Aug. 15, 1939. H. KIMMEL 2,169,360

TRANSMISSION LINE

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Fig. 1

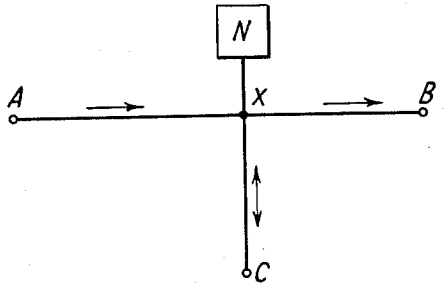


Fig. 2

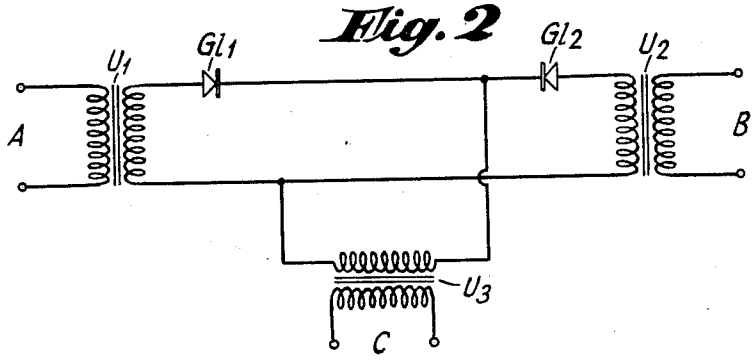
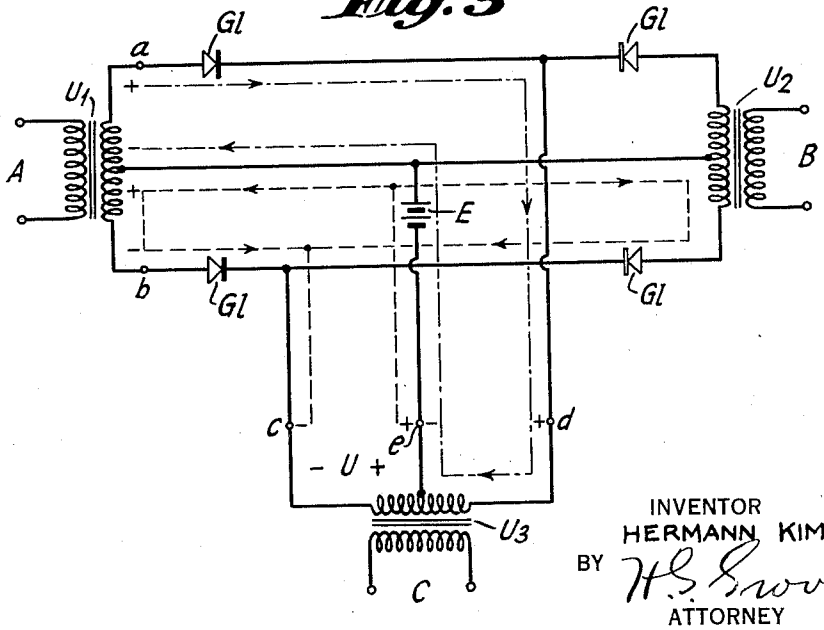


