Dec. 22, 1925. 1,566,802

I. L. MILTON

LOADING COIL AND METHOD OF CONSTRUCTION

Filed May 1, 1923

Fig. 1

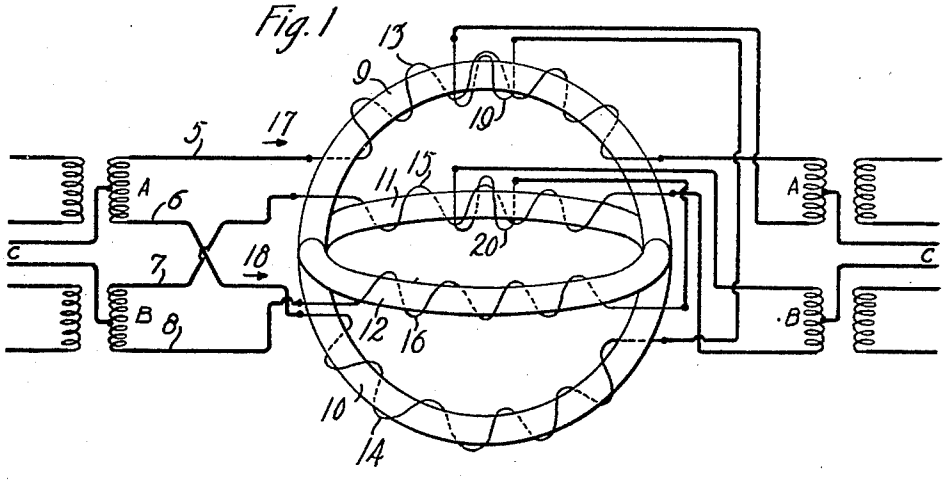
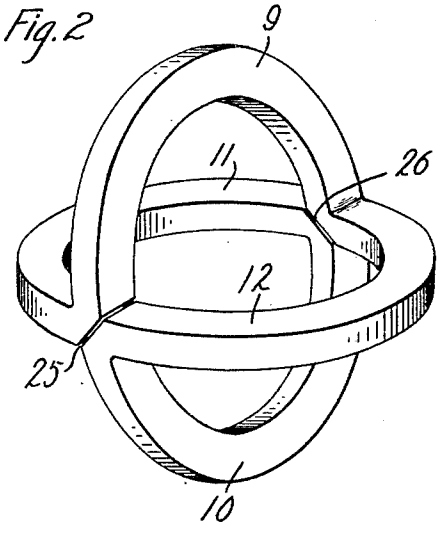



Fig. 2




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by Joel C. Palmer Atty

Patented Dec. 22, 1925. 1,566,802

# UNITED STATES PATENT OFFICE.

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## LOADING COIL AND METHOD OF CONSTRUCTION.

Application filed May 1, 1923. Serial No. 635,869.

*To all whom it may concern:*

Be it known that I, IVAN L. MILTON, a citizen of the United States, residing at Western Springs, in the county of Cook, State of Illinois, have invented certain new and useful Improvements in Loading Coils and Methods of Construction, of which the following is a full, clear, concise, and exact description.

This invention relates to the loading of telephone systems, and more particularly to means and methods for reducing or preventing inductive interference or cross-talk between the circuits of systems in which the same loading unit is used to load more than one circuit, as may be done in the case of two physical circuits and their derived phantom circuit.

In order that the cross-talk arising in such a loading unit shall be a minimum, the mutual inductances between each of the line windings in one physical circuit and those in the other physical circuit should be equal or at least very nearly so. For, if one line winding is more susceptible than the other line winding of the same physical circuit to the variations of flux accompanying speech currents flowing in the windings of the other physical circuit, cross-talk currents will be set up in the first circuit due to the inequality of electromotve forces induced in its two windings and their consequent failure to balance each other; in like manner inequalities of mutual inductance between the windings may cause cross-talk between either of the physical circuits and the derived phantom circuit.

Inequalities of mutual inductance may arise, for instance, from lack of homogeneity as to permeability of the core of the loading unit, such as may be caused in cores made up of laminations or the like by differences in the laminations or the closeness of their contact. The effects of such inequalities, though perhaps negligible in short lines in which low voltages and small currents are encountered, become accentuated to a harmful degree under the high pressures occurring in long lines, especially in systems in which amplifying repeaters are employed.

It is the object of this invention to provide a loading unit in which the mutual inductances between the several windings are so closely balanced as to prevent appreciable cross-talk under severe service conditions; a further object is to afford a method for producing such a condition of balance.

Briefly, the objects of this invention are obtained by connecting in circuit with one of the main windings for each side circuit a supplementary winding located on the section of the core carrying the mate winding for that side circuit. These windings are adjusted to produce by mutual inductance between the windings an E. M. F. having the proper amplitude and phase to overcome the cross-talk difficulties encountered.

Referring to the drawings, Fig. 1 represents this invention applied to a loading unit for simultaneously loading two physical circuits and their derived circuit, and Fig. 2 illustrates more in detail the type of core used in the loading unit shown in Fig. 1.

Referring to Fig. 1, A indicates one side circuit comprising the line conductors 5 and 6, B represents the other side circuit comprising the line conductors 7 and 8 and C represents a phantom circuit derived from the two physical circuits in a well-known manner. The loading unit illustrated in this figure has four semi-annular core sections 9, 10, 11 and 12 joined together in such a manner as to form in effect two complete rings intersecting at right angles on a common diameter. The two rings may be of any suitable magnetic material but are preferably formed of finely divided iron with the individual particles insulated from one another, this material being molded under high pressure into the required form.

