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TELEPHONE LOADING UNIT AND METHOD OF BALANCING SAME

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FIG. 1

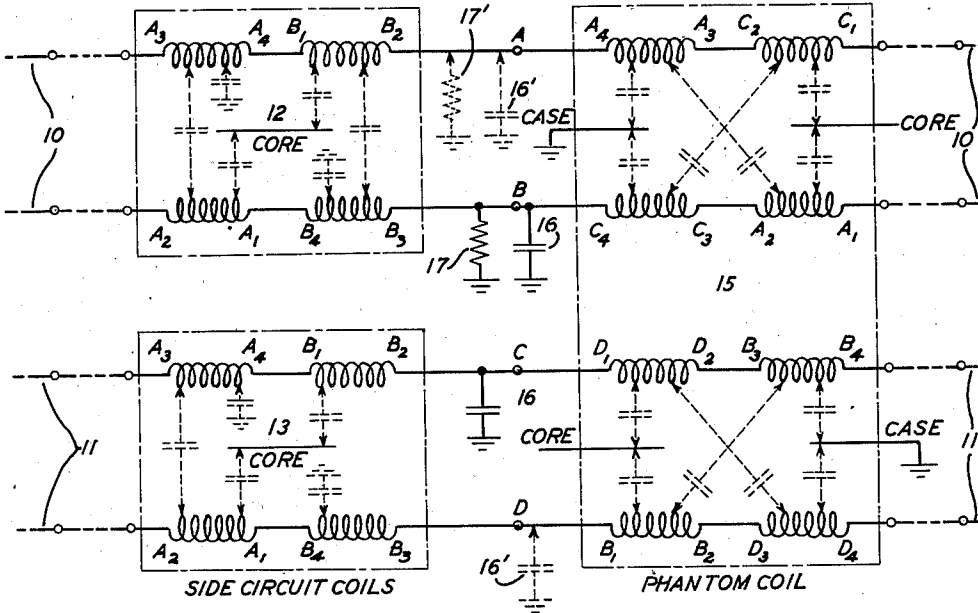
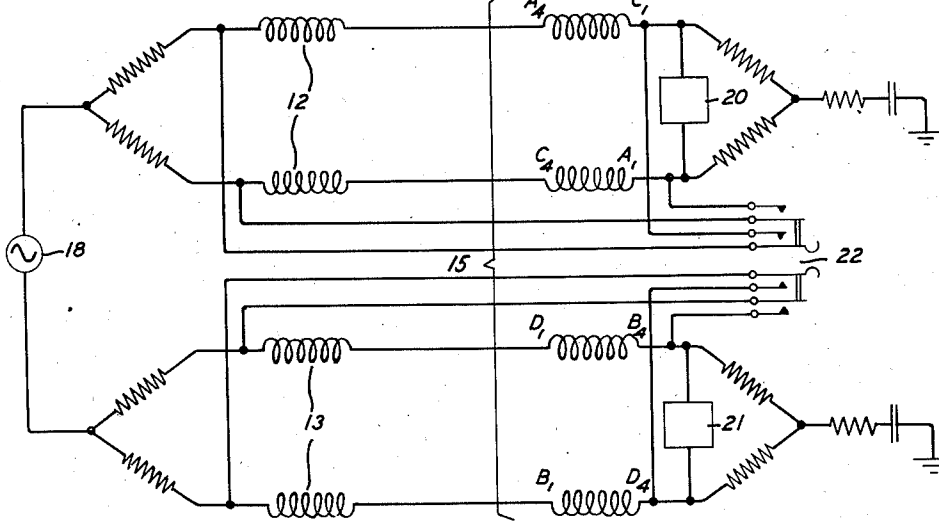


FIG. 2



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TELEPHONE LOADING UNIT AND METHOD
OF BALANCING SAMEJoseph A. Worcester, Middletown, N. Y., assignor
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10 Claims. (Cl. 179-78)

The present invention relates to the loading of so-called phantom systems wherein two separate telephone or other lines are associated to derive a third or phantom circuit, the two line circuits being called side circuits.

