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TELEPHONE TRANSMISSION CIRCUITS

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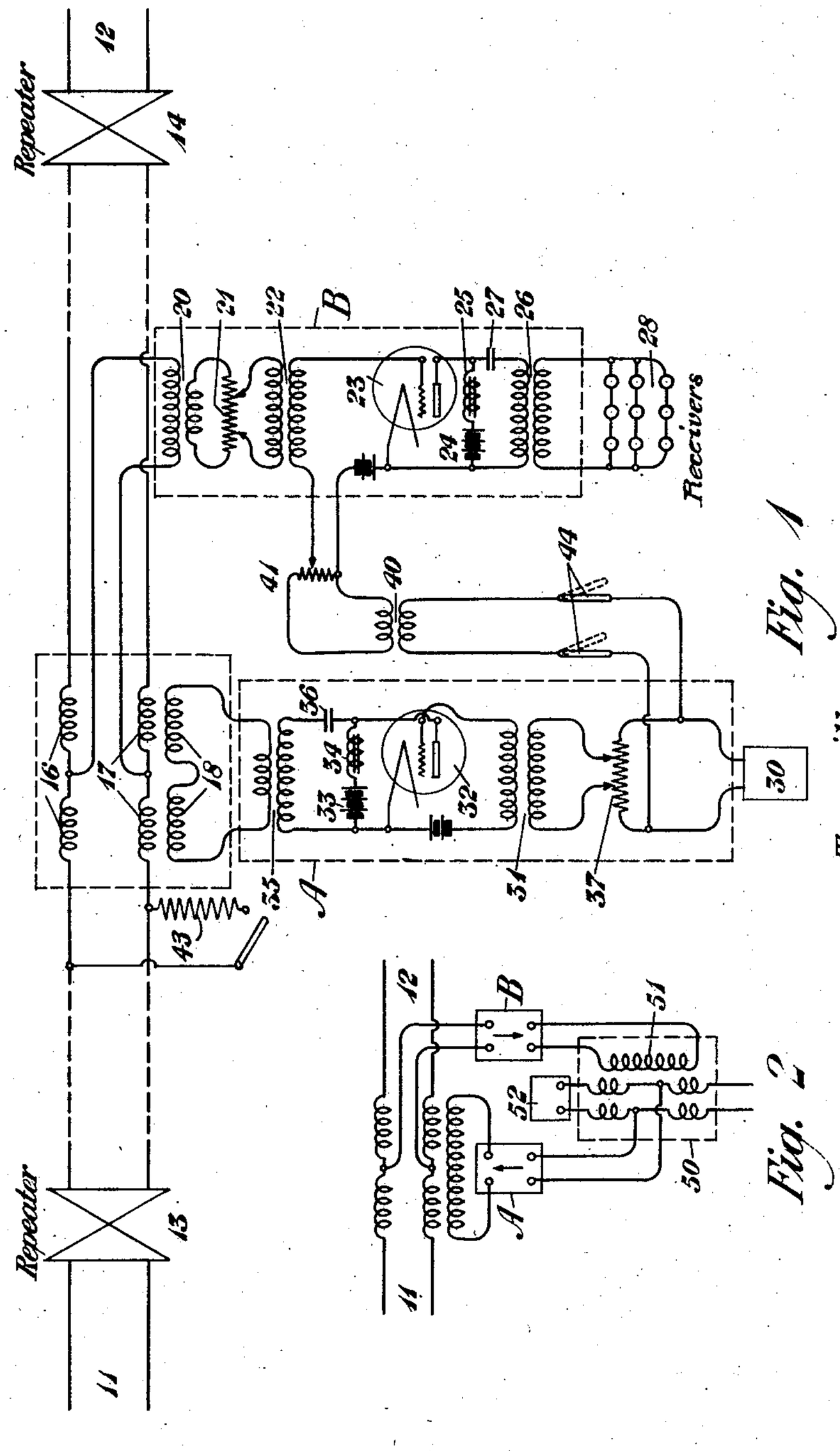

Fig. 1

Fig. 2

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TELEPHONE-TRANSMISSION CIRCUITS.

