

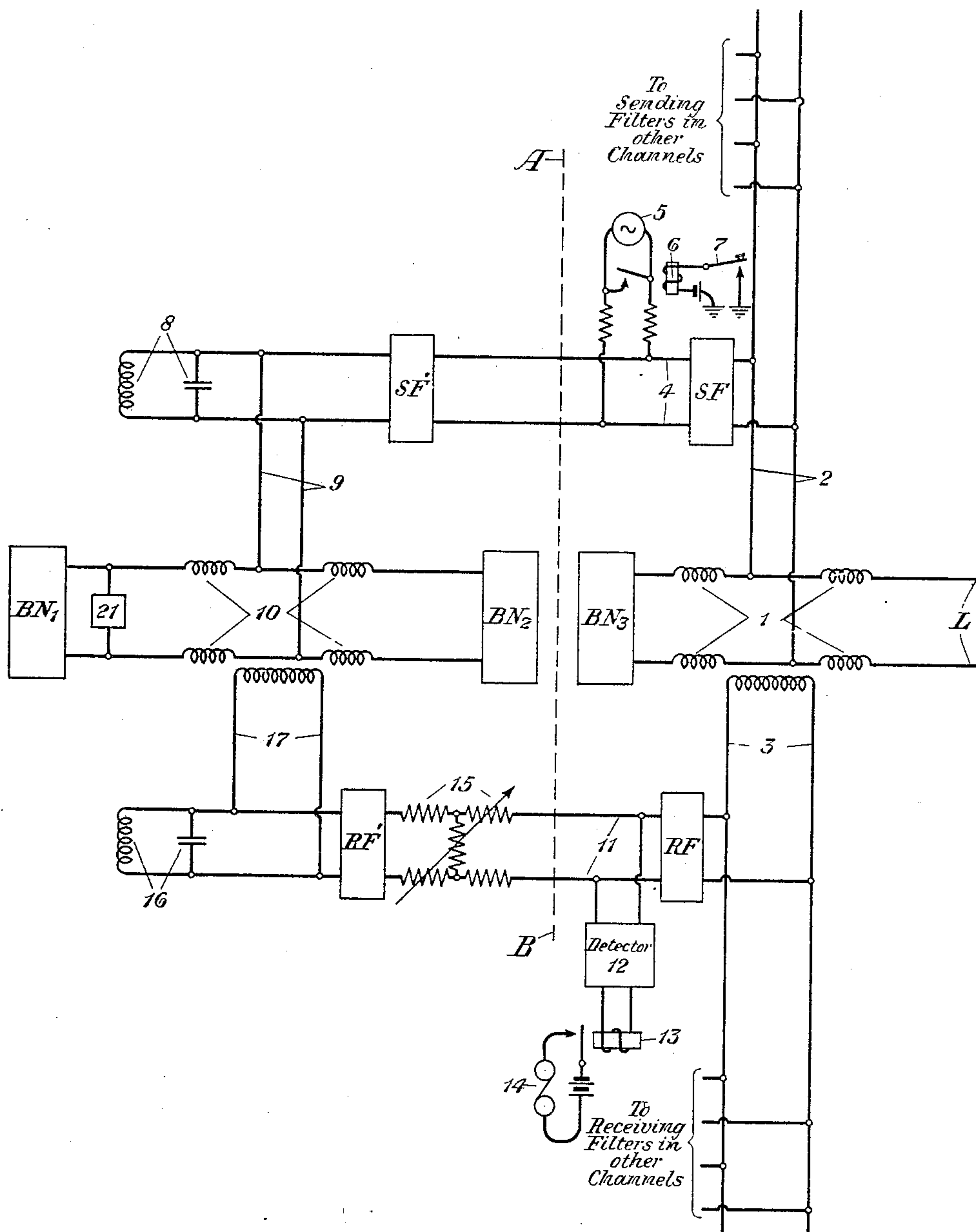
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TRANSMISSION LINE

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TRANSMISSION LINE

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This invention relates to transmission systems, and more particularly to a method of and means for obtaining separation between incoming and outgoing signals applied to the lines of such systems.

A transmission line over which signals are being applied in both directions may be terminated at a central office in a balancing network and may include the windings of a hybrid coil. Associated with the windings of the hybrid coil might be an incoming or receiving circuit and an outgoing or transmitting circuit. It is well known in the art that if the balancing network balances the line perfectly, there would be perfect separation between the incoming and outgoing signals and no interference would result. However, in certain instances it may not be practical from commercial or other standpoints to construct a network which will substantially or exactly balance the transmission line, and the primary object of the invention is to provide a means for obtaining the desired separation between incoming and outgoing signals under such instances.

