Sept. 3, 1935. H. T. FRIIS 2,013,140

TRANSLATING CIRCUIT

Filed Sept. 16, 1932

FIG. 1

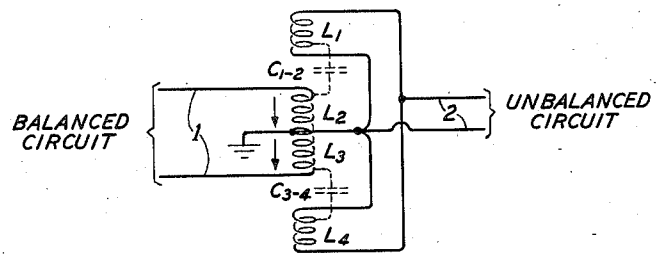


FIG. 2

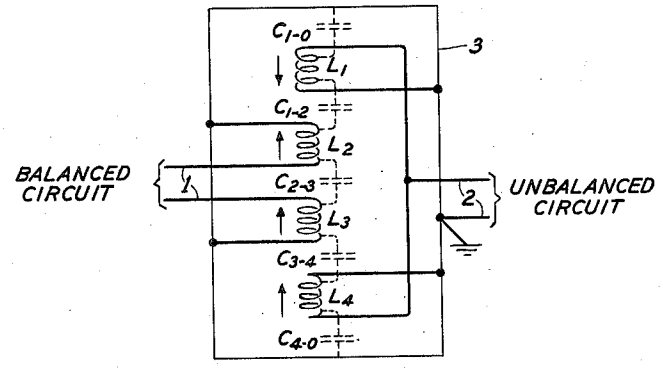
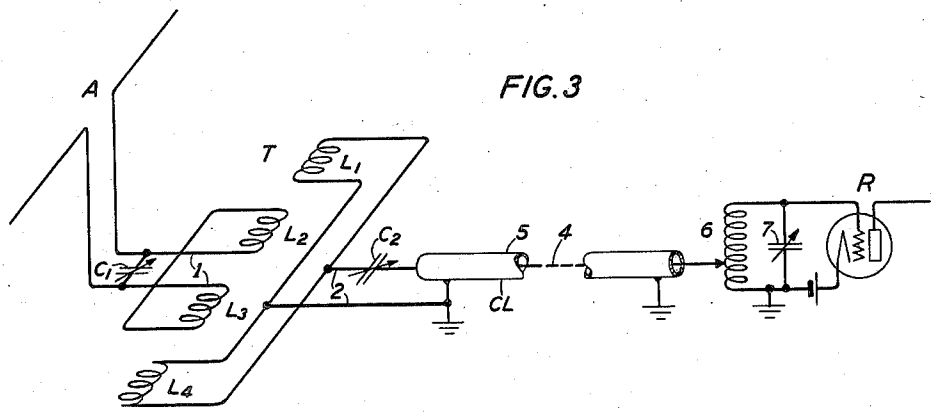


FIG. 3



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TRANSLATING CIRCUIT

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11 Claims. (Cl. 178—44)

This invention relates to electrical wave transmission systems and more particularly to coupling devices for high frequency signaling systems.

In the design of high frequency signaling systems there is frequently met the problem of coupling a balanced circuit to an unbalanced one. The difficulty usually involved is to prevent the unbalanced circuit, one side of which may be at ground potential, from disturbing the electrical balance with respect to ground of the other circuit. The maintenance of the balanced condition at high frequencies such as employed for short wave radio communication is complicated by the fact that the introduction of the slightest difference in the capacitance of the sides of the balanced circuit to ground may materially affect the efficient operation of the system. So critical are such circuits in this respect that special attention must be given to the small capacitances existing between the windings of transformers and other circuit elements.

An object of the present invention is to provide means for coupling an unbalanced circuit to a balanced circuit without disturbing the electrical balance of the latter.

Other objects and features of the invention will appear in the following detailed description of a specific embodiment of the invention. The accompanying drawing shows in Fig. 1 a coupling device heretofore proposed; in Fig. 2 a coupling device in accordance with the present invention; and in Fig. 3 an application of the coupling device of Fig. 2.

