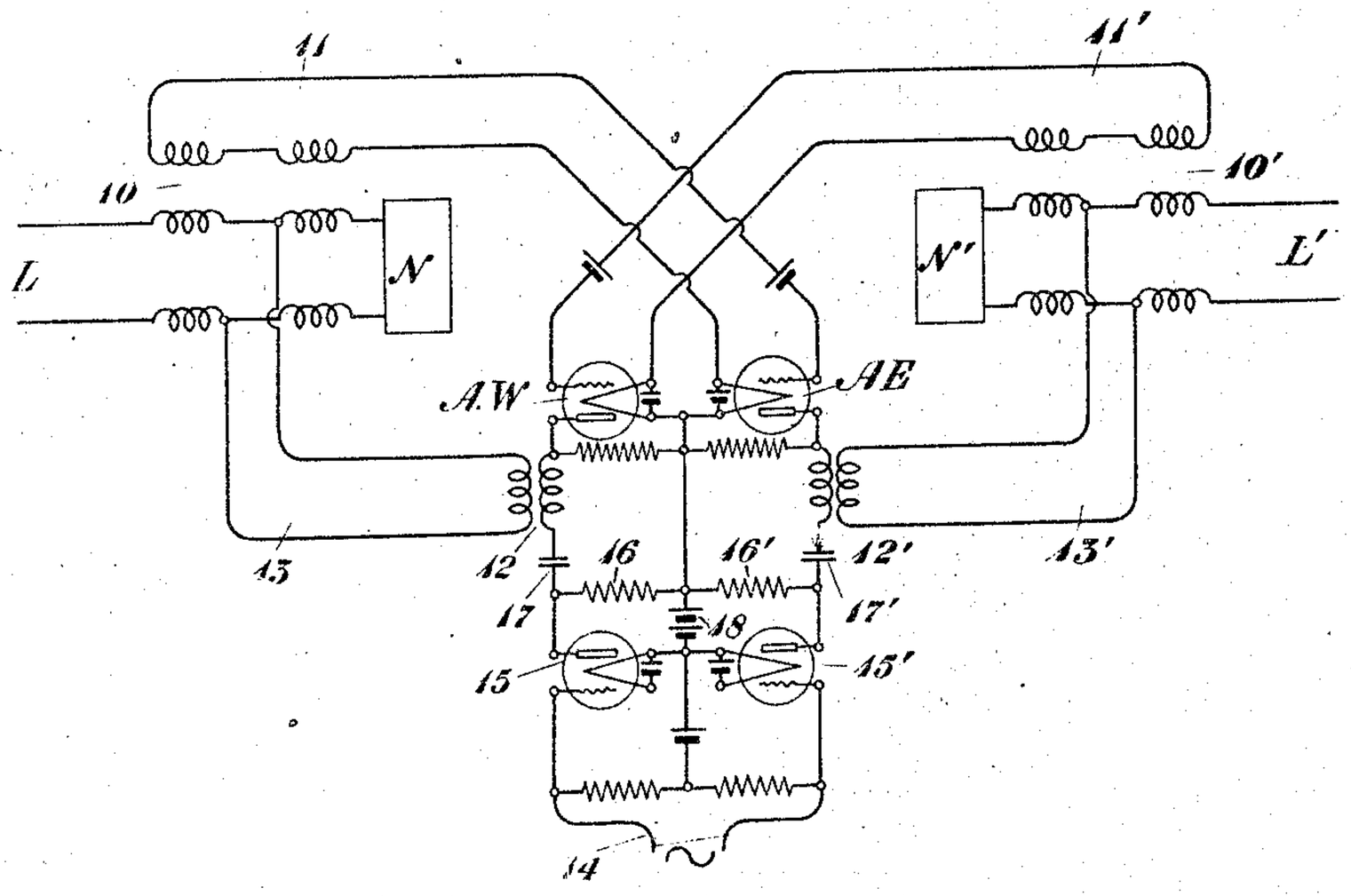

Fig. 2

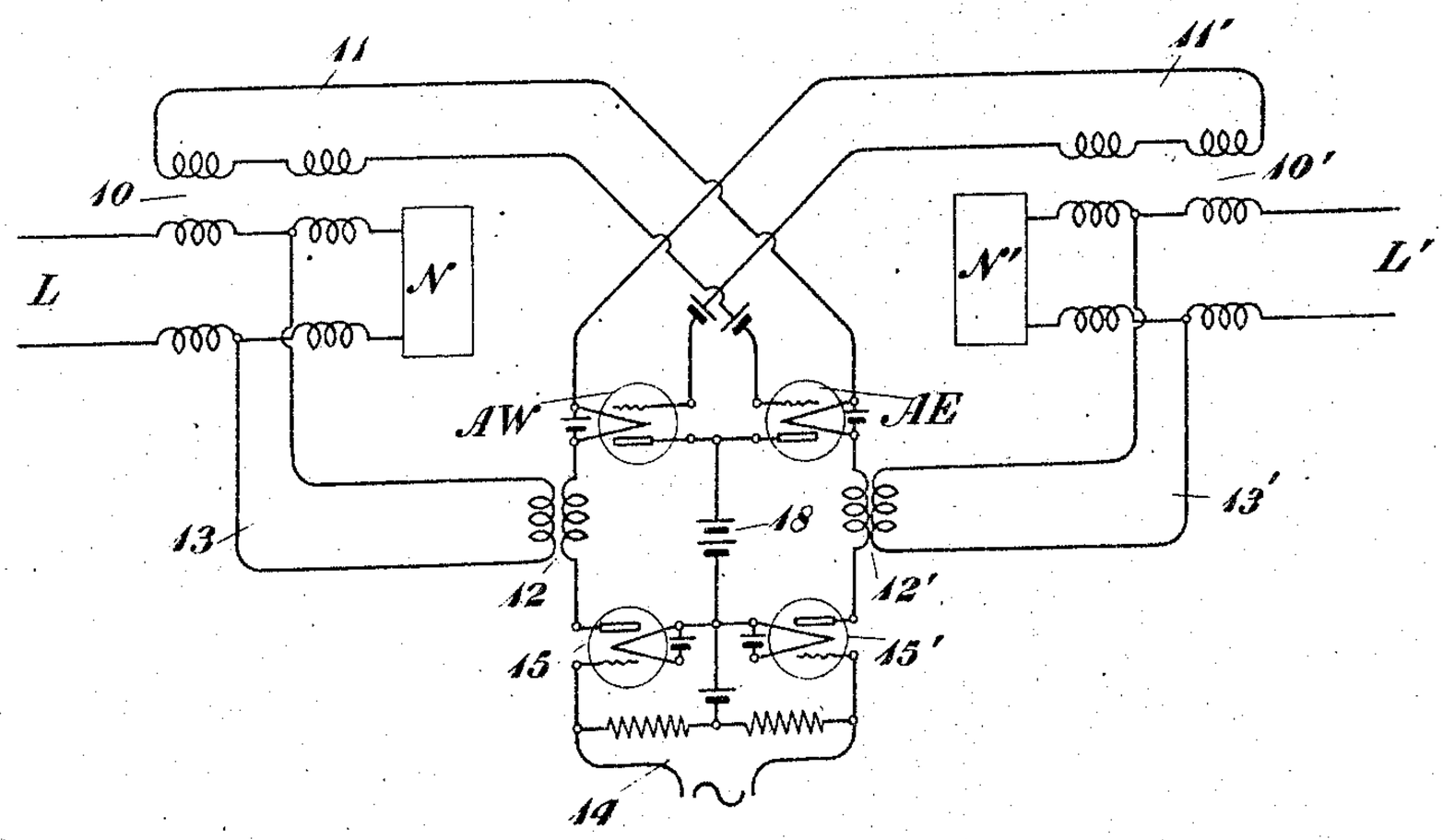

Fig. 3

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UNITED STATES PATENT OFFICE.

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REPEATER CIRCUIT.

Application filed July 2, 1921. Serial No. 482,182.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Repeater Circuits, of which the following is a specification.