Slight circuit unbalances in such systems give rise to cross-talk between the phantom and side circuits. These unbalances may appear as inductance, resistance, capacity or conductance unbalances between different elements of the system. The total cross-talk is the summation of the cross-talk from these separate unbalances and, depending on the relative magnitudes may vary widely from near end to far end and will vary with frequency. Considering a loading unit comprising both phantom and side circuit coils, the inductance and resistance unbalances may be neutralized by the addition at suitable points of inductance and resistance, respectively, in series with the windings, and these unbalances are often referred to as series unbalances. The major capacity unbalances are shunt unbalances occurring between coil windings and either the core or the casing, the latter of which is generally at ground potential.

Methods heretofore proposed of compensating for the shunt and series unbalances individually to a high degree of accuracy have involved special methods of applying the windings and use of elaborate testing procedures.

It is an object of the present invention to reduce the cross-talk unbalances individually (and the total cross-talk) to negligibly low values in a simple and economical manner not requiring the use of particular winding arrangements.

A related object is to reduce to negligibly low value both near end and far end cross-talk over a wider frequency range than heretofore.

A further object is to secure a more perfect compensation of unbalances giving rise to cross-talk than has been achieved heretofore.

Other objects and the various features and aspects of the invention will be made clear from the following detailed description with the aid of the accompanying drawing, in which:

Fig. 1 is a schematic diagram of the windings and circuit connections of a phantom loading unit; and

Fig. 2 is a schematic diagram of a cross-talk measuring bridge for carrying out an adjusting method according to the invention.

Fig. 1 shows the various windings employed for a complete phantom loading unit consisting of two side circuit loading coils 12 and 13 for the side circuits or lines 10 and 11, and a phantom

loading coil 15. The latter coil may comprise an annular core divided around its periphery into four equal winding sections or quadrants. In each quadrant there is an inner winding next the core (designated by subscript numerals 1 and 2, for example, A_1 , A_2) and an outer winding, wound over the inner winding (designated by subscripts 3 and 4, as A_3 , A_4). The windings occupy quadrants in succession around the core in alphabetical order as A_1 , A_2 and A_3 , A_4 windings in one quadrant; B_1 , B_2 and B_3 , B_4 windings in the next quadrant, etc. Subscript 1 (e. g. A_1) designates the inner end of an inner winding. Subscript 3 (e. g. A_3) designates the inner end of an outer winding. Subscripts 2 and 4 refer to outer ends of inner and outer windings, respectively.

In the phantom coil of Fig. 1, all windings are applied to the core in the same winding direction which is an advantage from a manufacturing standpoint since the coils can be wound by machine without inverting in the machine.

The principal shunt capacities between the various windings, in the case of both the side-circuit coils and the phantom coil, are indicated in the figure by small dotted condensers drawn in between the various windings or between a winding and the core or the case, which is grounded. The capacity between windings appears principally between the outer layer of an inner winding and the inner layer of the outer winding that is wound over it, for example, between turns near the terminal A_2 and turns near the terminal A_3 , as shown.

It is desirable that a loading unit be balanced for both near end and far end cross-talk in order that the same unit may be used indiscriminately in circuits where either type of cross-talk is of importance. Examination of formulas for near end and far end cross-talk shows that if the admittance unbalance is reduced to zero, the expressions for both types of cross-talk become identical. The admittance unbalance is made up of capacitive and conductance unbalances, of which the former greatly predominates. It is desirable, therefore, to reduce the capacity unbalance to zero and for a very high degree of equality of balance for both near end and far end cross-talk to reduce the conductance unbalance to zero also.