Fig. 3



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Fig. 4

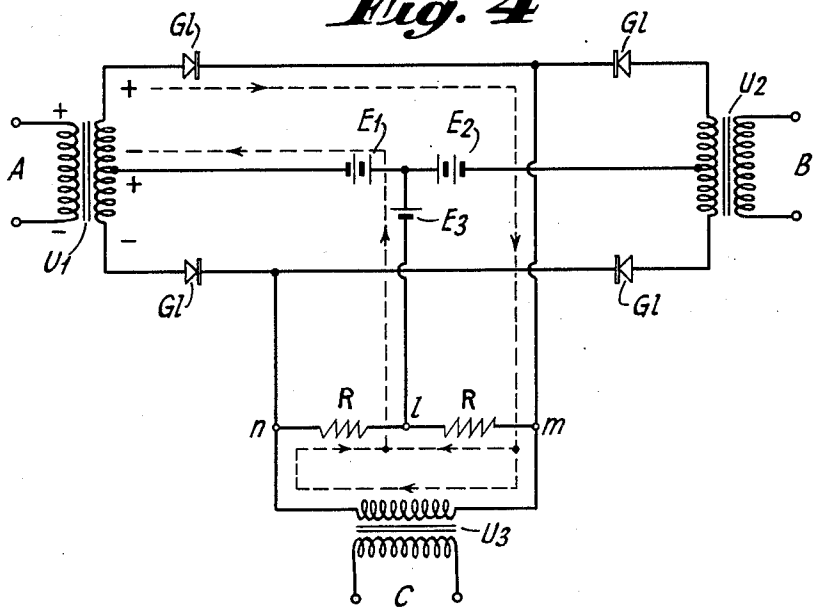


Fig. 5

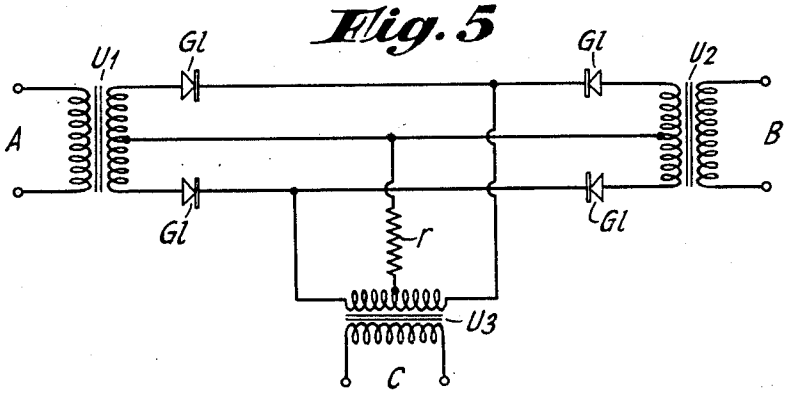
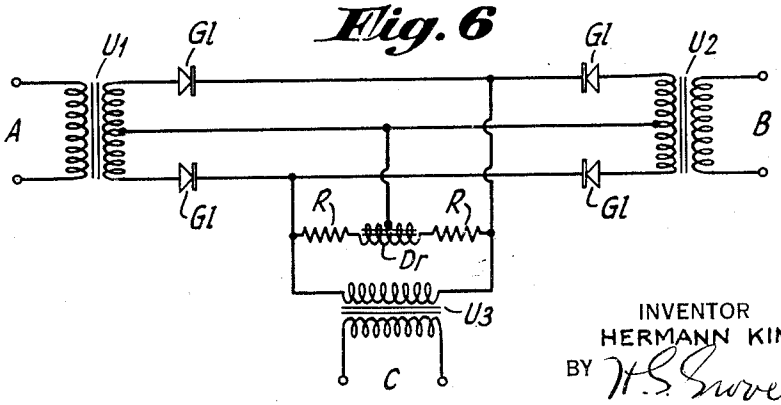


Fig. 6



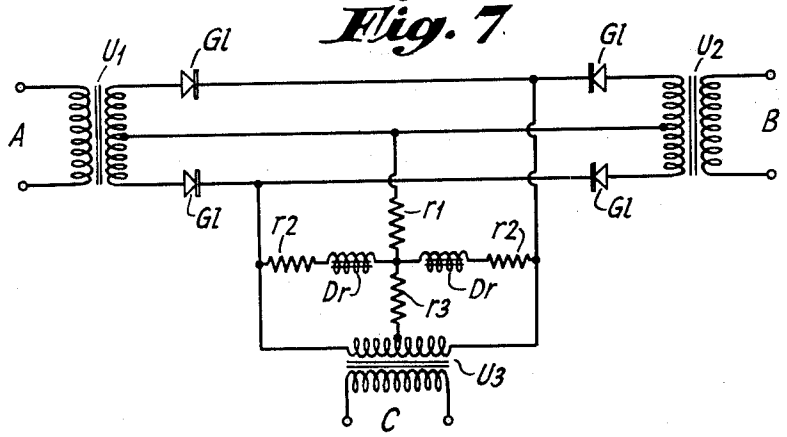
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TRANSMISSION LINE