An illustration of an instance wherein the arrangements of the invention would be desirable would be in connection with a transmission line, such as a loaded cable, over which carrier currents are utilized to transmit telegraph signals. The cable would terminate in a balancing network in the usual manner, but it is probable that the ordinary network would not exactly balance the cable, principally for the reason that the cable might not be uniform in structure and, as a result, there would be reflections from the various irregularities which would give rise to an unbalance current, which might result in imperfect separation between the incoming and outgoing currents. An obvious way of overcoming this drawback would be to modify the balancing network so that it would simulate the line impedance. However, to do this over a large frequency range it is necessary to effectively duplicate the line by means of an artificial line or network, which simulates the real line in its propagation characteristics as well as in its characteristic impedance. While such a solution is possible, nevertheless

it would lead to the construction of a very elaborate balancing network. The arrangements of the invention provide a solution of the problem which does not involve the construction of an elaborate balancing network.

In the arrangements of the invention an auxiliary circuit is provided between the incoming and outgoing circuits connected to the transmission line. The paths of this auxiliary circuit are interconnected by a hybrid coil having its windings balanced to the same degree as the windings of the hybrid coil in the transmission line. A condition of unbalance in the auxiliary circuit is thus obtained which simulates the condition of unbalance between the incoming and outgoing circuits and the effect of unbalance currents between said circuits will be prevented by the unbalance currents in the auxiliary circuit.

While reference has been had to cable circuits and to the use in connection therewith of carrier currents for telegraph purposes, it is pointed out that this reference has been for purposes of illustration only, and that the arrangements of the invention are applicable to other types of transmission systems. Further objects and features of the invention will appear more fully from the detailed description thereof hereinafter given.

The invention may be more fully understood from the following description, together with the accompanying drawing in the figure of which is illustrated a preferred form of the invention.

In the drawing the invention is shown in connection with a transmission system in which carrier currents are utilized for telegraph signalling purposes. A transmission line L is shown terminating in a balancing network BN, and including the windings of a hybrid coil 1. Connected to the mid-points of the windings of the hybrid coil would be a transmitting circuit 2 common to a number of individual transmitting circuits. Only one of these circuits, namely the circuit 4, is shown in detail. The circuit 4 would include a filter SF and a circuit including a source 5 of carrier frequency. The application of current from this source to the line

would be controlled by a relay 6 and a telegraph key 7. Connected to one of the windings of the hybrid coil is an incoming or receiving circuit 3 which is common to a number of individual receiving circuits such as 11. The circuit 11 would include a filter RF, a detector 12, and a relay 13 associated therewith. The relay 13 would control the operation of a sounder 14. The arrangements heretofore described are old in the art. If the network BN_3 exactly balanced the line L, currents transmitted from the circuit 2 to the line L would not affect the incoming or receiving circuit 3. Furthermore, currents coming in over the line L would be transmitted to the circuit 3 and operate the receiving apparatus. Part of the current would also enter the circuit 2 and would be dissipated in the sending circuits 4 and 9, only a negligible portion reaching the receiving detector 12 through the hybrid coil 10. However, as has been pointed out, a perfect condition of balance may not exist between the network BN_3 and line L, particularly if the line L is a circuit of the type of a loaded cable. If a condition of balance does not exist between the network BN_3 and the line L, unbalance currents will arise in the windings of hybrid coil 1 and a perfect separation between incoming and outgoing signals will not be attained.

In accordance with the arrangements of this invention, the apparatus to the left of the dotted line AB is added to the usual terminal arrangements of the line L. The circuit 4 would include a filter SF' similar to the filter SF, and would be connected to a circuit 9 connected to the mid-points of the windings of hybrid coil 10. The circuit 11 would include a filter RF' similar to the filter RF, and would be connected to the circuit 17 connected to one of the windings of the hybrid coil 10. The windings of the hybrid coil 10 would be connected to the balancing networks BN_1 and BN_2 . The networks BN_1 and BN_2 would be made equal to each other and one of them, such as BN_1 , would be built out by means of an auxiliary network, such as 21, so that a degree of unbalance between the windings of hybrid coil 10 would be caused to exist, which would simulate the degree of unbalance existing between the windings of the hybrid coil 1. By this means the auxiliary path between circuits 4 and 11 would be so designed that the current transmitted through it would be substantially equal to and of opposite phase to the unbalance current arising from a condition of imperfect balance between the line L and the balancing network BN_3 . The current transmitted through this auxiliary path would thus neutralize the effect of unbalance currents arising in the windings of the hybrid coil 1.

Not only must the unbalance in the two paths be equal but also the attenuation, phase

shift, and delay in the filters. For this reason the reactances 8 and 16 are included in the circuits 4 and 11, respectively, to balance the impedance of the channel filters in the frequency range involved. Also, a variable attenuator line 15 is shown in one of the portions of the auxiliary circuit, such as in circuit 11.

Auxiliary circuits substantially similar to the one heretofore described would be included between each individual transmitting circuit and its corresponding receiving circuit.