The invention offers a method of reducing both the capacity unbalance and the conductance unbalance substantially to zero. Moreover, it offers a method of neutralizing capacity unbalance between phantom and one side circuit without affecting the capacity unbalance between the

phantom and the other side circuit. Using designations, P for phantom, S₁ for one side circuit and S₂ for the other side circuit, the capacity unbalance

$$\begin{aligned} \text{P to } S_1 &= (C_{AC} + C_{DA}) - (C_{BC} + C_{BD}) + \frac{1}{2}(C_{AG} - C_{BG}) \\ \text{P to } S_2 &= (C_{AC} + C_{BC}) - (C_{BD} + C_{DA}) + \frac{1}{2}(C_{CG} - C_{DG}) \end{aligned}$$

Where C_{AC}, C_{DA}, C_{BC} and C_{BD} are respectively the capacity unbalances between the respective junction points A, B, C and D in Fig. 1, and C_{AG}, C_{BG}, C_{CG} and C_{DG} represent the capacity of the respective line windings to ground. By adjusting these capacities to ground, the last term only of each of the expressions for phantom to side circuit unbalance is changed since these quantities do not appear in the other terms. Moreover, in the expression for P to S₁ unbalance, the term representing capacities to ground contains no quantity present in the expression for P to S₂ unbalance so that by adjusting these quantities the P to S₁ unbalance may be controlled independently of the P to S₂ unbalance.

Referring to Fig. 1, applicant's method of correcting for capacity unbalance is to connect a condenser of suitable size, such as 16, between the appropriate side of the line and ground. The effect of this is to balance any resultant effective unbalance capacity effect that may be present between the opposite side of the line and ground, such as indicated at 16'.

Unbalance shunt conductance, indicated at 17', is balanced by connecting a small conductance (high resistance) 17 between the opposite line conductor and ground. The capacity 16 and resistance 17 may be connected between the side circuit terminals and ground, the phantom coil terminals and ground, or the junction of the side circuit and phantom coils and ground.

The procedure for adjusting the circuit to minimize the unbalances will now be described with reference to Fig. 2. By means of the cross-talk bridge illustrated in simplified diagrammatic form, the loading unit is first measured and adjusted to reduce the shunt admittance unbalance to zero, that is, to compensate for shunt capacity and conductance unbalance. For this purpose key 22 is closed, shunting out the windings in each of the four sides of the lines. Testing current of suitable frequency from generator 18 is then applied through the resistance arms shown and since the series impedance of the various windings is now shunted out, the indicating circuits 20 and 21 show only the effects of shunt unbalances. The circuits 20 and 21 may each be provided with variable capacities, for example, a three plate condenser with the center plate grounded and movable so that the amount of capacity unbalance can be determined by adjusting to a minimum indicator reading. The necessary amount of capacity 16 is then connected as in Fig. 1 to exactly compensate the capacity unbalance. The minimum indicator current obtainable by this method may be sufficiently small for the intended purposes. If a still lower minimum is desired, some shunt conductance is connected between the proper side of either or both lines and ground as shown at 17 in Fig. 1, and by this means the shunt unbalance may be reduced practically to zero.

The key 22 is now opened and a test made for the total cross-talk unbalance which, after the shunt balance has been made as described, will consist of series inductance and resistance un-

balance. The amount of series inductance and resistance that must be added to one or the other side of each line to secure a balance can be determined by adjustable inductance and resistance devices in series with the line conductors at some point to the left (in Fig. 2) of the indicating circuits 20 and 21. The variable inductances used for this purpose may advantageously be of the type disclosed in U. S. Patent to R. M. C. Greenidge, No. 1,930,269, October 10, 1933. After the necessary inductance and resistance has been inserted in the appropriate sides of the lines, a substantially zero indicator reading is obtained and the procedure of balancing the system has been completed.