Coupling devices of the type shown in Fig. 1, it has been noted, have been suggested heretofore. The balanced circuit 1 is connected to the terminals of a continuous winding L_2, L_3 which at its midpoint is grounded. The unbalanced circuit 2 is connected to the parallel-connected windings L_1, L_4, which are disposed in inductive relation with the balanced winding and on respectively opposite sides thereof with their grounded terminals adjacent the line terminals of the latter winding. With this method of connection, it will be observed that the respective sides of the balanced circuit are capacitively connected to ground through the inherent inter-winding capacitances. The capacitance C_{1-2} existing between windings L_1 and L_2 is effectively between the upper side of the balanced line 1 and ground, and the capacitance C_{3-4} existing between windings L_3 and L_4 is, in effect, similarly connected between the other side of the balanced line 1 and ground. The balance of circuit 1 is therefore made dependent on an exact equality between these two inherent capacitances.

Referring now to Fig. 2 there is shown a specific embodiment of the present invention comprising a balanced transformer, the windings of which are so disposed relatively to each other and so connected as to minimize the possible unbalancing effect of inter-winding capacitances. The balanced circuit 1 is in this case connected to the adjacent terminals of the windings L_2 and L_3, the outer terminals of these windings being connected together, preferably by virtue of their respective direct connections to container 3. Windings L_2 and L_3 are so arranged as to be inductively in series-aiding relation. Windings L_1 and L_4 are arranged on respectively opposite sides of the central windings. Their adjacent terminals are connected together and to the grounded side of the unbalanced circuit 1, preferably by respective direct connections to container 3. Their outermost terminals are similarly joined to the high potential side of the unbalanced circuit. The winding directions of L_1 and L_4 are opposite to each other so that the voltages induced in these windings are in phase agreement with respect to the unbalanced circuit. The container 3, which may be of copper or other suitable material is used to shield the transformer against external interference.

The physical dimensions of the windings and the separation between windings may, of course, be varied within wide limits. In one air-cored transformer which was found to operate satisfactorily at a wave length of approximately twenty meters, windings L_2 and L_3 were solenoidal is form and comprised two turns each of one-eighth inch copper tubing wound on a three inch form. Windings L_1 and L_4 comprised four turns of the same diameter separated approximately an inch from the central windings. The dimensions of shield 3 may be determined by the maximum allowable values of the capacitances C_{1-0} and C_{4-0} existing between the shield and the outer turns of windings L_1 and L_4, respectively. Provision may be made also for moving the central windings axially so that an exact electrical balance can be more readily obtained.

Direct capacitive connection to ground from the terminals of the balanced circuit 1, as Fig. 2 shows, is substantially eliminated. The possibility of capacitive unbalance of that circuit is therefore minimized. Of the inter-winding capacitances that are present, none tend toward unbalance. The capacitance C_{2-3} between L_2 and L_3 shunts the balanced circuit but does not affect

the electrical symmetry with respect to ground. Capacitances C_{1-2} and C_{3-4} are terminated at points of ground potential, i. e., the adjacent terminals of windings L_1 and L_4, respectively. They have no effect on the balanced circuit, however, since their points of connection with the latter circuit are the outer turns of windings L_2 and L_3, which, being at the mid-potential of the balanced circuit, are likewise at ground potential.

The shunt capacitance C_{2-3} referred to is disadvantageous in some systems. Its magnitude may be reduced by increasing the separation of windings L_2 and L_3, or by arranging the windings in accordance with the invention of A. G. Jensen, disclosed in his application for Letters Patent bearing Serial No. 632,097 and filed September 8, 1932.

In other systems, as in that shown in Fig. 3, this capacitance may cooperate with additional shunt capacitive elements to tune the system.

In Fig. 3 is shown an application of the transformer of Fig. 2 to a directional radio receiving system employing a balanced antenna system A, which may be, for example, of the horizontal double V or rhomboid type. The directional characteristic of the antenna, which depends to a large degree on the balance of the coupling circuit, is preserved by the use of a transformer T in accordance with the present invention. A condenser C_1 connected across the antenna A and the balanced side of transformer T is used for tuning purposes. The unbalanced side of the transformer T is connected through a tuning condenser C_2 to a transmission line CL comprising coaxial conductors 4 and 5, which leads to the remotely located radio receiver R.