This invention relates to transmission circuits, and more particularly to transmission circuits of the general type exemplified by two-way repeater circuits.

In repeater circuits of the so-called 22-type, it has been customary to differentiate between the sending and receiving channels by balancing the channels with respect to the line sections, the well-known hybrid coil and artificial line or network being employed for this purpose. The problem of balancing a line involves grave difficulties, however, and frequently the degree of balance is so poor that the amplification must be maintained quite low to prevent singing.

In accordance with the present invention, it is proposed to effect two-way transmission by differentiating between the sending and receiving channels on a time basis—that is, by associating the channels with the line alternately at a frequency high as compared with the signaling frequency. This results in switching the line at both ends of the repeater at a rapid rate between the sending and receiving terminals of the repeater. This will obviously permit of operating the repeater at very high gain without encountering difficulties due to singing, since the problem of repeater singing is essentially one of discriminating between the oppositely directed channels. This method of switching may be used either to supplement the discrimination due to balance or may be substituted for the balancing method.

An important feature of the present invention resides in the employment of vacuum tubes for performing the switching function, the vacuum tube having in this connection the characteristic advantage, as compared with mechanical switching means, of substantial absence of inertia, thereby permitting of high speed switching and absence of contacts with their attendant troubles.

More specifically considered, the invention involves an arrangement whereby the vacuum tube amplifiers in the oppositely directed channels of the 22 repeater circuit are alternately rendered operative at a high frequency rate by impressing proper operating potentials upon the tubes.

For controlling the amplification of the tubes alternately, the space currents for the tubes may be supplied from some external source of alternating current so that one half-wave controls the space current for one amplifier and the other half-wave the space for the other amplifier. The amplifiers will, therefore, be operated alternately and not simultaneously.

An important feature of the invention resides in the provision of means whereby the switching of the channels of repeaters included in tandem in the same circuit may take place simultaneously, or synchronously in time phase with reference to the arrival of a given signal impulse at successive tandem repeaters. It is necessary that the switching of all the repeaters in the same circuit take place in such synchronism as otherwise the circuit might be rendered inoperative due to one repeater in the circuit being in nonamplifying condition upon the arrival of a signal impulse passed by the other repeaters repeating in the same direction when in an amplifying condition.

The invention may now be more fully understood from the following description, when read in connection with the accompanying drawing, Figure 1 of which illustrates schematically an arrangement for controlling the synchronous switching of a number of repeater sets, and Figs. 2 and 3 of which illustrate two forms of repeater sets which may be employed in the circuit arrangement of Fig. 1.

Referring to Fig. 1, L_1 to L_5 inclusive indicate schematically a number of pairs of conductors included in the same cable or carried along the same pole line or the like. Each of these pairs of wires may be used as a separate transmission circuit and at suitable points along the line each pairs of wires, with the exception of the pair L_1, may be provided with repeater sets such as R_2 to R_5 inclusive, and R_2' to R_5' inclusive, etc. These repeater sets may be of the so-called 22-type and may be arranged as previously described so that the amplifiers for amplifying in opposite directions will be operated alternately. Without considering

for the moment the means by which this result is accomplished, it will be assumed that the amplifiers of each repeater set will be rendered operative alternately by supplying to the repeater set a high frequency alternating current, one half-wave of which will cause one amplifier in each set to be operated and the other half-wave of which will cause the other amplifier in the set to be operated. It is essential that the amplifiers in repeater sets such as R_5 and R_5' included in the same line shall be rendered operative in a given direction in the same time relation with respect to a voice wave train successively arriving at the repeater points. This involves the provision of some means for supplying the alternating currents to repeater sets in the same line in such phase relation that all the repeaters included in tandem in a given line, will repeat in the same direction at the proper time.

