Nov. 18, 1924. 1,515,643

S. B. WRIGHT

TRANSMISSION CIRCUITS

Filed Nov. 3, 1923 2 Sheets-Sheet 1

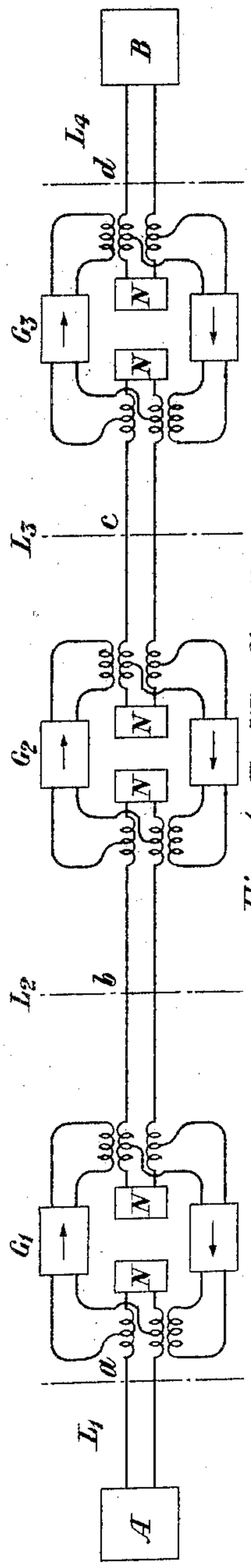

Fig. 1 – Two-Wire Circuit

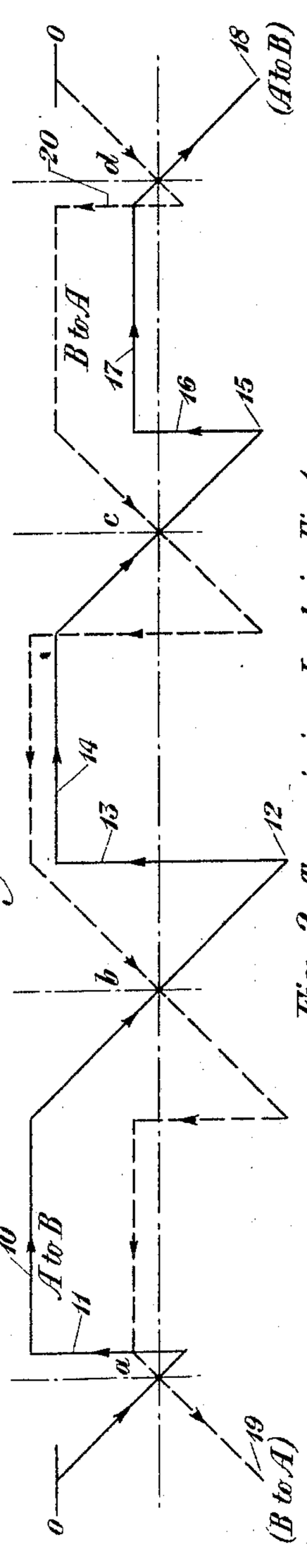

Fig. 2 – Transmission Levels in Fig. 1