The core sections 9 to 12 are provided respectively with the main windings 13, 14, 15 and 16.

Due to the relative positions of the four windings 13 to 16, there will be a mutual inductance effect between each winding and each of the remaining windings. In the general case, it will be found that these mutual inductances between the four main windings will not neutralize each other but will give rise to a resultant E. M. F. in the transmission circuit which will cause cross-talk between the two side circuits or between the phantom circuit and one of the side circuits. Cross-talk is, of course, objectionable in a high quality circuit and the arrangement of this invention has therefore been provided to eliminate this effect due to any inequality

of mutual inductance between the respective windings of the loading coil unit.

The manner in which cross-talk is eliminated in accordance with this invention will be understood if we assume that phantom circuit currents are flowing in the phantom circuit C and that due to the mutual inductance between winding 13 of side circuit A and windings 15 and 16 of side circuit B an electromotive force is produced in winding 13 giving rise to a current in the direction indicated by arrow 17. The mutual inductance between winding 14 and each of the windings 15 and 16 will be assumed to give rise to an electromotive force in winding 14, producing a current flowing in the direction indicated by arrow 18 which is in the opposite direction with respect to the side circuit A from that of the current produced by the electromotive force in winding 13. In general, the electromotive forces induced in this manner in windings 13 and 14 will be unequal and will therefore result in a differential current flowing in the side circuit A produced by the phantom circuit current. This is, of course, the effect usually called cross-talk.

In accordance with this invention, the electromotive forces introduced in the above manner into windings 13 and 14 may be equalized and therefore annulled by connecting in series with winding 14 a supplementary winding 19, the few turns of which are wound on the core section, surrounded by winding 13 provided that the electromotive force introduced in winding 14 is of the lesser magnitude. This winding 19 should be so adjusted as to produce an electromotive force in winding 13 of the proper magnitude and phase to neutralize the electromotive forces induced in windings 13 and 14 due to the mutual inductance effects with the windings 15 and 16 of the side circuit B. The procedure to be employed in testing and adjusting the values of the winding 19 is similar to the procedure outlined in detail in the U. S. patent to W. J. Shackelton No. 1, 334,321 of March 23, 1920.

In case the electromotive force in winding 13 due to this mutual inductance is smaller than that induced in winding 13, winding 19 need not be employed but a corresponding supplementary winding in series with winding 13 and wound around core section 10 would be employed.

The side circuit B may be similarly treated by connecting in circuit with one of the windings 15 or 16 a supplementary winding wound on that part of the core surrounded by the other of the two windings. For example, winding 20 is shown surrounding core section 11 and in circuit with winding 16 to bring about the desired equality in mutual induction and to eliminate the cross-talk difficulties.

The above described method of reducing cross-talk by placing in series with one winding a few turns wound around the core surrounded by its mate winding is of particular utility when air gaps are employed in the Gimbal core to separate the core branches in the manner well known in the art and as shown, for example, in Fig. 2 in which air gaps 25 and 26 are inserted in the Gimbal core at the junction of the two annular rings and at right angles to each other to provide the desired separation between the core branches 9, 10, 11 and 12. This is probably due to the mutual inductances in such a case being small compared to the self inductances.

It is to be understood that the form of this invention described above is not the only embodiment of this invention and that modifications thereof may be made without departing from the spirit of this invention, as defined in the appended claims.

The invention claimed is:

1. The method of compensating for different permeability between sections of the core of an induction coil which carry the main windings for the physical circuits in which the coil is to be connected mounted on different sections, which method comprises connecting to one main winding a supplementary winding mounted on that section of the core which carries the mate winding for said one main winding and proportioning the number and direction of the turns of said supplementary winding to obtain an inductance balance between the windings of the induction coil.

2. The method of compensating for differences of mutual inductance between the windings of a loading coil adapted for use with two physical circuits and a derived phantom circuit, the loading coil having a core of a plurality of branches on which the main windings for the two physical circuits are distributed, which method comprises including in series with one winding of each physical circuit a supplementary winding mounted on the branch of the core surrounded by the mate winding of said one winding and adjusting by trial the number and direction of turns of said auxiliary windings to obtain a mutual inductance balance between the various windings of the loading coil, both for side circuit working and for phantom circuit working.

3. The method of compensating for differences of mutual inductance between the windings of a loading coil adapted for use with two physical circuits and a derived phantom circuit, the loading coil having a core comprising a plurality of branches the main windings for one physical circuit being arranged on alternate branches with the windings for the other physical circuit, which method comprises including in series with one main winding of each physical cir-

cuit a supplementary winding mounted on the same branch of the core as the mate winding for said one winding and adjusting by trial said supplementary windings so as to produce equal mutual inductances between each of said one winding and each of the two main windings of the second physical circuit.

4. A loading coil comprising a core of a plurality of sections, two main windings on different sections of said core for each physical circuit to be loaded by said loading coil, and a supplementary winding the turns of which are proportioned in number and direction to give an inductance balance between the windings in series with one main winding of each physical circuit and mounted on the core section surrounded by the mate winding of said one main winding.

5. A loading coil comprising a core of four semi-annular core sections joined together to form in effect two complete toroids intersecting at right angles on a common diameter, gaps of high specific resistances at the intersecting points for separating the four semi-annular core sections, a main winding on each of said core section and a supplementary winding connected in series with the winding on one of said core sections and mounted on the other half of the toroid formed thereby, and a supplementary winding in series with the main winding on a third of said core sections and mounted on the fourth of said core sections.

In witness whereof, I hereunto subscribe my name this 26 day of April, A. D. 1923.

IVAN L. MILTON.