T. SHAW.

PHANTOMED LOADED CIRCUIT.

APPLICATION FILED FEB. 12, 1910.

981,015.

Patented Jan. 10, 1911.

2 SHEETS—SHEET 1.

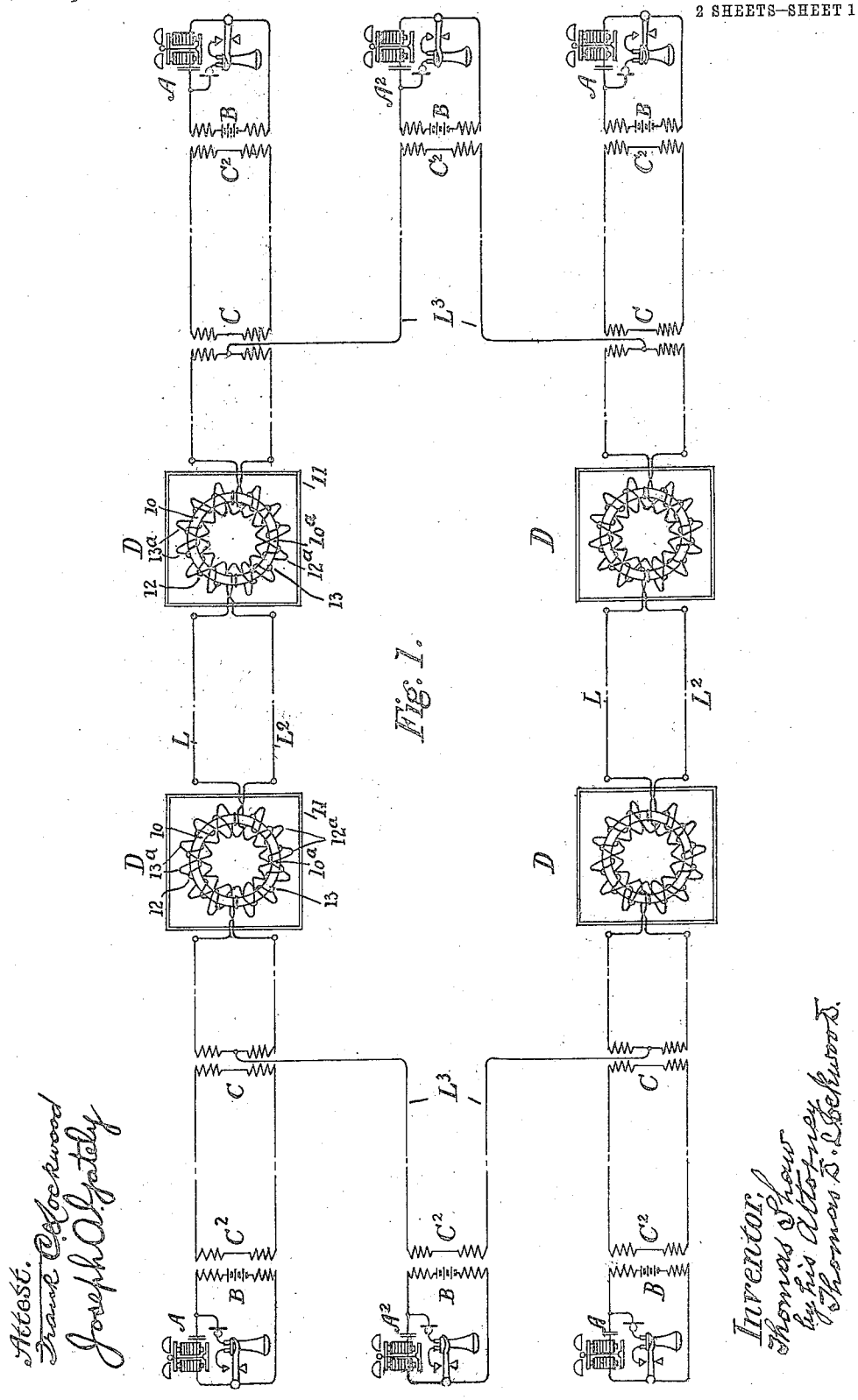

Fig. 1.