In accordance with the present invention. this result is accomplished by utilizing one of the pairs of wires, as, for example, the pair L_1, to transmit alternating current from a given source S over said pair of wires to all of the repeater stations. At each repeater station branch circuits through the amplifiers A and A′ will be provided for supplying the repeater sets. The branch circuits may include phase changers P and P′, etc., for regulating the phase of the alternating current supplied to the repeater sets. The function of the amplifiers A, A′, etc., is to adjust the amplitude of the controlling currents in accordance with the requirements of the repeaters at different stations. The branch circuits at the repeater stations will be provided with parallel connections leading to each of the repeater sets at a given repeater station. This will permit of one common source supplying all of the repeater sets of the system, and it only necessitates employing one pair of wires out of a large number of pairs for transmitting the controlling currents, all of the other pairs being used for signaling through repeater sets in the usual manner.

Each of the repeater sets as schematically indicated in Fig. 1 may be of the type illustrated in Fig. 2 and Fig. 3. Referring to Fig. 2, L and L′ designate transmission line sections which are associated with amplifiers AE and AW through the usual hybrid coil arrangements 10 and 10′. Balancing networks or artificial lines N and N′ may be provided as is customary in 22 repeater circuits. The input circuits 11 and 11′ of the repeater are connected to the grids of vacuum tube amplifiers AE and AW, respectively, and the output circuits of these amplifiers are associated through transformers 12 and 12′ with the outgoing circuits 13 and 13′ connected to the midpoints of the hybrid coils.

The usual battery or other source of direct current for the plate circuits of the amplifiers AE and AW is omitted in this case, the space current being provided by means of the alternating source S of Fig. 1, leads 14 being associated with the branch circuit including the amplifier and phase changer of Fig. 1. Rectifying tubes 15 and 15′ are provided for rectifying the alternating currents supplied over the leads or conductors 14. These rectifiers are of the three-element type in which the grid circuit has such a normal potential applied thereto that no space current flows in the plate circuit due to the B battery. When, however, a half-wave of the proper potential is applied to the grid, a space current is permitted to flow in the output circuit of the tube 15 or 15′ as the case may be, through a resistance 16 or 16′. Condensers 17 and 17′ connect the plates of the rectifying tubes 15 and 15′ with the plates of the amplifying tubes AE and AW so that when a pulse of current passes through one of the resistances 16 or 16′, a pulse is induced in the plate circuit of one of the amplifiers.

The operation is as follows: assuming that at a given instant the half-wave of alternating current incoming over the circuit 14 is of such a polarity as to overcome the normal space charge, tending to prevent the flow of current in the plate circuit of tube 15, it will be apparent that a pulse of current will flow from the battery 18 across the filament plate gap of the tube and through the resistance 16. The alternating half-wave incoming over the circuit 14 is of such a polarity with respect to the grid of the tube 15′ as to increase the space charge in said tube so that no current flows in the plate circuit thereof. The impulse of current flowing in the plate circuit of the tube 15 charges the condenser 17 so that a potential is applied to the plate circuit of the amplifier AW of such polarity as to cause a pulse of current to flow in the output circuit thereof through the primary winding of the transformer 12. During the period that the current is flowing through the output circuit of the amplifier AW, it is apparent that the amplifier will be rendered operative so that speech may be transmitted from the line L′ through the amplifier to the line L.

The amplifier AE is inoperative at this time as no space current flows in the output circuit of the tube 15′ and hence no potential to drive a space current through the tube AE is supplied. When the alternating wave of opposite sign is received from the circuit 14, however, the grid of the tube 15′ has its potential so changed as to permit the space current to flow in said tube, thereby inducing a potential on the plate of the amplifier AE. Accordingly, a space current flows through the output circuit of the amplifier

AE and voice currents may be transmitted from the line L to the line L'. These operations alternate with each succeeding half-wave of alternating current incoming from the circuit 14 and the repeater set operates to amplify alternately in opposite directions. A high impedance leak is provided to prevent accumulation of charge on condensers 17 and 17'.