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Fig. 7



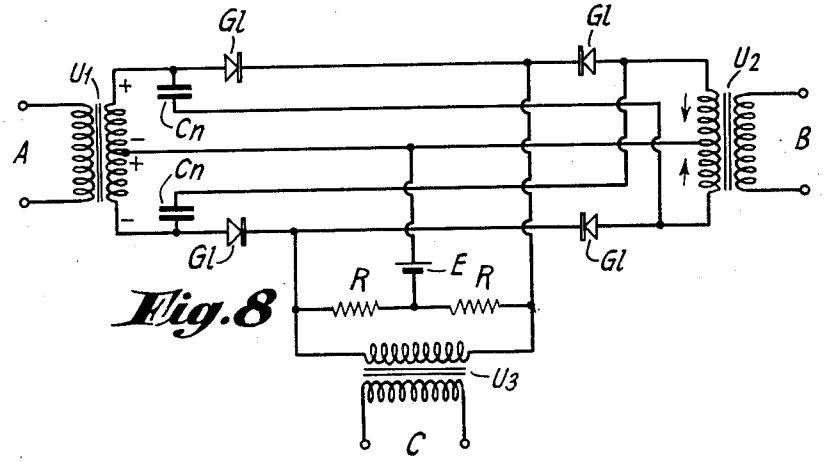
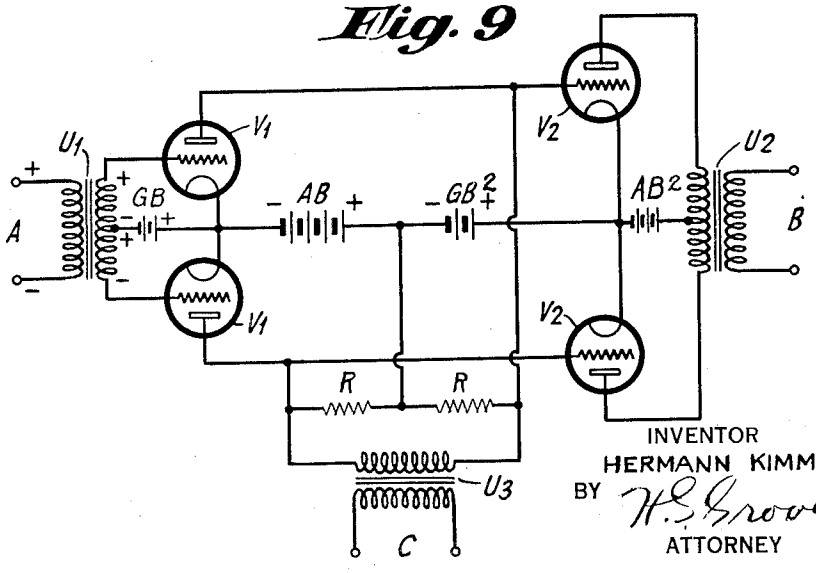


Fig. 8

Fig. 9



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Patented Aug. 15, 1939

2,169,360

UNITED STATES PATENT OFFICE

2,169,360

TRANSMISSION LINE

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Application August 12, 1937, Serial No. 158,729
In Germany August 13, 1936

11 Claims. (Cl. 178—44)

In communication transmission systems the problem is often encountered to connect a two-wire line with a four-wire system. The connection circuit must be such that on the one hand a transmission is possible from the two-wire line into a transmission path of the four-wire system, and on the other hand, from the other transmission path of the four-wire system into the double wire line, but not a transmission from the one transmission path of the four-wire system to the other one.

In the practical embodiment of the systems this problem is solved with the aid of the known bridge circuit.

The following detailed description is accompanied by drawings in which Figures 1 and 2 are circuit diagrams used in explaining the principles of my invention; Figure 3 is a circuit diagram of the embodiment of my invention, while Figures 4, 5, 6, 7, 8 and 9 show modifications thereof.

Referring, now, to Figure 1, which shows schematically the bridge circuit used in solving the above mentioned problem, C indicates the two wire line over which intelligence is transmitted in both directions, as indicated by the arrows. Items A and B designate the receiving and transmitting branch, respectively, of the four-wire system, of which A represents, for instance, the output of the receiving amplifier, and B the input of the transmitter amplifier. The bridge circuit is indicated by the connection point X. As is shown, transmission from A to B can, in this circuit, be prevented only if the resistance of the line connected at C is exactly imitated by the member N. However, an exact reproduction is not in all cases possible with economical means. The value of the damping from A to B (so-called damping of the fork error) therefore will depend on the quality of the respective reproduction. This is a serious disadvantage especially notable if the fork type circuit is to be connected to double wire lines having different apparent resistance.