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This invention relates to telephone circuits and more especially to an arrangement for talking and listening on a transmission line at some intermediate point. It finds its application in such work as monitoring on a telephone line where it may be desirable to permit the supervisor to talk into the line as well as to listen on the line. It finds further application in connection with telephone demonstrations or in connection with the distribution of public speeches in which at one or more points on a line it may be desirable to permit audiences to hear speech coming from a single point, and which may at the same time permit talking into a line from these various stations. It will find application in many other fields such as on leased wire telephone lines in which service is to be distributed to a number of stations along the line in a manner to permit any one station to talk to any other station.

The purpose of the invention is to provide facilities for doing this which will not introduce excessive loss to the direct transmission of energy between the two terminal stations. Another object is to introduce apparatus for this purpose of such a character that the reflections or echo effects on a line shall be reduced to a minimum. Still a further object is to provide apparatus with such characteristics that it will not substantially alter the impedance characteristics of the transmission circuit as viewed from one terminal station or the other. Other objects will appear in connection with the specification.

I accomplish these results by inserting in the transmission line, at an intermediate point, a hybrid coil to which are connected respectively a listening circuit and a talking circuit, the impedances of these two circuits being changed with respect to the line impedance in such a way as to absorb only a small amount of power from the line. The invention will be better understood by reference to the following specification and the accompanying drawing, in which Figure 1 shows one specific circuit arrangement for producing the desired results, and Fig. 2 is a circuit showing certain extensions of the circuit of Fig. 1.

Referring to Fig. 1, there is shown a through transmission line 11 and 12, which may include, if desired, repeaters such as 13 and 14. At some intermediate point on the line it may be desirable to have a talking and listening arrangement and for this purpose I introduce at such a point a hybrid coil of a standard form, which is here shown as consisting of two windings 16 and 17 in series with the line and a winding 18 inductively connected to the windings 16 and 17. Across the midpoints of the windings 16 and 17 is connected a bridge circuit, which I have shown here as consisting of the primary of a transformer 20, the secondary of which leads to telephone receivers. This part of the circuit may take on a variety of forms but in the particular circuit shown the secondary of the transformer 20 is closed through a resistance 21. Variable contacts are provided through which this resistance 21 is connected to a transformer 22, the secondary of which is connected to the input circuit of a vacuum tube amplifier 23. In the output circuit of this amplifier there may be connected in an appropriate manner indicating devices such as telephone receivers. This is accomplished by connecting in the output circuit of the amplifier a power source 24 in series with a retard coil 25 and across these is connected the primary of a transformer 26, in the secondary of which I have shown the indicating devices which may consist of a large number of telephone receivers in series and multiple relation. A condenser 27 is connected in the primary of the transformer 26 to prevent a flow of direct current from the battery 24 through said circuit.

Connected to the hybrid coil winding 18 is apparatus for talking in on the line. Specifically I have shown this as consisting of a transmitter 30, the output of which is connected to a transformer 31, the secondary of this transformer being connected directly to the coil 18 or connected thereto through a second transformer. Preferably, however, for reasons which will appear later, I have found it desirable to amplify the output power of the transformer 21, and for this reason I have shown the output of transformer 31 as being connected to the input of a vacuum tube amplifier 32 in the output of which there is connected in the usual way a source of power 33 and a retard coil 34, around which is connected a transformer 35, the secondary of which is connected to winding 18. In order to prevent flow of direct current through the transformer 35 it is de-

sirable to insert a condenser 36. Also in order to control the amount of power supplied to the amplifier 32 it is desirable to use a potentiometer 37, which may be inserted on the one side or the other of the transformer 31, although I have here shown it as being connected across the primary of said transformer.

