T. SHAW.

TRANSFORMER.

APPLICATION FILED SEPT. 29, 1913.

1,133,750. Patented Mar. 30, 1915.

Fig. 1.

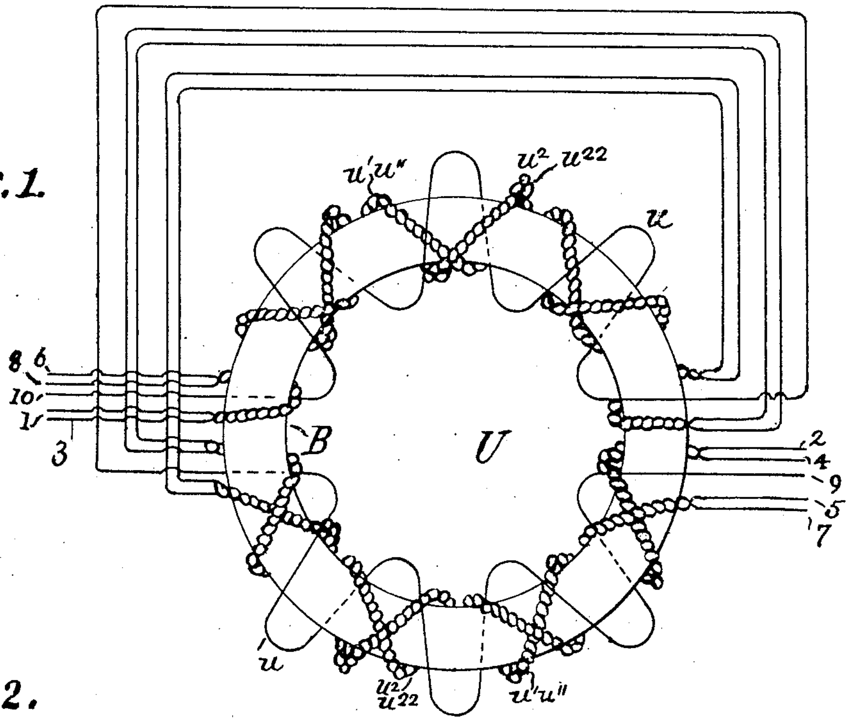
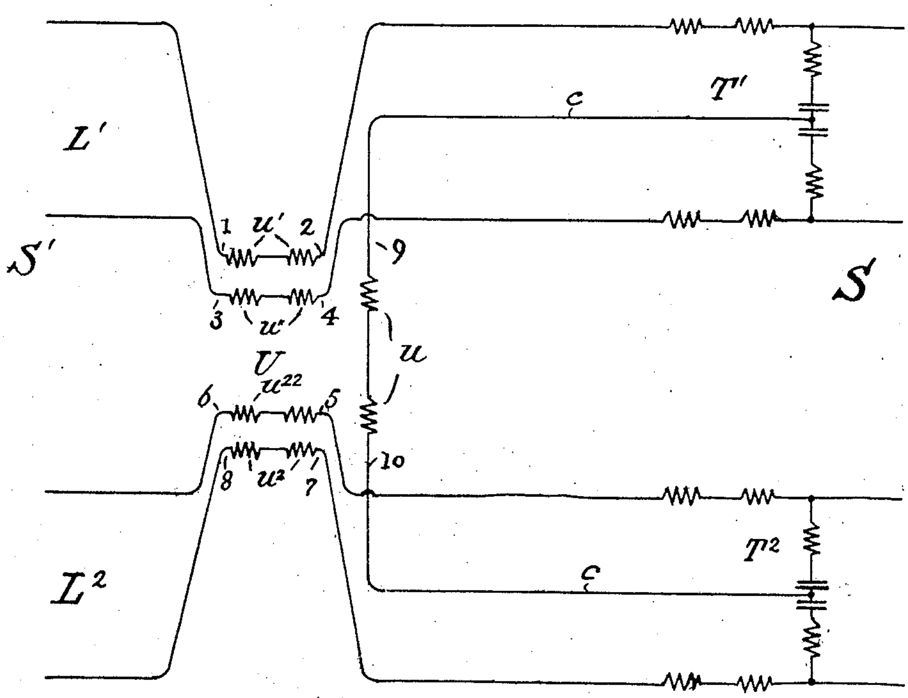


Fig. 2.



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UNITED STATES PATENT OFFICE.

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TRANSFORMER.

1,133,750. Specification of Letters Patent. **Patented Mar. 30, 1915.**

Application filed September 29, 1913. Serial No. 792,474.

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 Transformers, of which the following is a specification.

This invention relates to electrical transformers, and especially those intended for use in phantom telephone circuits, its principal objects being to provide an efficient device of this character which shall be so balanced as to minimize crosstalk.

The invention is illustrated in one of its embodiments in connection with a system for reducing reflection losses in phantom circuits, which is the subject of my application for Letters Patent filed February 28, 1913, Serial No. 751,288, of which this application is a division.

Figure 1 of the drawing represents my improved transformer diagrammatically; and Fig. 2 shows it connected in the phantom circuit.

Similar characters of reference designate like parts throughout.

In Fig. 2 appears a portion of a phantom telephone circuit consisting of physical circuits L′, L^2 with the conductors in parallel furnishing the sides of the phantom. The physical circuits are considered to be in successive sections furnished by connected lines or portions of a single line, these sections presenting different impedances. The phantom would therefore have corresponding sections S, S′, likewise different in impedance, S being the low and S′ the high impedance section. At the junction of these sections reflection losses naturally occur.

