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MEANS FOR REDUCING REFLECTION LOSSES IN DUPLEX CIRCUITS.

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Fig. 1.

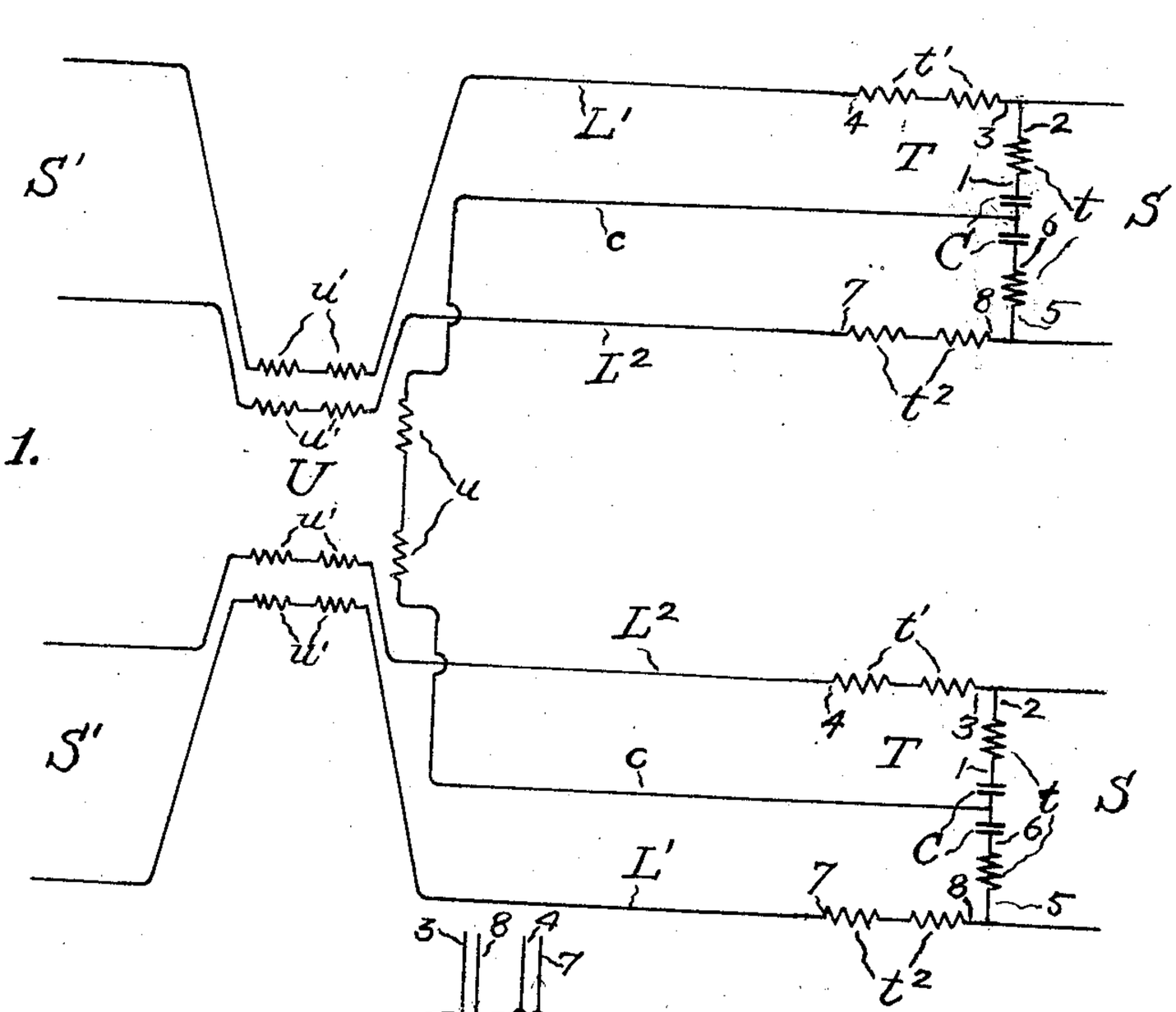
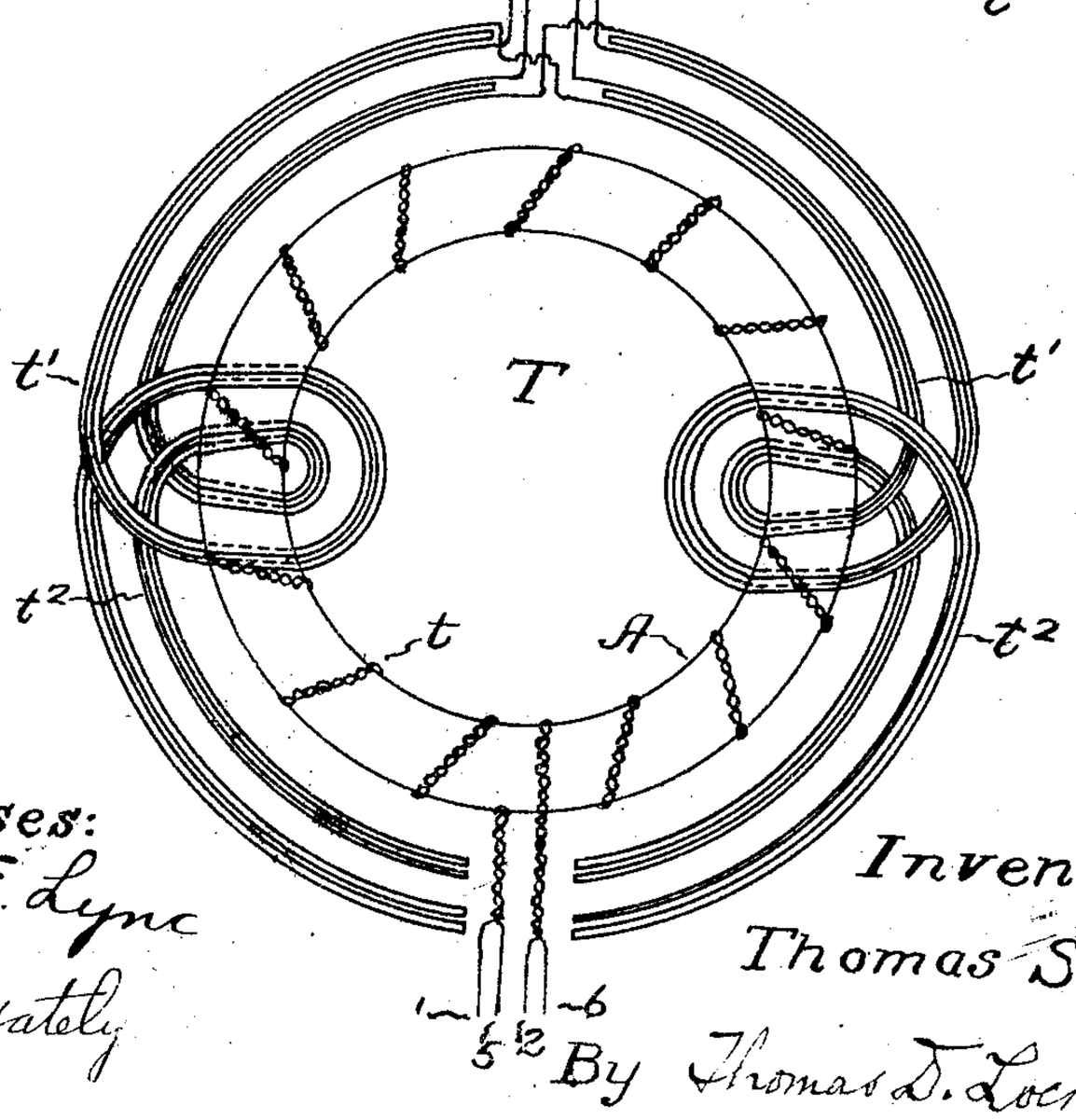