While the invention has been disclosed as embodied in certain specific arrangements which are deemed desirable, it is understood that it is capable of embodiment in many and other widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. A transmission line terminating in a hybrid coil and a balancing network, a transmitting circuit and a receiving circuit connected to the windings of said hybrid coil, and an auxiliary circuit connecting said transmitting circuit with said receiving circuit, said auxiliary circuit being so designed that the currents transmitted therethrough will be substantially equal to currents arising due to a condition of unbalance between said transmission line and said balancing network.

2. A transmission line terminating in a hybrid coil and a balancing network, a transmitting circuit and a receiving circuit connected to the windings of said hybrid coil, and an auxiliary circuit connecting said transmitting circuit with said receiving circuit, said auxiliary circuit being so designed that the currents transmitted therethrough will be substantially equal to and will oppose the currents which might be transmitted from said transmitting circuit to said receiving circuit through said hybrid coil due to a condition of unbalance between said transmission line and its balancing network.

3. A transmission line terminating in a balancing network, transmitting and receiving circuits connected to said line in a condition approaching conjugacy, and an auxiliary circuit interconnecting said transmitting and receiving circuits, said auxiliary circuit comprising two paths connected to each other in a relation of balance substantially similar to the existing relation to balance between said transmitting and receiving circuits.

4. A transmission line terminating in a hybrid coil and a balancing network, transmitting and receiving circuits connected to said hybrid coil, auxiliary circuits connected to said transmitting and receiving circuits, and means for connecting said auxiliary circuits together, said last mentioned means

comprising means for simulating a condition of balance between said auxiliary circuits similar to the condition of balance existing between said transmitting and receiving circuits.

5 5. A transmission line terminating in a hybrid coil and a balancing network, transmitting and receiving circuits connected to the windings of said hybrid coil, and an
10 auxiliary circuit interconnecting said transmitting and receiving circuits, said auxiliary circuit including a translating device whereby the current flow in said auxiliary circuit may be controlled.

15 6. A transmission line terminating in a hybrid coil and a balancing network, transmitting and receiving circuits connected to the windings of said hybrid coil, and an
20 auxiliary circuit interconnecting said transmitting and receiving circuits, said auxiliary circuit comprising two paths interconnected by a hybrid coil having its windings balanced to a degree similar to the degree of
25 balance existing in said first mentioned hybrid coil connection.

30 7. A transmission line terminating in a hybrid coil and a balancing network, transmitting and receiving circuits connected to the windings of said hybrid coil, auxiliary
35 circuits connected to said transmitting and receiving circuits, a second hybrid coil having its windings connected to said auxiliary circuits, and balancing networks connected to
40 said second hybrid coil.

45 8. A transmission line terminating in a hybrid coil and a balancing network, transmitting and receiving circuits connected to the windings of said hybrid coil, auxiliary
50 circuits connected to said transmitting and receiving circuits, a second hybrid coil having its windings connected to said auxiliary
55 circuits, balancing networks connected to said second hybrid coil, and means for adjusting the constants of one of said last
60 mentioned networks.

9. A transmission line terminating in a hybrid coil and a balancing network, a transmitting circuit and a receiving circuit connected to the windings of said hybrid coil, a
50 plurality of individual transmitter circuits connected to said transmitting circuit, filters in each of said individual transmitter circuits, a plurality of individual receiver circuits connected to said receiving circuit, fil-
55 ters in each of said individual receiver circuits, and auxiliary circuits connecting each of said individual transmitter circuits with its corresponding individual receiver circuit, and means in each of said auxiliary circuits
60 for establishing a condition of balance therein like unto the condition of balance existing between said first mentioned transmitting and receiving circuits.

10. A transmission line terminating in a
65 hybrid coil and a balancing network, a trans-

mitting circuit and a receiving circuit connected to the windings of said hybrid coils, selective means in said transmitting and said receiving circuits, an auxiliary circuit inter-
70 connecting said transmitting and said receiving circuits, said auxiliary circuit comprising two branches interconnected through the windings of a hybrid coil, means for balancing the windings of said hybrid coil to a degree similar to that existing between the
75 windings of said first mentioned hybrid coil, and a variable attenuator included in one of the branches of said auxiliary circuit.

11. A transmission line terminating in a hybrid coil and a balancing network, a trans-
80 mitting circuit and a receiving circuit connected to the windings of said hybrid coils, selective means in said transmitting and said receiving circuits, an auxiliary circuit inter-
85 connecting said transmitting and said receiving circuits, said auxiliary circuit comprising two branches interconnected through the windings of a hybrid coil, means for balancing the circuits including the windings of
90 said second hybrid coil to a degree similar to that existing between the circuits including the windings of said first mentioned hybrid coil, a variable attenuator included in one of the branches of said auxiliary circuit, and
95 reactance devices in each of the branches of said auxiliary circuit to balance the impedance of said selective means.

In testimony whereof, I have signed my name to this specification this 18th day of
100 May, 1931.

HARRY NYQUIST.

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