

G. A. CAMPBELL.
INDUCTION COIL.
APPLICATION FILED OCT. 8, 1904.

2 SHEETS—SHEET 1.

Fig. 1.

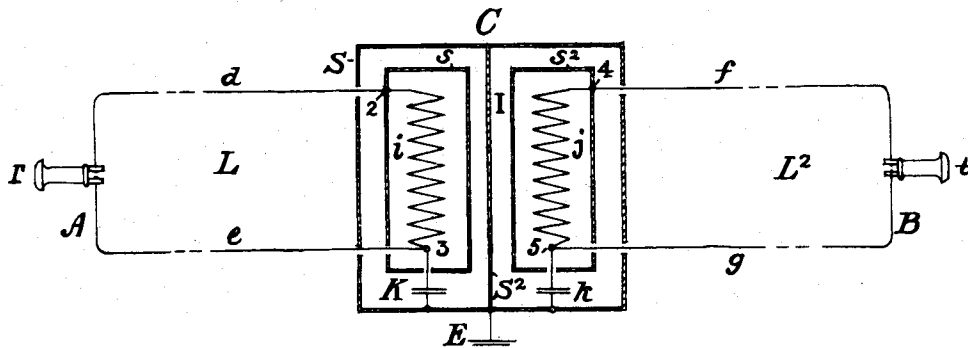


Fig. 2.

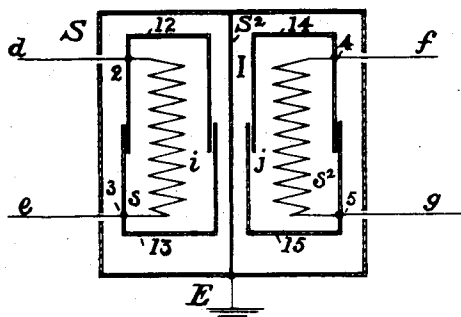
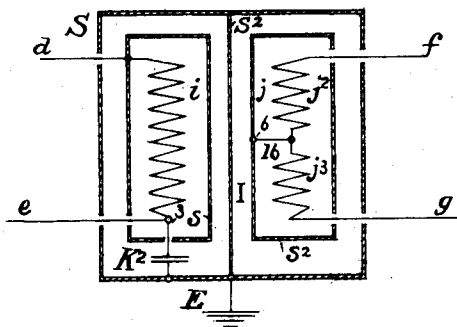


Fig. 3.



WITNESSES:

Joseph Algate
James E. Lynch

INVENTOR.

George A. Campbell
BY Thomas J. Lockwood

ATTORNEY.

G. A. CAMPBELL.
INDUCTION COIL.

APPLICATION FILED OCT. 8, 1904.

2 SHEETS—SHEET 2.

Fig. 5.