Fig. 2 shows such fork type circuit which was used in attempting to solve the aforementioned problem without dependence on the imitation of the two-wire line. The reference characters A, B and C refer to the same parts as those in Fig. 1 and this is also the case in the following figures. Hence, it is always required that energy be transmitted from C to B, and also from A to C without energy passing from A to B. Items Gl_1 and Gl_2 are circuit elements having a resistance dependent on the direction of current flow such as dry contact rectifiers, for instance, inserted in such manner into a connection line of the two transformers U_1 and U_2 that they permit passage of current in opposite directions. A transmission from A to B may in this way be suppressed while permitting the simultaneous transmission from A to C. However, it was found that this circuit is not suited to fulfill the above requirement. The signals arriving from the receiving branch A cause a wave current in the circuit Gl_1U_3 composed of an alternating current component and a direct current component. The direct current component will be short circuited by the low ohmic resistance of the transformer U_3. The alternating current component produces at U_3 an alternating voltage proportional to the impedance. At the terminals of the transformer U_3 there exists practically a pure alternating voltage applied to B across Gl_2.

This disadvantage is eliminated in accordance with the invention if the dimensioning of the input resistance of the two-wire line and its coupling is so chosen that the currents arriving across the circuit elements of the receiving branch which are dependent on direction, produce a direct voltage drop at the input resistor of the two-wire line, and which at any time furnishes a bias potential for the circuit elements of the transmission branch which depend on direction, such that the latter are practically impervious to the arriving alternating currents.

The push-pull circuit eliminates also a further disadvantage of the circuit shown in Fig. 2, in that only an alternating current is transmitted, and the noise factor is correspondingly reduced.

As circuit elements having a resistance dependent upon direction of current flow, dry contact rectifiers whose working point can be chosen within the region of highest rectification action by means of an additional bias potential are most desirable. By a proper dimensioning of the bias potential a filtering of small amplitudes can be carried out at the same time which is of importance to the stability of the transmission system in the non-modulated state. In order to reduce errors caused by the curvatures of the rectifier characteristics, it is advisable to choose the amplitudes applied to the fork type circuit which are above the range of the high initial curvature of the rectifier characteristics.

In place of dry contact rectifiers under certain conditions tube rectifiers may have advantages since the latter have a lower natural capacity and when using triodes they furnish an additional amplifying action.

The rectifier characteristics may also be varied to approach an ideal bend characteristic by means of known linearity methods.

Other particulars of the idea of the invention will be elucidated in connection with examples of construction represented in the Figs. 3 to 9.

In Fig. 3, there is shown a construction of the fork type circuit in a push pull arrangement. The ends of the windings of the transformers U_1 and U_2 connected to the transmission paths A and B are connected across two respective rectifiers *Gl* placed in series and arranged to permit the passage of current in opposite directions. The transmitter U_3 of the two-wire line is connected with its secondary side between the rectifiers. With the battery E, said rectifiers can have imparted thereto across the common connection of the center taps of all transformers the bias potential that is most favorable to a maximum rectification effect. If a direct potential is applied to the terminals *a*, *b* of the circuit Fig. 3, then the current passes for a certain polarity of the direct potential in the manner shown by the dash lines. Correspondingly, the current passage in the circuit shown in dotted lines is for a certain polarity of a direct potential applied to the terminals *e*, *d*. In both cases, a similar condition exists for the other polarity of the direct potential. The current passing in the fork type circuit thus takes different paths within the fork type circuit in accordance with the respective polarity of the applied voltage. The circuit operates in such manner that the transmission takes place in the sense of the above stated requirements, i. e., when applying direct potentials having either polarity, the rectifiers appertaining to the circuit of U_2 prevent passage of current through the whole primary.

If an alternating potential is applied in A, then the current passage through the right half of the secondary winding of the transformer U_3 induces a voltage U in the left half of the winding. This voltage is so directed that a current passes through the lower winding half of U_2 and through the rectifier *Gl* at the lower right. Thus, an undesirable transmission from A to B takes place.

While in order to eliminate this undesirable transmission from A to B, it is necessary in the circuit shown in Fig. 2 to utilize a two-wire line whose apparent resistance has the effect of a circuit consisting of ohmic resistors and condensers, or combinations thereof, in the push-pull arrangement of the fork type circuit shown in Figure 3 it is possible to avoid a transmission from A to B for any desired construction of two-wire line. Through the push-pull arrangement, it is possible so to couple the twin wire line to the fork type circuit that a direct voltage drop appears at its input impedance which at any time supplies the circuit elements of the transmitter branch which depend on direction, with such bias potential that the said elements practically block the arriving alternating current. Thus, it is possible in the push-pull arrangement, for instance, to connect the twin wire line to the fork type circuit by means of a transformer such as is principally impossible in the simple circuit shown in Fig. 2.