The circuit connections as thus far described are similar to those used in connection with the so-called 21-type repeater except for an important difference, namely, that the output of the bridge circuit is not connected to supply power to the winding 18. There is a further important difference which may be explained as follows: In the case of the 21-type repeater in which a hybrid coil of the same form as here shown is used, it is the practice to make the impedance of the bridge connection, as seen from the hybrid coil, equal to $\frac{Z}{2}$, where Z is the impedance as seen from the hybrid coil looking towards one of the terminal stations. Also it is the practice to make the impedance of the circuit of coil 18 appear equal to $\frac{Z}{2}$ when viewed from the line. This is the condition for a 21-type repeater yielding the highest efficiency and a minimum of reflection effects. It is well understood in the art that under these conditions power coming over the line from the direction 11 will divide equally, half of it going into the bridge circuit to operate on the amplifier and half of it being absorbed and lost in the circuit of winding 18, while none of this incoming power passes directly through to the terminal of the line 12. Thus the transmission loss through such a circuit for direct transmission from 11 to 12 is infinite and in case the connection between the bridge circuit and the circuit of winding 18 is interrupted, no speech will be received in the line 12. In this invention I propose to change the values of the impedances in the circuits A and B in such a way as to unbalance the system and thus permit direct transmission of speech from 11 to 12. Also I propose to do this in such a manner that the loss introduced for such direct speech shall be small. To this end I make the impedance of the bridge circuit B substantially larger than the normal value of $\frac{Z}{2}$. Direct transmission now takes place towards the station 12, and the greater the departure from the normal value for the impedance of the circuit B the less loss will this bridge circuit introduce so far as direct transmission is concerned. This increase in the impedance of the bridge circuit may be accomplished in a number of ways. The one which I have shown, however, consists in making the transformer 20 a step-down transformer, that is, one in which the primary has a larger number of turns than the secondary. Looking from the hybrid coil into this bridge circuit, then, there is seen substantially the impedance of the resistance 21, multiplied by a factor which is equal to the square of the turn ratio of the transformer.

A further substantial loss in direct transmission is that due to the absorption of energy in the circuit A, which by virtue of the hybrid coil is electrically equivalent to inserting in series in the line an impedance equal to the impedance of the circuit A, as seen from the line. To reduce this loss in direct transmission I arrange the circuit in such a manner that this equivalent series impedance is reduced and this is accomplished by making the impedance of the circuit A smaller by the use of the transformer 35, which is a step-up transformer as viewed from the hybrid coil. Under these conditions the apparent impedance of the circuit A as viewed from the hybrid coil, will be equal to its actual impedance, divided by the square of the turn ratio of the transformer 35.

Attention may be called here to the fact that as normally operated, a 21-type repeater placed at the position in the line shown would be so adjusted that if Z is the impedance of the line 11 as viewed looking away from the hybrid coil, then the impedance as viewed from the line 11 and looking into the hybrid coil with its associated circuits will be also equal to Z. This is the condition for maximum or most efficient transfer of energy over the line. It will be noted, however, that increasing the impedance of the bridge circuit B will increase the impedance as seen looking into the hybrid coil. It will be noted also that the reduction of the impedance of the circuit A, as seen looking from the hybrid coil, has the opposite effect of reducing the impedance as seen when looking into the hybrid coil, so that it is apparent that these two changes tend to offset each other. It can be shown theoretically that if the normal impedance of the bridge circuit B is multiplied by a factor N, and the normal impedance of the circuit A is divided by this same factor, then the two changes offset each other and the impedance as seen looking into the hybrid coil remains equal to Z, hence reflection losses and impedance irregularities at this point are avoided.

The increase of the impedance of the circuit B decreases the efficiency with which power from the line is transferred to said circuit. From one point of view this is desirable, and is in fact the end sought in order that the loss in direct transmission to the line 12 shall be small. However, it has this disadvantage, that the power available for listening in is relatively small. This is overcome by the introduction of the amplifier 23,

which obviously may be a plurality of amplifiers connected in parallel, in a tandem, or in any other well known manner for increasing the power, it being borne in mind that the audion type of amplifiers is a voltage-operated device, and therefore does not require much power in the input circuit. The change of the impedance of the circuit A is such as to reduce the loss for direct transmission, which is a desired end, but it also has the disadvantage that the efficiency of transfer of energy from this circuit A to the line is low. To overcome this defect I introduce amplifiers such as 32 into this circuit by means of which it is possible to increase the energy which is to be impressed on the transmission line to any extent desired.