Fig. 2.



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MEANS FOR REDUCING REFLECTION LOSSES IN DUPLEX CIRCUITS.

1,092,956. Specification of Letters Patent. Patented Apr. 14, 1914.

Application filed February 28, 1913. Serial No. 751,239.

To all whom it may concern:

Be it known that I, THOMAS SHAW, a citizen of the United States, residing at Hackensack, in the county of Bergen and State of New Jersey, have invented certain Improvements in Means for Reducing Reflection Losses in Duplex Circuits, of which the following is a specification.

To decrease the transmission losses caused by reflection at the junction of telephone lines of different impedance, a well known expedient consists in connecting these lines through a transformer adapted to step up or down, as the case may be, the impedance of one line to that of the other; this reflection reducing means being most effective when the impedance ratio of the transformer equals the ratio of the impedance of the lines.

The present invention has for its object certain improvements in reflection reducing means of this character, it being especially applicable to duplex telephone circuits, as a phantom circuit and the side or physical circuits of which it is composed.

Because of the greater efficiency over the separate winding transformer, both with respect to copper and iron losses, of the type of device commonly known as an autotransformer, in which the windings are conductively connected, and because of its maintenance of the direct conductive continuity of the circuits, this device is useful in the present connection, and with it my invention is more specifically concerned.

In the accompanying drawings, in which similar reference characters designate like parts throughout, Figure 1 shows diagrammatically duplex circuits having my invention applied thereto; and Fig. 2 is a diagram in greater detail of an autotransformer illustrating an embodiment of the invention.

Referring to Fig. 1 of the drawings, there are portions of duplex telephone circuits, these comprising in the present instance the physical or side circuits, each consisting of conductors L^1 and L^2, and the phantom circuit furnished by the conductors L^1 and L^2, in parallel, together with the usual terminal arrangements. In describing this invention it will be assumed that at least one of the side circuits is made up of successive lines or line sections S and S^1 of different impedance, S presenting less impedance than S^1, at the junction of which reflection losses tend to occur. These portions S and S^1 of the circuits may consist of normally independent lines temporarily joined to give a transmission circuit of greater length, or may be merely sections of a circuit permanently connected, but hereafter when the term line sections is used it is to be understood to apply to either arrangement.

At the junction of sections S and S^1 is an inductive repeating device, preferably an autotransformer T conventionally represented in Fig. 1 and more completely in Fig. 2. Such a transformer appears in each of the side circuits, though but one will be particularly described. It has two sets of windings t and t^1, t^2, which may conveniently be called the bridge and series windings, respectively. The winding t is bridged across the junction of the two circuit sections, while the series windings are connected to the extremities of the bridge in each of the conductors L^1 and L^2 in the high impedance section S^1. The current in the high impedance section flows through the bridge and series windings, the latter carrying this current only. The resultant current in the bridge winding is the difference between that in the low and high impedance sections, the current of the low impedance section being confined to said bridge winding.

To allow common battery signaling, and for other purposes in which a metallic bridge of the line is objectionable, the continuity of the winding t is broken by a condenser, or preferably a balanced system of condensers C, C, from between which any desired connection, as c, may be led. This conductor c is here shown as joined to an extremity of the bridge winding u of an autotransformer U, having series windings u^1 in each of the conductors of both side circuits. This transformer U, which belongs to the phantom circuit, will not be further described, its details playing no part in the present invention.

One of the principal aims in a reflection reducing device applied to duplex circuits is to cause the production of its full effect upon the circuit to which it is directly related, while minimizing the effect upon the associated circuits. That is, in the present instance the impedance of the bridge winding t should correspond as closely as possible to the impedance of the section S of the physical circuit, and the impedance of the bridge winding t and the series windings t^1, t^2 to-