A slightly modified arrangement is illustrated in Fig. 3, in which case a source of space current 18 is included in the output circuits of the amplifying tubes AE and AW and of the rectifying tubes 15 and 15' in series. At a given instant the half-wave of alternating current incoming from the circuit 14 may be of such polarity as to overcome the space charge in tube 15, permitting current to flow from 18 through the plate circuits of tubes 15 and AW, making the latter operative as an amplifier. At this instant the voltage applied from circuit 14 to the grid of tube 15' will be of such polarity as to oppose the flow of current in the plate circuits of tubes 15' and AE, and practically no current will flow, rendering tube AE inoperative as an amplifier. During the next incoming half-wave of alternating current from 14, conditions will be recovered, AE being operative while AW will not function. The amplifying tubes, therefore, amplify alternately and but one is operated at a time.

It will be obvions that the general principle 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 transmission circuit, a line, a plurality of 22 repeaters arranged in tandem in said line, said repeaters being separated by line sections of sufficient length to introduce a change of phase in transmission thereover, each repeater including separate amplifiers for transmitting in opposite directions, alternating current controlled means for alternately rendering the oppositely transmitting amplifiers of each repeater operative, and means for supplying controlling alternating current waves to the tandem repeater sets of a given circuit in such phase relation that all the amplifiers transmitting in the same direction will be operated in the same time relation with respect to a voice wave train successively arriving at the repeater points.

2. In a transmission circuit, a transmission line, a plurality of repeaters arranged in said line in tandem, said repeaters being separated by line sections of sufficient length to introduce a change or phase in transmission thereover, and means operating said tandem repeaters in the same time relation with respect to a voice train successively arriving at the repeater points to render them alternately operative and inoperative for transmission in the same direction.

3. In a transmission circuit, a line, a plurality of one-way amplifiers arranged in said line in tandem, said amplifiers being separated by line sections of sufficient length to introduce a change of phase in transmission thereover, and operating means for rendering each of said amplifiers alternately operative and inoperative in the same time relation with respect to a voice wave successively arriving at the amplifier points.

4. In a transmission circuit, a plurality of transmission lines, repeaters arranged in tandem in each of said lines, said repeaters being separated by line sections of sufficient length to introduce a change of phase in transmission thereover, each repeater including separate amplifiers for transmission in opposite directions, alternating current controlled means for rendering oppositely repeating amplifiers operative alternately and in the same time relation with respect to a voice wave train successively arriving at the repeater points, and a common source of alternating current for all of said repeaters.

5. In a transmission circuit, a plurality of transmission lines, repeaters arranged in tandem in each of said lines, said repeaters being separated by line sections of sufficient length to introduce a change of phase in transmission thereover, each repeater including separate amplifiers for transmission in opposite directions, alternating current controlled means for rendering oppositely repeating amplifiers operative alternately, and a common source of alternating current for operating the controlling means of all the repeaters in the same time relation with respect to a voice wave train successively arriving at the repeater points.

6. In a transmission circuit, a plurality of transmission lines, repeaters arranged in tandem in each of said lines, said repeaters being separated by line sections of sufficient length to introduce a change of phase in transmission thereover, each repeater including separate amplifiers for transmission in opposite directions, alternating current controlled means for rendering oppositely repeating amplifiers operative alternately, a transmission circuit common to all of said lines, a source of alternating current for said circuit, connections from said common circuit to all of the tandem repeaters of all of the lines, and means whereby the controlling means of all of the repeater sets will be operated by the alternating current transmitted over said common circuit in the same time relation with respect to a voice wave train successively arriving at the repeater points.

7. In a repeater apparatus, line sections over which signaling currents may be transmitted, separate amplifiers interconnecting

said lines for transmission in opposite directions, a source of alternating current independent of said signaling currents, and means to rectify succeeding half-waves from said source of alternating current, the rectified half-waves alternately rendering the said oppositely repeating amplifiers operative.

8. In a repeating system, line sections over which signaling currents may be transmitted, separate vacuum tube amplifiers interconnecting said line sections for repeating in opposite directions, a source of alternating current independent of said signaling currents, and means for rectifying successive half-waves from said alternating current source and for supplying alternate rectified pulses to the output circuits of the oppositely repeating amplifiers.

In testimony whereof, I have signed my name to this specification this 29th day of June 1921.

HERMAN A. AFFEL.