Dec. 31, 1935. A. G. GANZ 2,026,308

BALANCED INDUCTANCE DEVICE

Filed Dec. 21, 1933

FIG. 1

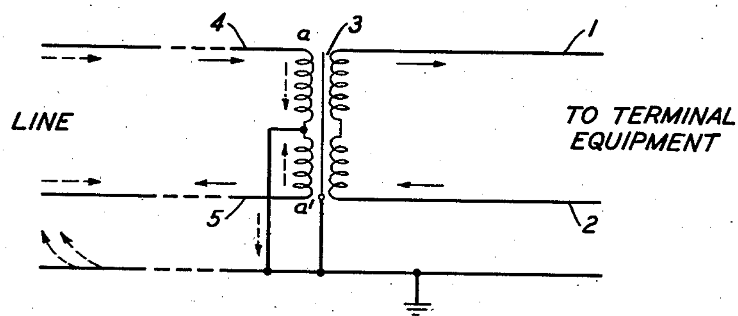


FIG. 2

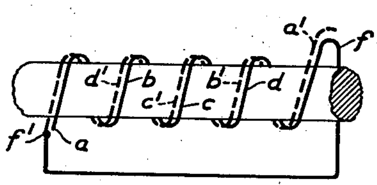


FIG. 3

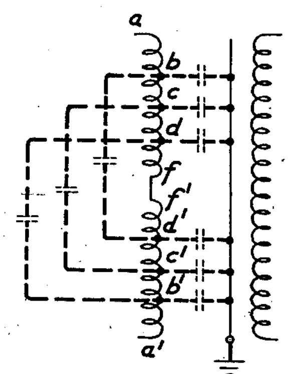


FIG. 4

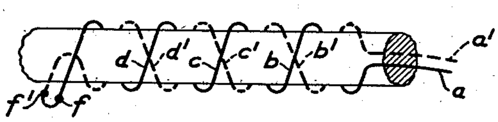
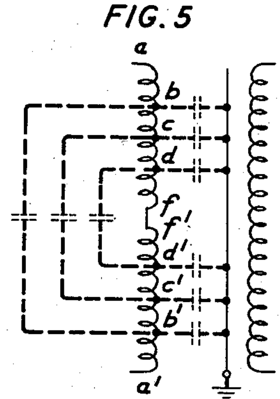


FIG. 5



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BALANCED INDUCTANCE DEVICE

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3 Claims. (Cl. 179—78)

This invention relates to transmission devices and more especially to transformers or similar devices for use with high frequency currents.

In the utilization of open wire circuits, especially those for the transmission of high frequency waves, considerable difficulty has been experienced due to interference from neighboring power and communication circuits. Induction from such neighboring circuits gives rise to longitudinal currents in the high frequency communication circuits. Unbalances in the transformer which terminates such a circuit convert a portion of the longitudinal currents to transverse currents which add directly to the communication currents in the circuit, causing noise and crosstalk. The unbalances may be due to inductance unbalances in the windings of the transformer and also due to unbalanced capacities existing between turns of the windings or between the windings and shield.

Methods have been used to obviate the difficulty due to inductance unbalances such as winding the primary with twisted pairs of wire and impressing the longitudinal currents on the twisted pairs in such a manner that for a given direction of current, the magnetomotive forces generated are equal and opposite and the effect of such currents on the secondary neutralized. Such expedients, however, do not overcome capacity unbalances and for high quality transmission lines such as are required for high frequency circuits further refinements are necessary.

An object of the present invention is to improve the quality of transmission of high frequency circuits by minimizing the interference from neighboring power and communication circuits.

Another object of the invention is a transformer device for use where the phantom and side circuits are separated in which cross-talk from phantom to side circuit and vice versa is reduced to a minimum.

These and other objects which will appear hereinafter are attained by using a transformer, the primary winding of which is composed of a pair of wires wound in opposite directions around the core, each turn of one wire being next to the correspondingly numbered turn of the other wire. With this arrangement, the magnetomotive forces due to parallel currents neutralize each other so as to have no effect on the secondary winding while for series currents, the magnetomotive forces add so as to have a full effect on the secondary.

As the correspondingly numbered turns of the primary are next to each other and as the potential gradients for longitudinal currents along the two wires of the pair are equal, the capacities between them virtually connect points of equal potential. These capacities therefore can have no effect on the balance of the windings. Also the capacities between one wire and shield or the secondary winding are balanced by the capacities of the other wire to said shield or said secondary winding.