gether in series to that of the section S¹. But for the phantom circuit of which the physical circuit is a component, the impedances of the transformer should be as nearly as possible negligible. At the same time the transformer should be so organized as not to introduce electromagnetic or electrostatic crosstalk between the side and phantom circuits, the operating current in both of which traverse it. These features are provided by the present invention. The preferred arrangement of the elements of the transformer is illustrated in detail in Fig. 2. The windings are best identified in this figure by numbers applied to their terminals; these numbers also appearing in their proper relation in Fig. 1. A core A having a closed magnetic circuit is shown, this being preferably of toroidal form. Extending about the entire core is the bridge winding t and the series windings t^1 and t^2. The winding t is divided into sections between which the condensers are inserted, these sections having the terminals 1—2 and 5—6. The series winding t^1 in conductor L^1 has the terminals 3—4, and the series winding t^2 in conductor L^2 has terminals 7—8. Each series winding may be divided into two sections, all the sections having the same number of turns. Either the bridge or series windings preferably consist of a twisted pair of conductors. In the present instance the bridge winding is thus arranged, and it is situated next to the core. Each series winding also embraces the entire core with its sections upon opposite halves, the sections of the same winding being at different distances from said core. In other words, each series winding has inner layers upon one portion of the core next to the bridge winding, and outer layers upon the opposite portion. As these windings are distributed and connected, they are in series with respect to current in the side circuit with their mutual inductance aiding the self inductances; and the impedance ratio, which controls the reflection reducing efficiency of the device, will be the ratio of the impedance of windings 4—3, 2—1, 6—5 and 8—7, in series-aiding, to that of the bridge winding sections 2—1, 6—5 similarly related. The effect of the transformer on the phantom circuit will be to include therein impedance equal to the series windings 4—3, 7—8 in parallel with their mutual inductance opposing their self inductances, plus the bridge winding sections 2—1, 5—6 also in parallel-opposing. Because of the symmetrical arrangement of the windings, the mutual inductance between one portion of the bridge winding and the series windings will balance that between the other portion and the series windings; and since the uniform distribution of the windings about the entire core avoids any substantial leakage impedance between them, the effect of the transformer upon the phantom circuit will amount only to the introduction of the practically negligible direct current resistance of the transformer windings in parallel groups.

A very complete impedance balance is obtained in this transformer with a resultant freedom from electromagnetic crosstalk between the side circuit and the phantom. This results from the equality of the sections in the bridge and series windings, respectively, and the symmetrical distribution of these sections. The twisting of the bridge sections together gives perfect mutual symmetry with regard to the series windings. Nothing would be gained in this direction by also twisting the series windings, and by interleaving the latter good balance is obtained between them without the introduction of transmission losses through shunt capacities, which are greater in twisted conductors. As to electrostatic crosstalk through direct admittances, these are symmetrical and balance one another in the organization illustrated, except between the bridge winding and the core, and between the outer layers of said bridge winding and the inner layers of the series windings, between which there will be differences of potential. This, however, does not cause serious disturbance and may be less objectionable than further complication in the transformer construction.

By properly proportioning the various transformer windings an impedance ratio may be obtained adapting it to any particular values of circuit section impedance, and therefore leading to a maximum reflection reducing efficiency. I will give the approximate data for a transformer such as hereinbefore described, having the ratio of 3 to 1. The bridge winding sections 1—2 and 5—6 may each have 635 turns of conductor with a direct current resistance of 5 ohms, and the series windings 3—4 and 7—8 each 465 turns with a direct current resistance of 5 ohms. For each side circuit there will be introduced, for a frequency of 800 cycles and neglecting the condensers, series impedance of 190 ohms and 0.8 henry, a bridge impedance of 342 ohms and 1.49 henrys, and a mutual impedance of 244 ohms and 1.085 henrys. For the phantom circuit there will be series and bridge impedance of 3 ohms and 0.0005 henry each.

The matter disclosed herein relating to the phantom circuit coil situated at the junction of the phantom sections and to the combination of this coil and the side circuit coil located between the line sections is not herein claimed, as the same forms the subject matter of and is claimed in my copending application Serial No. 751,288, filed February 28, 1913. The transformer construction U, also shown herein and not

claimed, forms the subject-matter of and is claimed in my copending application Serial No. 792,474, filed September 29, 1913, which is a division of my application Serial No. 751,288.

I claim:

1. Two physical circuits associated to furnish a phantom circuit, each of the physical circuits comprising successive sections of different impedance, a transformer having a winding bridged across the junction of the sections and other windings in series with the high impedance section, and a connection to the bridge winding for the current in the phantom circuit.

2. Two physical circuits associated to furnish a phantom circuit, each of the physical circuits comprising successive sections of different impedance, a transformer having a winding bridged across the junction of the sections, and other windings in series with the high impedance section, a connection to the bridge winding for the current in the phantom circuit, and condensers in the bridge on each side of the connection for the phantom circuit.

3. The combination with line sections, of a transformer at the junction of the line sections, said transformer comprising a core, a winding upon the core bridged across the line sections, and other winding in series with a section, one of said windings consisting of a twisted pair.

4. The combination with line sections, of a transformer situated at the junction of the sections and having a core, a winding upon the core bridged across the sections, and other windings in series with one of the sections, one of said windings consisting of a twisted pair extending about the entire core.