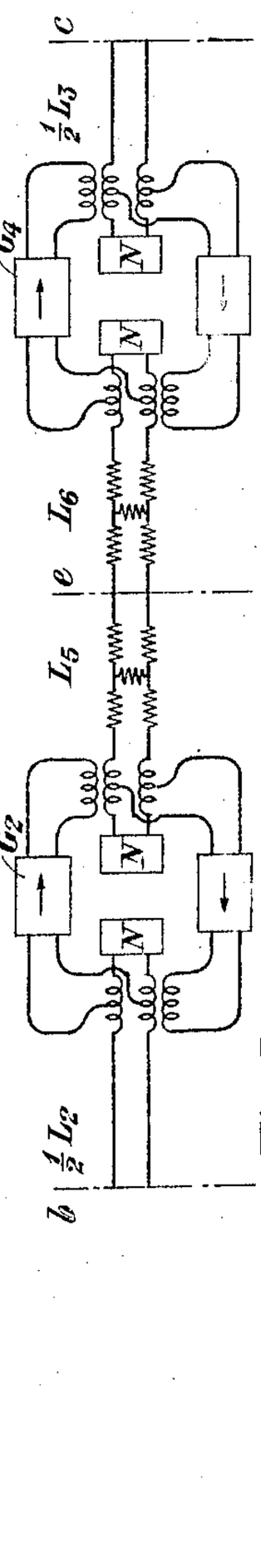

Fig. 3 – Repeater Point with Artificial Line and Compensating Repeater

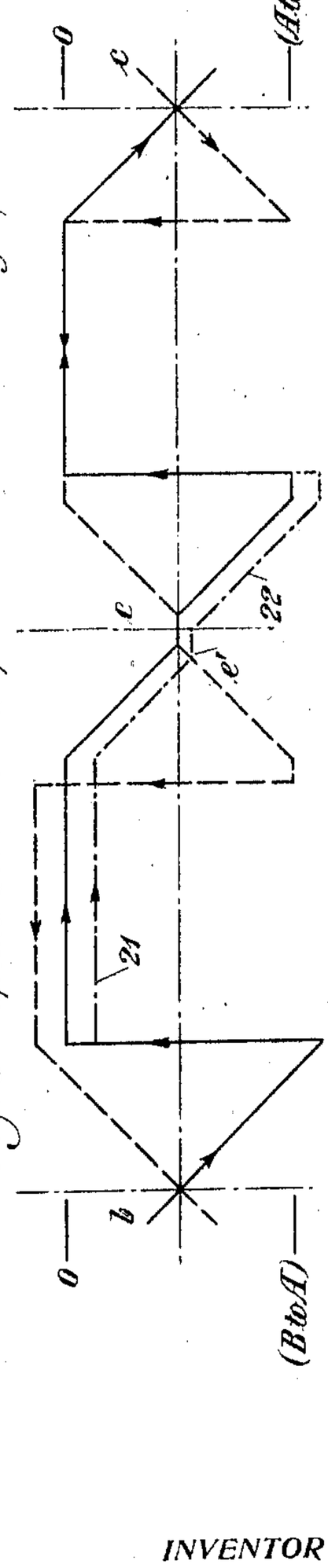

Fig. 4 – Transmission Levels in Fig. 3

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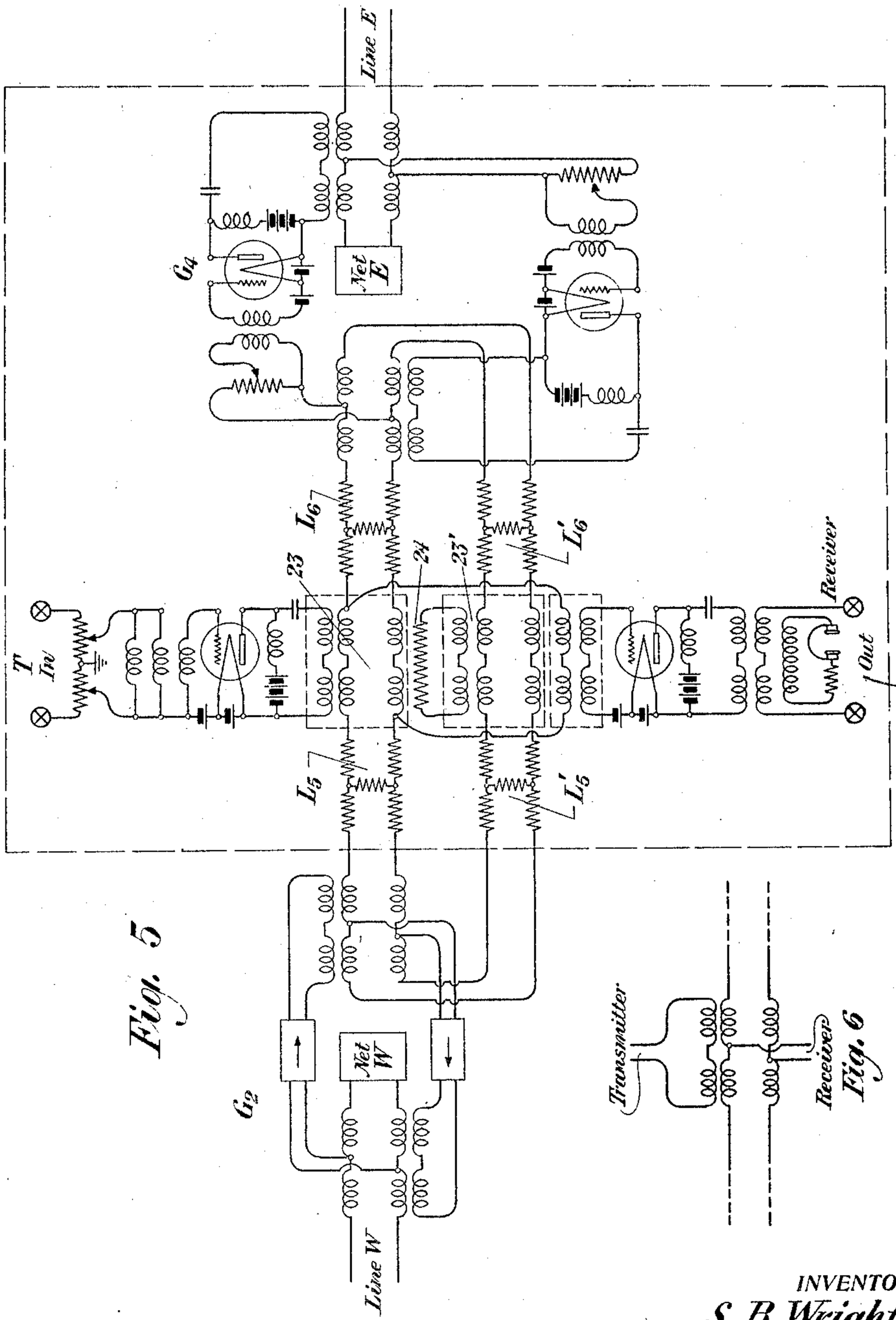