As an example of the results obtained with applicant's method, three loading units gave an average phantom to side circuit near end cross-talk of 9.6 cross-talk units before adjustment. Adjustment of the shunt capacity unbalance by the method that has been described reduced this figure to 2.7 cross-talk units. By making suitable series resistance adjustment, the cross-talk was reduced to 0.5 unit. Use of a conductance to ground as described enabled the cross-talk unbalance to be brought to 0.3 unit which was the final value for both near end and far end cross-talk. In addition it was found that with the aid of these adjustments the cross-talk variation with frequency could be virtually eliminated over the voice frequency range.

While the side-to-side cross-talk is not discussed in the foregoing, this may be kept at suitably low value by methods known in the art.

The method that has been disclosed of adjusting the shunt unbalances of the phantom coil itself can be used to advantage for adjusting the assembly of loading units and stub-cable. For this purpose the connections to the testing circuit of Fig. 2 are made at the ends of the stub-cable remote from the coils, the stub-cable conductors for one quad being indicated by the dotted line conductors leading from the loading unit terminals to the lines 10, 11 proper.

For example, in a type of loading coil case, such as is disclosed in U. S. Patent to Doering et al. 1,668,710, May 8, 1928 in which the coils are suspended from the cover, the entire mounted assembly of coils and stub-cable can be balanced up outside the case by measuring up the unbalances of coils and stub-cable in the manner that has been described and connecting the compensating capacities, resistances and inductances as required on the terminal strips of the individual loading units, after which the coil assembly is lowered into the case. In this manner the capacity unbalances in the stub-cable as well as the unbalances in the loading unit are compensated for.

The specific values and details given are not to be construed as limiting the invention, the scope of which is indicated by the claims.

What is claimed is:

1. The method of compensating the shunt capacity unbalance of a phantom loading unit whose windings are all applied in the same direction, comprising temporarily effectively removing the series impedances and connecting impedance of suitable magnitude between one conductor of the line pair and ground to produce a balanced condition.

2. The method of compensating the phantom-to-side circuit cross-talk in a phantom loading coil for one side circuit independently of the phantom-to-side circuit cross-talk for the other

side circuit comprising increasing the admittance to ground of one conductor of said first side circuit.

5 3. In a phantom loading coil system, a closed core having four winding sections all wound in the same winding direction to provide loading for a phantom circuit, and means compensating shunt capacity unbalance independent of series impedance unbalance comprising a condenser
10 connected from one conductor of a line pair to ground.

4. A combination, according to claim 3, including also a resistance connected between one line conductor and ground.

15 5. The method of compensating unbalances in a phantom loading unit comprising first testing for shunt unbalances only in a suitable measuring bridge and neutralizing the shunt unbalances by connecting shunt impedance to ground from
20 one side of either or both side circuits as required and then testing for total unbalance in a suitable measuring bridge and adding series impedance in the necessary lines to compensate the series unbalance.

25 6. As steps in the manufacture of loading coil systems, the method comprising testing the assembly of loading units and stub-cable for cross-talk unbalances, and compensating such unbalances by connecting to appropriate points in the
30 loading coil assembly the required capacities and/or resistances to balance both the loading units and the stub-cable quads.

7. The method of compensating the unbalances in a phantom loading unit comprising first shunting out the series impedances and adding suitable shunt impedance at the proper point or points to compensate the shunt unbalance, then unshunting the series impedances and adjusting impedance in series with the unit to compensate the series unbalance. 5

8. The method of compensating cross-talk unbalance in a phantom loading unit throughout a wide frequency range comprising supplying testing current in simplex through arms of impedance bridged across the terminals of each side circuit coil, short-circuiting the series impedances of said unit and adjusting the impedance to ground of one side of the appropriate side circuit to secure a balance of the shunt admittances, then removing the short circuit connections and adjusting impedance in series in the appropriate side to compensate the series unbalance. 10 20

9. The method of compensating the shunt unbalance of a phantom loading unit comprising shunting out the series impedances of the unit and adjusting the admittance to ground of one side of a side circuit to an appropriate value to produce a balanced condition. 25

10. A phantom loading coil system according to claim 3 comprising also series impedance of a value to compensate series unbalance. 30

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