As thus described, the circuit arrangement provides effective and useful means for listening and talking into a transmission line at an intermediate point in such a way that the loss to the direct transmission can be reduced to any desired value. Further, it provides means whereby the difficulty due to the corresponding inefficient transfer of energy from the line to the listening circuit, and from the talking circuit to the line, is overcome. At the same time, these results are accomplished in such a manner that large impedance irregularities are not produced in the line. This is of importance for the reason that under these conditions the reflection or echo effects, due to the introduction of the hybrid coil and its associated apparatus, will be reduced to a minimum. In addition to these features, however, it may be desirable to provide side-tone at this intermediate station, that is, to provide means by which the speaker, or any number of other persons listening in at the receivers, may hear what the speaker has to say. One means which I have provided for this consists of a transformer 40 the primary of which is bridged across the output of the transmitter 30, and the secondary of which may be connected in series with the secondary of the transformer 22 either directly or through a potentiometer 41. By means of this potentiometer a convenient adjustment can be made of the amount of sidetone introduced to the receiver group. It will be noted that inasmuch as the secondary of this transformer 40 or the potentiometer 41 is directly connected in the grid circuit of the amplifier 23 currents coming in over the bridge circuit do not react through the transformer 40 onto the input of the amplifier 32, nor do effects coming into the transformer 40 from the transmitter 30 produce any reaction on the line through the bridge transformer 20. The circuits are therefore to this extent electrically independent.

A second method by which sidetone may be introduced is by inserting an impedance 43, generally a pure resistance, in bridge across the line 11 or 12. This has the effect of unbalancing the impedances of the line, causing transfer of power from the circuit A into the circuit B. Under these conditions the sidetone circuit including the transformer 40 would not be used, and may be eliminated by a switch 44.

In certain cases it may be desirable to have the talking and listening stations at some considerable distance from the intermediate point at which the hybrid coil is introduced. Obviously, in this case the circuits A and B could be extended and become virtually a four-wire circuit. In case of considerable distances, however, it may be desirable to use a two-wire circuit. Fig. 2 illustrates one method by which this might be accomplished. For this purpose a hybrid coil 50 has its bridge terminals connected to the equivalent of circuit A of Fig. 1, and the winding 51 is associated with the equivalent of circuit B of Fig. 1. A network 52 is connected to one side of the hybrid coil and is made of such a value as to balance the line over which transmission is carried to the remote point in a manner which is well known in the art.

While I have described one specific embodiment of my invention, it is to be understood that numerous changes and modifications may be made without departing from the scope of the invention as set forth in the appended claims. For example, while I have shown the listening circuit as being connected to the bridge connection, and the talking source as being connected to the series coil, this connection may be reversed and substantially the same results will follow. Also, while I have made the bridge circuit of high impedance and the series circuit of low impedance these may also be reversed, still maintaining the relation that by whatever factor the one impedance is altered, the other shall be altered by the reciprocal of that factor. Also, while I have shown repeaters 13 and 14 in the transmission line it is to be understood that these are not necessary although in case of a long transmission circuit the introduction of such repeaters at appropriate points will be desirable in order to maintain a suitable transmission level.

What is claimed is:

1. In combination, a transmission line and two sets of apparatus associated therewith at an intermediate point, one set being of low impedance and connected in series and the other set being of high impedance and connected in shunt, one set being adapted for listening on the line and the other for talking into the line, whereby both sets of apparatus draw from the line a relatively small proportion of the energy involved in direct transmission over the line.

2. In combination, a transmission line, means associated therewith at an intermediate point for listening on said line, means also associated therewith at the same point for talking into said line, one such means alone being adapted slightly to increase the normal impedance of the line, the other such means being adapted slightly to diminish it whereby both together keep the impedance unchanged for direct transmission along the line.

3. In a transmission line, means for listening and talking into said line comprising a series transformer and a bridged circuit, listening and talking circuits each associated with a respective transformer or circuit, the impedances of said listening and talking circuits being of values that respectively only slightly change the impedance of the line whereby the loss to direct transmission is low.