Fig. 5

Fig. 6

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UNITED STATES PATENT OFFICE.

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TRANSMISSION CIRCUITS.

Application filed November 3, 1923. Serial No. 672,535.

To all whom it may concern:

Be it known that I, SUMNER B. WRIGHT, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain Improvements in Transmission Circuits, of which the following is a specification.

This invention relates to transmission circuits and more particularly to transmission circuits equipped with repeaters and arranged so that three or more stations may be simultaneously interconnected for telephonic transmission.

In telephone practice it is sometimes found desirable, especially in connection with public address demonstrations, to interconnect three or more cities simultaneously over a long distance circuit. This involves connecting two of the cities together over a long distance line equipped with telephone repeaters and then bridging a line leading from the third city to the first line at some intermediate point. This problem involves many difficulties, one of the most important of which is that the transmission level varies at different points along the line to which the three-way connection is to be made. In other words, if the amplitude of the current be measured at different points along the line it will be found to vary through wide limits, the amplitude being quite small on the input side of a repeater station and quite large on the output side. Furthermore, since the distances between repeaters vary and since the gains of the repeaters also vary the transmission levels at corresponding points of different repeater stations will be quite different. The result of all this is that rarely or never will it be found that the transmission level will be the same for transmission in the two directions at any repeater station and in order to find a point along the line at which the transmission level in the two directions is the same it will be necessary to go out to some point intermediate between two repeater stations. Since the three-way connection should be made at a point where the transmission level in both directions is substantially the same it follows that in many instances special apparatus would have to be provided at some out of the way point where it would be inconvenient and perhaps inexpedient to establish the connection.

In accordance with the present invention, arrangements are provided whereby a point having the same transmission levels in both directions may be established at a repeater station so that a three-way connection may be set up at such station. It is also an object of the invention to establish such a connection with a minimum amount of apparatus and, so far as possible, without the use of any special equipment other than that ordinarily provided at repeater stations.

The invention may now be more fully understood from the following description when read in connection with the accompanying drawing, in which Figure 1 shows schematically a two-wire repeatered circuit of the type to which the present invention is applied, Fig. 2 is a curve showing the transmission levels at various points along the circuit of Fig. 1, Fig. 3 shows schematically how points of the same transmission level may be produced at a repeater station, Fig. 4 is a curve showing the transmission levels of the apparatus of Fig. 3, Fig. 5 is a circuit diagram showing in some detail how a three-way connection may be established in the circuit of Fig. 3, while Fig. 6 illustrates the method of establishing a three-way connection at an intermediate point between repeater stations.

Referring to Fig. 1, a telephone circuit is shown interconnecting two distant stations A and B by means of line sections L_1, L_2, L_3, and L_4 with two-way repeaters G_1, G_2 and G_3, of the so-called 22-type, in circuit at repeater points between the adjacent line sections. In general the various line sections will be of different lengths or will be of different construction so that the losses due to the various line sections may be different. Furthermore, the gains introduced by the individual repeaters may also be different although, in general, the gain of each individual repeater will be substantially the same in each direction.