Witness.
Frank C. Lockwood
Joseph A. Gately

Inventor:
Thomas Shaw
by his Attorney
Thomas S. Sherburne

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2 SHEETS—SHEET 2.

Fig. 2.

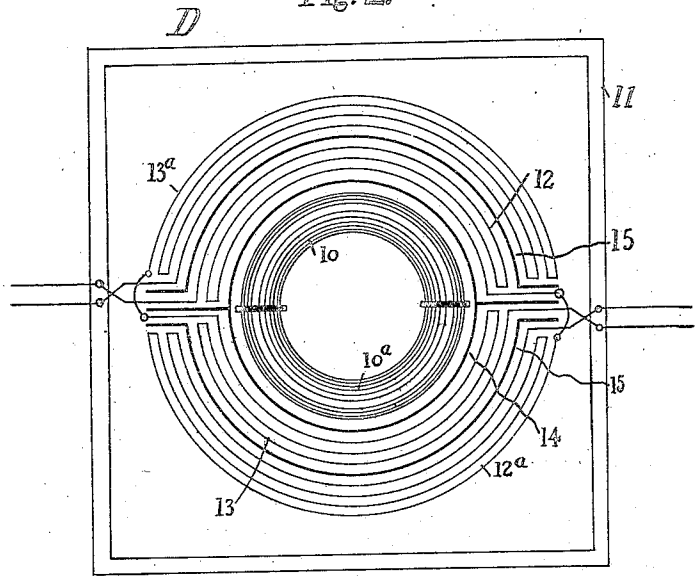
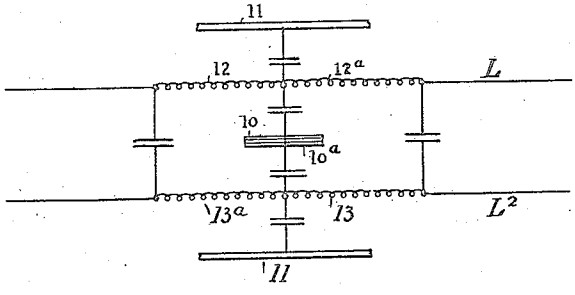


Fig. 3.



Attest,
Frank C. Lockwood
Joseph A. Gately

Inventor:
Thomas Shaw
by his Attorney
Thomas D. Lockwood

UNITED STATES PATENT OFFICE.

THOMAS SHAW, OF HACKENSACK, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

PHANTOMED LOADED CIRCUIT.

981,015. Specification of Letters Patent. Patented Jan. 10, 1911.

Application filed February 12, 1910. Serial No. 543,539.

To all whom it may concern:

Be it known that I, THOMAS SHAW, residing at Hackensack, in the county of Bergen and State of New Jersey, have invented certain Improvements in Phantomed Loaded Circuits, of which the following is a specification.

In dealing with lines for the transmission of electrical signals, as telephone or telegraph lines, loaded upon the Pupin system, that is, with inductances distributed throughout the circuit and serving to diminish the attenuation of the signaling waves or impulses, it obviously may be desirable to combine two or more transmitting circuits to form a third, or, as it is termed in telephony, "phantom" circuit. This is commonly effected by employing in parallel the two limbs of a metallic circuit to furnish each side of the phantom, the impulses generated in either of the original or physical circuits and in the combined or phantom circuit being caused to act only upon their respective receiving instruments by means of a differential repeating coil in a manner well known. It has been found, however, that when the physical circuits are provided with the usual toroidal loading coils, in which the two line windings are upon opposite sides of a ring core, there is introduced into the phantom circuit a loss of energy, appearing as directly measurable effective resistance, which markedly impairs the efficiency of transmission. The chief cause of this loss is leakage of lines of force from the convolutions of the coils, where they give rise to useful inductance, into the unlaminated cast-iron cases, ordinarily employed as inclosures. Here the magnetic flux produces eddy currents, which dissipate the energy as heat. This loss is negligible when the current flows serially in the two windings, with their mutual inductance aiding or being added to their self inductance, as is the case in the original circuits, since the effect is of a continuous coil, and, if this is symmetrically distributed, no external field results. But the loss is considerable when the current in the phantom traverses the windings in parallel, with the mutual inductance opposing the self inductance, for in this instance the two windings produce between them in the core adjacent portions of the same polarity from which the lines of force stream into the case. As the toroidal coil has proved in practice to be the most compact and effective which has been designed, it is expedient to retain it, and the problem which this invention aims to solve is the elimination of the excessive energy losses from a phantom circuit, the component circuits of which are loaded with toroidal or similar coils.