Although the present invention has been described with reference to a specific embodiment of it, it is not thus limited in nature but is capable of various other embodiments within the spirit and scope of the appended claims.

What is claimed is:

1. In a high frequency transmission system, a balanced circuit and an unbalanced circuit and an air-cored transformer coupling said circuits, said transformer comprising a first pair of windings axially spaced and connected to said unbalanced circuit in parallel-aiding relation, a second pair of windings arranged between and in symmetrical relation to said first pair of windings, the adjacent terminals of said second pair of windings being connected to said balanced circuit and the other terminals of said second pair of windings being connected together.

2. In a high frequency transmission system, a balanced circuit, an unbalanced circuit, and a transformer coupling said circuits, said transformer comprising a first pair of windings axially spaced and connected in parallel to said unbalanced circuit, adjacent terminals of said windings being connected together and to ground, a second pair of windings positioned symmetrically between and in balanced inductive relation to said first pair of windings, said second pair of windings being arranged in series-aiding relation with adjacent terminals thereof connected to said balanced circuit.

3. A high frequency air-cored transformer comprising four solenoidal windings disposed at spaced intervals along a common axis, a pair of terminals connected to the adjacent ends of the two central windings, a connection between the other ends of the central windings, means connecting the inner ends of the outer of said four windings, means connecting the outer ends of said outer windings, and a pair of terminals connected to said connecting means.

4. In a high frequency transmission system, a balanced circuit and an unbalanced circuit, and an air-cored transformer coupling said circuit, said transformer comprising a pair of windings connected to said balanced circuit, a pair of windings connected to said unbalanced circuit, said pairs of windings being in inductive relation and symmetrically positioned with respect to each other, the ends of said first-mentioned windings adjacent said second-mentioned windings being at substantially the midpotential of said balanced line.

5. In a high frequency transmission system, a balanced circuit and another circuit and an air-cored transformer coupling said circuits, said transformer comprising two pairs of inductively related windings, connections from said balanced circuit to corresponding ends of a symmetrically positioned pair of said windings, said symmetrically positioned pair of windings presenting to the others of said windings only their low potential ends, and said other circuit being connected to said other pair of windings.

6. In a high frequency transmission system, a balanced circuit and another circuit, and an air-cored transformer coupling said circuits, said transformer comprising a multiplicity of windings, two of said windings being connected in series with each other and with said balanced circuit, said two windings being so positioned that the high potential ends of said two windings are substantially free from inter-winding capacitances to ground, and connections from a plurality of the other of said windings to said unbalanced circuit.

7. In an electrical signaling system, a balanced circuit and another circuit, and a transformer coupling said circuits, said transformer comprising a plurality of windings connected to said other circuit and a plurality of windings inductively balanced and symmetrically positioned with respect to said first plurality of windings and connected to said balanced circuit, the terminals of said second plurality of windings that are connected to said balanced circuit being not adjacent windings comprising said first plurality of windings.

8. A balanced circuit, another circuit, a high frequency transformer comprising four non-overlapping windings symmetrically disposed along a common axis, means for connecting a pair of said windings in parallel to said other circuit, means for connecting the other pair of said windings in series to said balanced circuit, only the low potential ends of said other pair of windings being adjacent said first pair.

9. A combination in accordance with claim 8 in which the low potential ends of said first pair of windings are adjacent the low potential ends of said other pair of windings.

10. In a system for coupling a single ended circuit with a double ended circuit, comprising a transformer having a pair of primary windings and a pair of secondary windings, one pair of said windings being wound in opposite directions and connected in parallel in said single ended circuit and the other pair of windings being wound in the same direction and connected in balanced relation in said double ended circuit, and the points of zero alternating potential on both pairs of windings being placed in close proximity to each other.

11. In a system for coupling a single ended cir-

cuit with a double ended circuit, comprising a transformer having a pair of primary windings and a pair of secondary windings, one pair of said windings being wound in opposite directions and connected in parallel in said single ended circuit and the other pair of windings being wound in the same direction and connected in balanced relation in said double ended circuit, said pairs of windings being so spaced relative to each other as to produce a maximum of mutual inductance between the pairs of windings and a minimum of capacity between said pairs of windings.

HARALD T. FRIIS.