The invention will be better understood from the following description in connection with the accompanying drawing in which,

Fig. 1 is a schematic diagram of a transformer terminating a line;

Fig. 2 is a diagram of the primary winding of a transformer at present in use;

Fig. 3 illustrates the capacities which exist in the construction of Fig. 2;

Fig. 4 is a diagram of the primary winding of a transformer according to the present invention; and

Fig. 5 illustrates the capacities which exist in the construction of Fig. 4.

Referring now to Fig. 1, there is shown schematically a line consisting of two conductors, 4 and 5, terminating in a transformer 3. The leads 1 and 2 of the secondary winding connect to the terminal equipment. The longitudinal interference currents pass along conductors 4 and 5 through what will be spoken of hereinafter as the primary winding of transformer 3, combining at the midpoint of the winding to pass to ground.

The transverse communication currents pass along the conductors in the usual manner.

Assume that the longitudinal currents at any given instant pass in the direction indicated by the dotted arrows, the currents are impressed on transformer 3, at points a and a'. Refer now to Figs. 2 and 3 which illustrate the type of windings heretofore used. The more common type has been the twisted pair, but for simplicity in illustration an ordinary pair is indicated.

Longitudinal currents impressed upon the transformer have substantially the same potentials at points a and a' which potentials gradually decrease to the same value at f and f' where the currents are led off to ground. It is readily seen that the magnetomotive forces due to these currents will substantially neutralize each other because of the direction in which the currents pass around the coil.

Points b and b' are substantially at the same potential for longitudinal voltages but point b

is adjacent point *d'* which is at a different potential than *b* but at the same potential as *d*. Points *b'* and *d* are also adjacent but at different potentials. Due to the arrangement of the turns of the winding, capacities exist between these points. These capacities which are shown more clearly in Fig. 3 are not balanced, because of unavoidable differences in the spacing of the wires of the pair and in the dielectric properties of the insulation. Unbalanced effects are also due to the longitudinal currents passing through turns located in different portions of the winding. These unbalanced currents cause cross-talk and noise interference from the longitudinal to the transverse circuits.

The winding of the transformer of the invention is shown in Fig. 4 and the capacity condition in Fig. 5. The winding is shown for the sake of clarity as a single layer winding, but in practice it consists of a large number of similar layers. From Fig. 4 the inductive neutralization is readily seen without explanation as wire *af* (traced from end *a*) is wound about the core in the opposite direction to wire *a'f'* (traced from end *a'*), the two wires being joined at *f*, *f'*.

Points *a* and *a'* which have equal potentials for longitudinal currents are adjacent as are also points *b* and *b'* which have equal potentials but different from those of *a* and *a'*. Potentials at *c* and *c'* are equal but different from those at *b* and *b'*, etc., and whereas there is a capacity existent, since the potentials are the same there is no current flow and hence no interference.

This is true throughout the winding regardless of the number of layers because corresponding turns are adjacent to each other throughout and there exists substantially neither inductive nor capacitive unbalance and hence there can be no effect upon the secondary winding by longitudinal currents in the primary winding.

It is to be understood that whereas one form and one application of the invention has been shown and described, it is to be limited only by the scope of the appended claims.

What is claimed is:

1. A terminating transformer for a line for the transmission of ultra-audio frequency currents comprising a plurality of windings and a core, one of said windings comprising a pair of wires, the wires of said pair being wound about said core in opposite directions (as seen from the same end of the winding), each turn of one wire being adjacent the correspondingly numbered turn of said other wire for substantially the entire turn and a connection to ground from the midpoint of said winding.

2. In a transmission line for ultra-audio frequency currents, subjected to longitudinal currents, a transformer provided with a plurality of windings and a core, one of said windings comprising a pair of wires, each turn of one of said wires being wound immediately adjacent the corespondingly numbered turn of the other wire of said pair, connections from the outer ends of said winding to said transmission line, a connection from the midpoint of said winding to ground whereby the inductive and capacitive impedance of said winding to longitudinal currents is substantially zero.

3. The combination with a two-wire circuit for transmitting currents, of a coil furnishing a connection to said circuit for longitudinal currents, comprising a pair of terminals for connection to the opposite conductors of said circuit and a tap connection for a circuit conveying the longitudinal currents, said coil comprising two windings applied to a core in turn-for-turn overlapping relation and in respectively opposite direction as viewed from the same end, said wire at one end of the winding being connected together and to said tap, their opposite ends being connected to said terminals.

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