In Fig. 2, a transmission level diagram is shown illustrating how the amplitude of the currents transmitted varies at different points along the line in each of the two directions of transmission. The full line curve of Fig. 2 represents the transmission from A to B, while the dotted line curve represents the transmission in the opposite direction. Beginning at station A it will be seen that the current leaves the station at

the normal or so-called zero transmission level and decreases in amplitude until it arrives at the repeater station G_1. At this point a certain amount of gain is introduced, thereby increasing the transmission level to the point 10, the gain introduced being represented by the vertical part of the line at 11. As the current leaves the repeater it begins to decrease in value, due to the attenuation along the line section L_2, until it reaches the point 12 at the repeater station G_2, when the gain represented by the vertical line 13 is introduced and the transmission is brought up to the level indicated at 14. Upon leaving the repeater the transmission level again drops down to a point 15, gain being introduced by the repeater G_3 as indicated at 16 so that the transmission is brought to the level indicated at 17. The current is again attenuated by means of the line section L_4 arriving at the station B with the amplitude indicated at 18. The over-all loss in transmission between stations A and B is represented by the drop in level from the point zero at the left of the curve to the point 18 at the right. The transmission level for transmission in the opposite direction is indicated by the dotted curve, the current starting from the station B with the same amplitude as that starting from station A and arriving at the station A with an amplitude indicated by the point 19, which is at the same level as the point 18 (it being assumed, of course, that the over-all transmission in the two directions is the same).

In the transmission level diagram above plotted it will be observed that the gain of each repeater is assumed to be the same in both directions. For example, the gain of the repeater G_3 in the direction from west to east, as indicated at 16, is equal to the gain of the same repeater in the opposite direction as indicated at 20. In order to make the case general, however, the gains of the three repeaters G_1, G_2 and G_3 are each different and the losses of the various line sections are also made different. The result is that the levels in the two directions at a given repeater point are not the same. For example, the transmission level 10 from west to east at repeater point G_1 is higher than the corresponding level from east to west. On the other hand, the transmission level 14 in the direction from west to east at repeater point G_2 is lower than the corresponding transmission level from east to west. Intermediate between each pair of repeaters, however, a point will be found where the transmission curves for the two directions cross each other and at these points, designated *b* and *c*, the transmission levels are the same in both directions. Similar points occur between each terminal station and the nearest repeater as indicated at *a* and *d*. It will also be observed that under the conditions assumed (each repeater having the same gain in both directions and the losses along the transmission line being uniform), the points along the line at which the transmission level is the same in both directions all lie on the same horizontal line. In other words, the transmission levels at points *a*, *b*, *c* and *d* are equal to each other and are the same in both directions. It will also be observed that the transmission level at these points falls half-way between the initial or zero transmission level and the terminal or final transmission levels, as indicated at 18 and 19.

It will become obvious at once that a three-wire connection may be established at any of the points *a*, *b*, *c* and *d* by the use of an ordinary hybrid coil, as illustrated in Fig. 6. Since the hybrid coil will be inserted at substantially the midpoint of the line section the hybrid connection will be balanced and since the transmission in the two directions is the same at this point the current entering the receiver branch of the three-wire connection will be the same from either station A or station B.

While it is theoretically possible to establish a connection of the kind above indicated the matter involves great practical difficulty by reason of the fact that points such as *a*, *b*, *c* and *d* lie out along the line between repeater stations where facilities for establishing the connection would not ordinarily be present and where the repeating apparatus (which must usually be included in the transmission and receiving branches of the three-way connection) could not well be provided.

Fig. 3 illustrates how a point having the same transmission level in both directions may be established at a repeater station, such as G_2, without the use of equipment other than that ordinarily provided at a repeater station. Referring to this figure, it will be seen that the half of the line section L_2 extending from the point *b* to repeater station G_2 will remain undisturbed and the repeater G_2 will remain in circuit as in Fig. 1, without any change. At the same repeater station, however, a similar repeater G_4 is inserted between the half of the line section L_3 and the repeater G_2, and between the two repeaters a pair of artificial lines L_5 and L_6 are inserted.