Included in the phantom circuit between the high and low impedance sections is a reflection reducing device consisting of my improved transformer U, connected in the present instance as an autotransformer. The windings u and u', u'', u^2, u^{22} of this transformer may be looked upon as bearing a bridge and series relation to the phantom. u' and u'' are separately in series with the two conductors of the side circuit L′, while u^2, u^{22} are similarly included in the conductors of L^2. Winding u is bridged by conductors c, c between neutral points of the side circuits through a suitable combination of inductances and capacities, here illustrated as in the bridge windings of autotransformers T′, T^2 belonging to the respective side circuits L′, L^2. The bridge winding u of transformer U, by virtue of its connection with the said circuits, is entirely independent of operating current therein and carries only operating current for the phantom, this being the difference between the current in the high and low impedance phantom sections. The current in said low impedance section does not traverse the series windings of the transformer U, through which flows the current in the high impedance section of the phantom, together with the operating current of the respective side circuits.

It is desired that the transformer U shall produce its full reflection reducing effect upon the phantom circuit without substantial effect upon the side circuits. To this end the impedance of the bridge of the phantom, which consists mainly of the impedance of the winding u, should approximate the impedance of the phantom section S; and the impedance of the bridge plus that of the series windings u', u'', and u^2, u^{22} should correspond to the impedance section S′. On the other hand, the side circuits should not be materially affected by the transformer U. The relation between the windings of the transformer should also be such as to minimize electromagnetic and electrostatic crosstalk between the phantom and its sides and between said sides.

Referring to Fig. 1, where, in addition to the letters indicating the windings as a whole, numerals are applied to designate the terminals, it will be seen that the series windings 1—2, 3—4 and 5—6, 7—8 corresponding to the side circuits L′ and L^2, respectively, are each in the form of a twisted pair of conductors with each pair encircling the entire core B of the transformer, this core furnishing a closed magnetic circuit, it being preferably toroidal. Each series winding is arranged to balance as to resistance and inductance by being divided into sections each having an equal number of turns and occupying opposite halves of the core, with the sections on each half at different distances from the core; that is, one section of each pair is adjacent to the core and the other section outside a section of the companion pair.

Over the series windings is placed the bridge winding 9—10, also enveloping the whole core and being in sections equally divided between the halves of said core. With the elements of the transformer in the relation shown, and considering first the phantom circuit, the series windings of each side circuit are in parallel, with the mutual inductance aiding the self inductances; and taken together the side circuit windings are in series with the mutual inductance between the pairs aiding the self inductances. Furthermore, the mutual inductance between the bridge winding and all the series windings increases the total inductance of the transformer for the phantom. The reflection reducing efficiency of the device may be expressed by the ratio of the impedance resulting from the series connection of the bridge winding 9—10 and the pairs 1—2, 3—4 and 5—6, 7—8 of the series windings in inductive-aiding relation (it being remembered that each of these pairs of series windings considered separately is in parallel inductively aiding) to the impedance of the bridge winding. As the peculiar connection of the bridge winding prevents its influencing the side circuits, the only effect of the transformer upon the side circuit will be the series opposing impedance of the series windings, which will be equivalent to their direct current resistance only.

The careful impedance balance between the various windings of the transformer practically eliminates electromagnetic cross-talk through it between the phantom and its sides. The twisting of both pairs of series windings and the alternating of the sections give perfect mutual symmetry with respect to the bridge winding, and of course one to the other. As to electrostatic cross-talk, the only direct admittances which can cause this and which are unsymmetrical are those between the outer layers of the series windings and inner layers of the bridge winding. This is comparatively unimportant.

By properly proportioning the various windings of the transformer U an impedance ratio may be obtained adapting it to any particular values of impedance of the circuit sections. I will give the approximate data for a transformer such as hereinbefore described having the ratio of 3 to 1. The sections of the bridge winding may have 1,000 turns of conductor with a direct current resistance of 8 ohms; series windings 1—2, 3—4; 5—6, 7—8, each 365 turns with a direct current resistance of 4 ohms. For the phantom circuit there will be introduced by the transformer at a frequency of 800 cycles a series impedance of 124 ohms and 0.493 henry, a bridge impedance of 233 ohms and 0.925 henry and a mutual impedance of 163 ohms and 0.67 henry. For each side circuit there will be a series impedance of 8 ohms and 0.001 henry.

I claim:

1. A transformer comprising a core, windings on the core consisting of plural conductors arranged in sections on different portions of the core, the sections being at different distances from the core, and a winding consisting of a single conductor extending about the entire core.

2. A transformer comprising a core, windings on the core consisting of plural conductors arranged in sections on different portions of the core, the sections being at different distances from the core, and a winding consisting of a single conductor extending about the entire core outside the sectional windings.

3. A transformer comprising a core, windings on the core consisting of a plurality of pairs of twisted conductors, said pairs being balanced with respect to resistance and inductance, and another winding consisting of a single conductor.

4. A reflection reducing transformer comprising a toroidal core, windings on the core including a plurality of pairs of twisted conductors, each pair being in sections situated on different portions of the core with the sections of the same winding at different distances from the core.

5. A transformer comprising a toroidal core, windings on the core consisting of a plurality of pairs of twisted conductors, and another winding consisting of a single conductor, the twisted windings being in sections situated on different portions of the core with the sections of the same winding at different distances from the core and with the single conductor farthest from the core.

6. A transformer comprising a core, windings on the core consisting of plural conductors arranged in sections on different portions of the core, the sections of the same winding being at different distances from the core on the different portions thereof, and a winding consisting of a single conductor extending about the entire core.

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

THOMAS SHAW.

Witnesses:
W. M. Gould,
John F. Rhame.