4. In a transmission line, means for listening and talking into said line comprising a series transformer and a bridged circuit, listening and talking circuits each associated with a respective transformer or circuit, the impedances of said listening and talking circuits being of values that respectively only slightly change the impedance of the line whereby the loss to direct transmission is low, and means associated with the talking circuit to put energy on the line comparable in magnitude to the energy directly transmitted over it.

5. In a transmission line means for listening and talking into said line at an intermediate point comprising a hybrid coil, transmission lines associated with the line terminals thereof and unequal impedances associated with the other terminals thereof and listening and talking apparatus associated with said impedances.

6. In a transmission line, means for listening and talking into said line at an intermediate point, comprising a hybrid coil, transmission lines associated with the line terminals thereof and listening and talking circuits associated with the other terminals thereof, the impedance of one of these circuits being larger than half the characteristic impedance of the line by an assigned factor, and the impedance of the other circuit being smaller than half the characteristic impedance of the line by the same factor.

7. In a transmission line, means for listening and talking into said line at an intermediate point, comprising a hybrid coil, a listening circuit bridged across the midpoints of said coil having an impedance equal to a multiple of the line impedance, and a talking circuit associated with the series winding of said coil having an impedance equal to a sub-multiple of the line impedance.

8. In a transmission line means for listening and talking into said line at an intermediate point comprising a hybrid coil, a listening circuit bridged across the midpoints of said coil having an impedance equal to a multiple of the line impedance, and a talking circuit associated with the series winding of said coil having an impedance equal to the same sub-multiple of the line impedance.

9. In a transmission line, means for listening and talking into said line at an intermediate point comprising a hybrid coil, transmission lines associated with its line terminals and unequal impedances associated with its other terminals, listening and talking apparatus associated therewith, and amplifying means introduced between the talking apparatus and the hybrid coil.

10. In a transmission line, means for listening and talking into said line at an intermediate point comprising a hybrid coil, transmission lines associated with its line terminals and unequal impedances associated with its other terminals, listening and talking apparatus associated therewith, means for amplifying the talking current before its introduction to the line and means for amplifying the listening current.

11. In a transmission line, means for listening and talking into said line at an intermediate point comprising a hybrid coil, transmission lines associated with its line terminals and listening and talking circuits associated with its other terminals, the impedance of one of these circuits being larger than the line impedance by an assigned factor, and the impedance of the other circuit being smaller than the line impedance by the same factor, and means for providing side-tone from the talking to the listening circuits at said intermediate point.

12. In a transmission line, means for listening and talking into said line at an intermediate point comprising a hybrid coil, transmission lines associated with its line terminals and unequal impedances associated with its other terminals, listening and talking apparatus associated therewith, means for amplifying the talking current before its introduction to the line, means for amplifying the listening current and means for introducing side-tone from the talking apparatus to the listening apparatus.

13. In a transmission line, means for listening and talking into said line at an intermediate point comprising a hybrid coil, transmission lines associated with its line terminals and unequal impedances associated with its other terminals, listening and talking apparatus associated therewith, means for amplifying the talking current before its introduction to the line, means for amplifying the listening current, and means for introducing side-tone from the talking apparatus to the listening apparatus; said

means comprising a voltage-operated device whereby no reaction is produced on the transmission line.

14. In a transmission line, means for listening and talking into said line at the intermediate point, comprising a hybrid coil, a step-down transformer bridged across the midpoints of said coil and a step-up transformer associated with the series winding of said coil, talking apparatus associated with one of these circuits and listening apparatus associated with the other.

15. In a transmission line, means for listening and talking into said line at the intermediate point comprising a hybrid coil, a step-down transformer bridged across the midpoints of said coil, and listening apparatus associated with said transformer, a step-up transformer associated with the series winding of said coil and talking apparatus associated with said transformer.

16. A transmission line, means associated therewith at an intermediate point for listening and talking into said line at that point without materially affecting the direct transmission, said means being adapted to electrically separate the listening and talking circuits, means independent of said line for introducing a desired amount of side tone from the talking circuit to the listening circuit.

In testimony whereof, I have signed my name to this specification this 28th day of September, 1921.

GEORGE CRISSON.