The Figs. 4 to 9 show push-pull arrangements so adapted that the undesirable transmission from A to B explained with reference to Fig. 3 can no longer take place, while at the same time any desired twin wire line can be connected to the fork type circuit.

In Fig. 4, the center tap of the transformer U_3 is substituted by a resistor RR tapped at the center. The current passage shown in dotted lines is for a certain incidental value of the alternating potential applied in A. It is seen that the point *l* is always negative relative to the points *m* and *n*, so that the rectifiers *Gl* near the transformer U_2 never let current pass through. The common bias potential of all rectifiers is replaced by several bias potentials E_1, E_2 and E_3. The bias potentials afford the setting of different working points of the rectifiers.

The Figs. 5 to 7 show examples of constructions in principle functioning in the same manner as the circuit according to Fig. 4. They differ from this circuit simply by another connection of the center line to the secondary winding of the transformer of the twin wire line.

In Fig. 5, the center line is connected to the secondary winding of he transformer U_3 through the resistor *r*.

In the circuit according to Fig. 6 in place of the ohmic parallel resistors shown in Fig. 4, there is employed a series connection formed of the two ohmic resistors R and the choke *Dr* having a center tap.

Fig. 7 shows a combination of the solutions shown in the Figs. 4 to 6. Aside from the two choke coils *Dr*, four ohmic resistors r_1—r_3 are employed.

Fig. 8 shows a fork type circuit having additional capacities *Cn* inserted in such manner that additional currents are produced which compensate the error currents due to the natural capacities of the rectifiers. If, for instance, owing to the voltage having the polarity indicated at the secondary winding of the transformer U_1, a current would be produced passing through the upper half of the primary winding of the transformer U_2 in the direction of the arrow across the natural capacities of the rectifiers, the same voltage would produce across the upper condenser *Cn* at suitable dimensioning of the latter, a current of equal value but opposite direction passing through the lower half of the primary winding of the transformer U_2. Due to the symmetrical construction of the transformer the currents cancel each other so that a transmission to B cannot take place.

Fig. 9 shows a circuit having electron tubes in place of dry contact rectifiers. The functioning is in principle the same as in the hitherto described circuits. Items V_1 and V_2 are push-pull amplifiers both functioning as so-called class B= (or class C=) amplifiers. This signifies that the working point of the tubes is so chosen that they operate at the lower bend of the grid voltage-plate current characteristics. Grid bias for tubes V_1 is supplied from battery GB and for tubes V_2 by battery GB^2. Plate potential for tubes V_1 is supplied from battery AB and for tubes V_2 from battery AB^2. If, for instance, the modulation is carried out from A, then in accordance with the indicated, instantaneous values of the alternating voltage that happens to be applied, the grid of the lower tube of the amplifier V_1 will be shifted into the negative, and the tube remains without plate current, whereas only the upper tube will be controlled since it has the positive alternation applied thereto. Consequently, the grid of the upper tube of V_2 will be displaced into the negative region so that the conditions in the plate circuit of this tube remain the same. The same is true in the plate circuit of the lower tube of V_2, since in fact the lower tube of the amplifier V_1 remains without

plate current. Energy originating at A can therefore not be transmitted to B, although to C across U_3. At modulation from C, transmission takes place as hitherto to B.

What is claimed is:

1. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers each having a center-tapped winding, a connection between said center-taps and means connecting the corresponding ends of said windings together, each of said means including a pair of rectifiers connected in series, a third transformer having its primary connected to said two wire line and a secondary, a connection between each end of said secondary to said means between said rectifiers, and means effectively connecting said center-tap connection to the electrical center of said secondary.

2. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers each having a winding connected to one of said branches and each having a center-tapped second winding, a connection between said center-taps and means connecting the corresponding ends of said second windings together, each of said means including a pair of rectifiers connected in series, a third transformer having its primary connected to said two wire line and a secondary, a connection from each end of said secondary to said means between said rectifiers, and means effectively connecting said center-tap connection to the electrical center of said secondary.

3. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers, each having a winding connected to one of said branches and each having a center-tapped second winding, a connection between said center-taps and means connecting the corresponding ends of said second windings together, each of said means including a pair of rectifiers connected in series, a third transformer having its primary connected to said two wire line and a secondary, a connection from each end of said secondary to said means between said rectifiers, and means effectively connecting said center-tap connection to the electrical center of said secondary, said last mentioned means including a pair of resistances connected in series across said secondary and a connection between their junction to said center-tap connection.

4. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers, each having a winding connected to one of said branches and each having a center-tapped second winding, a connection between said center-taps and means connecting the corresponding ends of said second windings together, each of said means including a pair of rectifiers connected in series opposition, a third transformer having its primary connected to said two wire line and a secondary, a connection from each end of said secondary to said means between said rectifiers, and means effectively connecting said center-tap connection to the electrical center of said secondary, said last mentioned means including a pair of resistances connected in series across said secondary and a connection between their junction to said center-tap connection.

5. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers, each having a winding connected to one of said branches and each having a center-tapped second winding, a connection between said center-taps and means connecting the corresponding ends of said second windings together, each of said means including a pair of rectifiers connected in series opposition, a third transformer having its primary connected to said two wire line and a center-tapped secondary, a connection from each end of the secondary to said means between said rectifiers and means connecting the center-tap of said secondary to said beforementioned center-tap connection.

6. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a first transformer having its primary connected to said transmission branch and a center-tapped secondary, a pair of thermionic discharge tubes each having a grid, a cathode and a plate, said pair of tubes having their grids connected to the ends of said secondary and their cathodes connected together, a second similar pair of thermionic discharge tubes having their grids connected to the plates of said first mentioned pair and their cathodes connected together, a second transformer having a center-tapped primary, the secondary of said second transformer connected to said reception branch and the ends of said primary connected to the plates of said second pair of tubes, a connection including a tapped source of potential from the center-tap of said first transformer to the center-tap of said second transformer and connections from the cathodes of each of said pairs of tubes to taps on said source of potential, a third transformer having its primary connected to said two wire line and its secondary connected to the plates of said first mentioned pair of tubes, a pair of resistances connected in series across said last mentioned secondary and a connection between their junction and an intermediate tap in said source of potential.

7. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers, each having a center-tapped winding, a connection between said center-taps and means connecting the corresponding ends of said windings together, each of said means including a pair of rectifiers connected in series, a third transformer having its primary connected to said two wire line and a secondary, a connection between each end of said secondary to said means between said rectifiers, and means effectively connecting said center-tap connection to the electrical center of said secondary, said last mentioned means including a source of potential.

8. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers, each having a winding connected to one of said branches and each having a center-tapped second winding, a connection between said center-taps and means connecting the corresponding ends of said second windings together, each of said means including a pair of rectifiers connected in series, a third transformer having its primary connected to said two wire line and a secondary, a connection from each end of said secondary to said means between said rectifiers, and means effectively connecting said center-tap connection to the electrical center of said secondary, said last mentioned means including a series resistance.

9. A circuit for connecting a two wire line to

transmission and reception branches of a four wire system comprising a pair of transformers, each having a winding connected to one of said branches and each having a center-tapped second winding, a connection between said center-taps and means connecting the corresponding ends of said second windings together, each of said means including a pair of rectifiers connected in series, a third transformer having its primary connected to said two wire line and a secondary, a connection from each end of said secondary to said means between said rectifiers, and means effectively connecting said center-tap connection to the electrical center of said secondary, said last mentioned means including a pair of impedances connected in series across said secondary and a source of potential connected between their junction and said center-tap connection.

10. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers, each having a winding connected to one of said branches and each having a center-tapped second winding, a connection between said center-taps and means connecting the corresponding ends of said second windings together, each of said means including a pair of rectifiers connected in series opposition, a third transformer having its primary connected to said two wire line and a secondary, a connection from each end of said secondary to said means between said rectifiers, means effectively connecting said center-tap connection to the electrical center of said secondary, said last mentioned means including a pair of resistances connected in series across said secondary, and a connection between their junction to said center-tap connection, and condensers connected from one end of each center-tapped winding to the opposite end of the other winding.

11. A circuit for connecting a two wire line to transmission and reception branches of a four wire system comprising a pair of transformers, each having a winding connected to one of said branches and each having a center-tapped second winding, a connection between said center-taps and means connecting the corresponding ends of said second windings together, each of said means including a pair of rectifiers connected in series opposition, a third transformer having its primary connected to said two wire line and a center-tapped secondary, a connection from each end of the secondary to said means between said rectifiers and means connecting the center-tap of said secondary to said beforementioned center-tap connection, said last mentioned means including a source of potential.

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