The transmission levels between points *b* and *c* in either direction are indicated by the diagram of Fig. 4. The gain of the auxiliary repeater G_4 is made the same in each direction and equal to the loss introduced by the artificial lines L_5 and L_6. Consequently, the transmission curves cross each other at the point *e*, thereby rendering it possible to obtain the same transmission level at this point from both directions, re-

gardless of how much difference there is between the levels in the case shown in Fig. 1. Where the repeater gains are made the same in both directions the two artificial line sections L_5 and L_6 will be equal. Obviously, the level at e may be changed by varying the gains of the two repeaters G_2 and G_4 so that the gain of each repeater in the two directions will be different, although the over-all gain of the two repeaters will be the same in both directions. This is indicated by the curve 21 and 22, indicated in dashed lines in Fig. 4. To obtain this curve the gain of the repeater G_2 transmitting from west to east is made less than the gain transmitting from east to west and the gain of the repeater G_4 transmitting from west to east is proportionately increased, the gain transmitting in the opposite direction remaining the same. The point at which the transmission curves cross each other will now be shifted nearer the repeater G_2 and the transmission level will be lower. In this case, the values of the artificial lines L_5 and L_6 will be proportionately changed so that the point e' will fall between the two artificial line sections. By a similar change in the values of the artificial line and in the gains of the repeaters the transmission level may be shifted in the opposite direction and thus raised.

A three-way connection may be established at the point e or e' by the circuit arrangement shown in Fig. 6, the circuit being shown in more detail in Fig. 5. In Fig. 5, the transmitting branch T of the three-way connection is shown connected through a suitable amplifier to the common level point between the artificial lines L_5 and L_6 by means of a hybrid coil 23. The receiving branch R is bridged across equal potential points of the circuit including the hybrid coil, as indicated, and likewise includes an amplifier. Instead of balancing the artificial lines L_5 and L_6 by balancing networks, as shown at N in Fig. 3, the terminals of the hybrid coils of repeaters G_2 and G_4 may be connected to a circuit, including artificial line sections L_5' and L_6', equal and equivalent to the sections L_5 and L_6. To further insure accurate balance a hybrid coil 23′ may be included between the artificial line sections L_5' and L_6' and an impedance 24, equivalent to the impedance looking into the transmitter circuit from the hybrid coil 23, may be included in circuit with the third winding of the hybrid coil 23′.

The introduction of the auxiliary repeater G_4 causes no additional unbalance nor time lag to the repeatered circuits since very good balances may be obtained at the points where the artificial lines are connected. Furthermore, transmission across the hybrid coil 23, which serves to connect the four wire loops, will be negligible because the two sides of the artificial line connected to this transformer balance each other. The regular 22-type repeater may be used at G_2 with all its talking facilities unchanged. The additional or auxiliary repeater G_4 may consist only of the bare elements of a repeater or it may be a spare standard 22-type repeater which is usually available at a repeater office. The gains in the two directions through the regular and auxilary repeaters need not be equal as there is no tendency to feed-back and therefore no necessity to balance out local transmission.

It will 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. An arrangement for establishing a three-way connection at a repeater point on a two-wire repeatered circuit comprising artificial lines included in the transmission circuit for producing a loss at the repeater point, and an auxiliary repeater having gains sufficient to make up for the loss introduced by the artificial line sections, and means to associate a three-way connection with the transmission circuit at a point between the artificial line sections such that the transmission level is substantially the same in both directions.

2. An arrangement for establishing a three-way connection at a repeater point on a two-wire repeatered circuit comprising artificial lines included in the transmission circuit for producing a loss at the repeater point and an auxiliary repeater having gains sufficient to make up for the loss introduced by the artificial line sections, and means to associate a three-way connection with the transmission circuit at a point between the artificial line sections such that the transmission level is substantially the same in both directions, said means comprising a hybrid coil introduced between the artificial line sections and transmitting and receiving branches conjugately related to the hybrid coil.

3. An arrangement for establishing a three-way connection at a repeater point on a two-wire repeatered circuit, comprising artificial line sections and an auxiliary repeater connected in tandem with the regular repeater at the repeater point between said repeater and one of its adjacent line sections, the gain of the auxiliary repeater being substantially equal to the total loss introduced by the artificial line sections, and means to establish a three-way connection at a point between adjacent artificial line sections having the same transmission level in both directions.

4. An arrangement for establishing a

three-way connection at a repeater point on a two-wire repeatered circuit, comprising artificial line sections and an auxiliary repeater connected in tandem with the regular repeater at the repeater point between said repeater and one of its adjacent line sections, the gain of the auxiliary repeater being substantially equal to the total loss introduced by the artificial line sections, and means to establish a three-way connection at a point between adjacent artificial line sections having the same transmission level in both directions, said means comprising a hybrid coil introduced between said adjacent artificial line sections and transmitting and receiving branches associated with said hybrid coil in substantially conjugate relation with respect to each other.

In testimony whereof, I have signed my name to this specification this 2nd day of November, 1923.

SUMNER B. WRIGHT.