5. The combination with line sections, of a transformer situated at the junction of the sections and having a core, a winding upon the core bridged across the sections, and other windings in series with one of the sections, the bridge winding consisting of a twisted pair extending about the entire core.

6. The combination with line sections, of a transformer situated at the junction of the sections and having a core furnishing a closed magnetic path, a winding upon the core bridged across the sections, and other windings in series with one of the sections, one of said windings extending about the entire core and the other windings being on different portions of the core and at different distances therefrom.

7. The combination with line sections, of a transformer situated at the junction of the sections and having a core, a winding upon the core bridged across the sections, and other windings in series with a section, one of said windings extending about the entire core and the other windings being in sections with the sections of each winding on different portions of the core.

8. The combination with line sections, of a transformer situated at the junction of the sections and having a core furnishing a closed magnetic path, a winding upon the core bridged across the sections, and other windings in series with one of the sections, the bridge winding consisting of a twisted pair extending about the entire core and the series windings being in sections on opposite halves of the core.

9. The combination with line sections, of a transformer situated at the junction of the sections and having a core furnishing a closed magnetic path, windings upon the core bridged across the sections, and other windings in series with one of the sections, one of said windings consisting of a twisted pair extending about the entire core and the other windings being in sections with the sections of each winding on different portions of the core, the sections of different windings being at different distances from the core.

10. Two physical circuits associated to furnish a phantom circuit, each of the physical circuits comprising successive sections of different impedance, a transformer having windings in series traversed by current in the high impedance section, and another winding having conductive connection with said windings and traversed by the resultant current of associated sections, and a connection to the last-named winding for the current in the phantom circuit.

11. Two physical circuits associated to form a phantom circuit, each of the physical circuits comprising successive sections of different impedance, a transformer having windings traversed by current in one of the physical circuits and a winding having conductive connection with said windings and traversed by the resultant current of both of said physical circuits, a connection to the last-named winding for the current in the phantom circuit, and condensers on each side of the connection for the phantom circuit.

12. The combination with line sections, of a transformer at the junction of the line sections, said transformer comprising a core, windings in series upon the core traversed by current in one section, and another winding having conductive connection with said windings and traversed by the resultant current of associated sections, one of said windings consisting of a twisted pair.

13. The combination with line sections, of a transformer at the junction of the sections and having a core, windings in series on said core traversed by current in one section, another winding upon said core having conductive connection with said windings and traversed by the resultant current of associ-

ated sections, one of said windings consisting of a twisted pair extending about the entire core.

14. The combination with line sections, of a transformer situated at the junction of the sections and having a core, windings in series upon said core traversed by current in one section and another winding having conductive connection with said windings, traversed by the resultant current of associated sections and consisting of a twisted pair extending about the entire core.

15. The combination with line sections, of a transformer at the junction of the sections having a core furnishing a closed magnetic path, windings in series upon said core traversed by current in one section, another winding upon said core having conductive connection with said windings and traversed by the resultant current of associated sections, one of said windings extending about the entire core and the other windings being on different portions of the core and at different distances therefrom.

16. The combination with line sections, of a transformer at the junction of the sections and having a core, windings in series upon the core traversed by current on one section, another winding upon the core having conductive connection with said windings and traversed by the resultant current of associated sections, one of said windings extending about the entire core and the other windings being in sections with the sections of each winding on different portions of the core.

17. The combination with line sections, of a transformer situated at the junction of the sections and having a core furnishing a closed magnetic path, windings in series upon said core traversed by current in one section, another winding upon said core having conductive connection with said windings, traversed by the resultant current of associated sections and consisting of a twisted pair extending about the entire core, the series windings being in sections on opposite halves of the core.

18. The combination with line sections, of a transformer situated at the junction of the sections and having a core furnishing a closed magnetic path, windings upon the core in series traversed by current in one of the sections, other windings upon the core having conductive connection with said first-named windings traversed by the resultant current of associated sections, one of said windings consisting of a twisted pair extending about the entire core and the other windings being in sections with the sections of each winding on different portions of the core, the sections of different windings being at different distances from the core.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses this eighteenth day of February, 1913.

THOMAS SHAW

Witnesses:
ELAM MILLER,
LLOYD ESPENSCHIED.