The invention also contemplates an arrangement whereby the circuits are substantially freed from crosstalk which might occur in the loading coils.

Figure 1 of the accompanying drawings shows diagrammatically two loaded phantomed lines equipped according to my system; Fig. 2 is an enlarged diagram illustrating one of the coils employed; and Fig. 3 illustrates diagrammatically the distribution of the admittances in a coil.

Similar characters are used to indicate like parts in all figures of the drawings.

The reference characters L and L^2 designate, respectively, the opposite limbs of two metallic circuit telephone lines, each having terminal stations A, A. Near the extremities of both lines are the usual simplex repeating coils C, to the center of one winding of each of which is joined a conductor L^3 which continues to stations A^2 the phantom circuit furnished by the pairs of conductors L, L^2 in parallel. Current from batteries B is supplied to the physical and phantom circuits through repeating coils C^2. In both of the lines L, L^2 are included loading coils D, there being a sufficient number to introduce the required amount of inductance. Each coil may comprise a core of iron wire constructed in the customary manner as a continuous ring, which for convenience in defining the invention is considered to have opposite sections 10 and 10^a about which the windings are placed. But the core may or may not be continuous, and when its sections are referred to they are to be understood as consisting of such opposite halves or portions, without reference to the condition of the magnetic circuit. The coils are inclosed in the usual iron cases indicated at 11.

In the present invention the windings for each side of the line consist of two sections of conductor with both windings encircling the entire core, there being a section of each winding upon each half core. Referring to either of the physical circuits, upon the core section 10 is a winding section 12 for the

conductor L of the line, and over the core section 10^a is a winding section 12^a belonging to the same line conductor, while the line conductor L^2 includes opposite windings 13 and 13^a. To render the coil symmetrical in the relation of its windings to one another and to the core, the sections are of approximately equal impedance and are placed alternately about the core and outside the sections of the companion winding. That is, the winding sections 12 and 13 encircle insulating material 14 covering the core sections 10 and 10^a, respectively, while winding sections 12^a and 13^a surround the winding sections 13 and 12, respectively, being separated therefrom by a layer 15 of insulation. This may be best seen in Fig. 2 of the drawing, where, to make the diagram more clear, the conductors are shown as concentric to the axis of the core; but it is to be understood that they actually surround the core as appears in Fig. 1. It will be noted that Fig. 2 shows the inner and outer sections as having a different number of layers. This is for convenience in bringing out the terminals; the impedance of the sections may, in spite of this, be made the same. The windings are of such length and direction and the sections are so connected that the desired inductance is introduced into each side of the physical circuit, the effective resistance being about the same as in the standard loading coil; and, on account of the symmetrical arrangement of the sections of the windings, it will be evident that a very perfect balance as to inductance, capacity and resistance may be maintained between them. When its effect upon the sides of the phantom is considered, it will be found that, since each winding embraces the entire core, neither will produce an external field. Therefore, the magnetic leakage is so reduced that but little energy is wasted in this way, and the effective resistance imposed upon the phantom by this improved organization is slight. The inductance of the two windings in parallel is negligible, therefore the phantom circuit is not loaded.

Between the superposed windings of coils, and between said windings and the core and case, there tends to be an electrostatic transfer of energy, and consequently crosstalk affecting the phantom and its component circuits, as a result of the direct admittances between the elements. With respect to the admittances from winding to winding, these may substantially balance one another, but, unless specially guarded against, those to core and case will be from points at different potentials and will act as bridges through which current flows. This capacity effect is practically localized at the outside of the windings, that is, at the first and last layers. I therefore so dispose the sections of the windings that the layers which are most closely adjacent to the core and case, respectively, are at substantially equal potential with respect to the current in the phantom circuit, while adjacent layers of the different sections are also at the same potential. This is best illustrated in Fig. 3 of the drawings. In this diagram the outer layers are represented as points and the admittances as condensers or capacities. In each winding the layers next to the core and case are succeeding portions at opposite sides of the junctures of the sections 12, 12^a and 13, 13^a. The admittances from winding to winding are between ends of the windings similarly located in the circuit. As a result of this organization, the admittances are perfectly balanced, and this, together with the otherwise symmetrical distribution of the windings previously mentioned, will eliminate crosstalk between the phantom circuit and the side in which the coil is inserted.

It may be said generally of the improved loading coil hereinbefore described, that its loading effect upon the physical circuits is secured without materially altering the working characteristics of the phantom circuit.

To show the results attained by a particular embodiment of my invention the following data is given: A loading coil of the old type, through which passed an alternating current of 800 microamperes at 800 periods per second, has been found to put upon a physical circuit a resistance of 9 ohms and an inductance of 0.176 of a henry, and upon a phantom circuit, of which its line formed one side, a resistance of 3.2 ohms and an inductance of 0.006 of a henry. A coil constructed and applied to the circuits as herein described, and consisting of the usual core of iron wire with approximately the same number of turns of conductor, gave the physical circuit under the same current conditions an effective resistance of 8.3 ohms and an inductance of 0.174 of a henry, while there appeared in the phantom but 0.83 of an ohm and 0.000068 of a henry.

I claim:

1. The combination with two telephone lines, of means for producing a phantom circuit from said lines, and a loading coil included in each of the component lines of the phantom circuit, each coil being provided with a core and windings thereon symmetrically arranged to minimize the magnetic leakage resulting from operating currents in the phantom circuit.

2. In a telephone system, line circuits associated to furnish a phantom circuit, and loading coils for the line circuits comprising a winding included in each side of its circuit, one of said windings surrounding the other.

3. In a telephone system, metallic circuits

associated to furnish a phantom circuit, and loading coils for the metallic circuits comprising a ring-shaped core about which is a sectional winding included in each side of its circuit, the sections of the same winding being upon opposite halves of the core and one section belonging to each side of the circuit being surrounded by a section belonging to the other side.

4. In a telephone system, line circuits associated to furnish a phantom circuit, and a loading coil for one of the circuits, said coil having sectional windings, the admittances between each section and other elements of the coil with respect to current in the phantom circuit being symmetrically distributed.

5. In a telephone system, line circuits associated to furnish a phantom circuit, and a loading coil for one of the circuits, said coil having sectional windings with each section including a plurality of layers, portions of sections which are in electrostatic inductive relation with like elements of the coil being at substantially equal potential.

6. In a telephone system, line circuits associated to furnish a phantom circuit, and a loading coil for one of the circuits, said coil comprising sectional windings surrounding one another with adjacent layers of different sections situated at points in a circuit at substantially equal potential.

7. In a telephone system, line circuits associated to furnish a phantom circuit, and a loading coil for one of the circuits, said coil comprising windings and associated elements in proximity to the windings, the layers of different sections which are adjacent to the same associated element being at points in the circuits at substantially equal potential.

8. In a telephone system, line circuits associated to furnish a phantom circuit, and a loading coil for one of the line circuits, said coil having sectional windings, the admittances between each section and other elements of the coil being distributed in such a symmetrical manner that like elements in the coil are at substantially equal potential with respect to the phantom current.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this twenty eighth day of January, 1910.

THOMAS SHAW.

Witnesses:
FRANK B. JEWETT,
KENNETH S. JOHNSON.