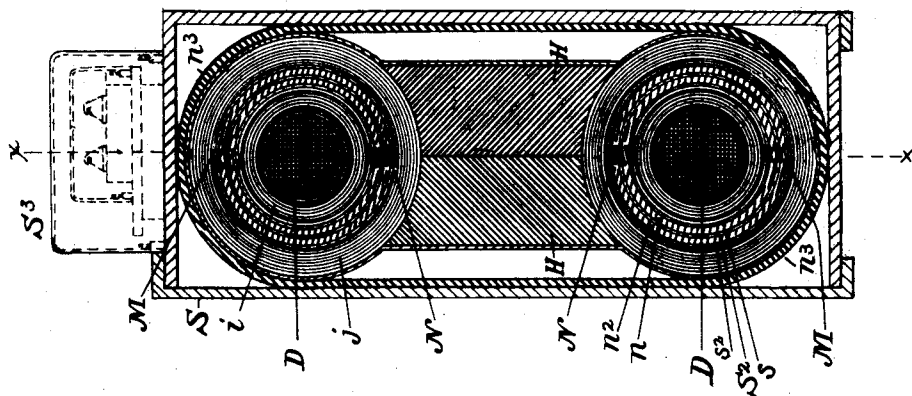
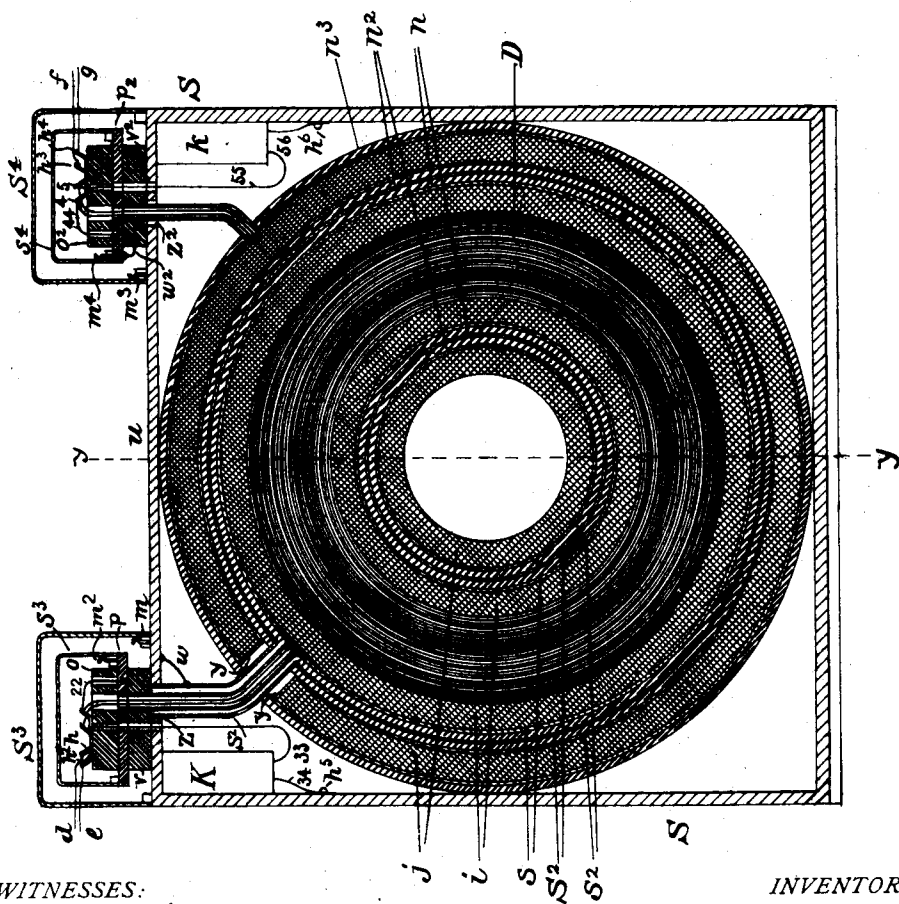


Fig. 4.



WITNESSES:

Joseph Albately
James E. Lynch.

INVENTOR.

BY *George A. Campbell*
Thomas D. Lockwood
ATTORNEY.

UNITED STATES PATENT OFFICE.

GEORGE A. CAMPBELL, OF NEWTON, MASSACHUSETTS, ASSIGNOR TO
AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION
OF NEW YORK.

INDUCTION-COIL.

SPECIFICATION forming part of Letters Patent No. 792,248, dated June 13, 1905.

Application filed October 8, 1904. Serial No. 227,722.

To all whom it may concern:

Be it known that I, GEORGE A. CAMPBELL, residing at Newton, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Induction-Coils, of which the following is a specification.

In the operation of telephone-circuits it has been demonstrated by experience that freedom from disturbance and the most satisfactory operation can be looked for only when the circuit is well balanced. This condition of good work has long been known; but with the steady expansion of telephone systems and the increasing length of lines its importance is becoming more fully recognized. One practical expedient for facilitating the production and maintenance of the required balance in the circuit-conductors and apparatus involves the introduction and employment in the circuit of repeating-coils, which practically divide a line of telephonic communication into two or more circuits or conductive sections of circuits; but while a repeating-coil thus aids in establishing and maintaining the required balance, and this especially where employed to establish connections between metallic and grounded circuits in the manner shown and described by United States Patent No. 232,788, issued to Thomas A. Watson and dated September 28, 1880, it is possible that it may itself, and it sometimes does, constitute an unbalancing element by reason of an unsymmetrical distribution of the resistance, inductance, and capacity of its windings. Moreover, although by careful proportionment, arrangement, and construction a coil can be made wherein an apparently symmetrical disposition of these magnitudes is effected it is very difficult even in this manner to secure a coil which when connected and operated in a circuit is found to be perfectly balanced.

The object of the present invention is to provide simple means applicable to repeating and other induction coils for securing a perfect balance for any circuit wherein such coils may be connected or for enabling such coils to be connected in an electric circuit without disturbing an electric balance previously es-

tablished therein; and the said invention, stated generally, consists in the combination of a repeating-coil or other induction-coil or transformer and its several windings with conducting-shields whereby the windings may be effectually screened or shielded from one another and both or the coil as a whole from any external source of disturbance.

The invention is illustrated by the accompanying drawings, wherein—

Figures 1, 2, and 3 are diagrams of different electrical arrangements of induction-coils thus shielded, while Figs. 4 and 5 show, respectively, central cross-sections of a repeating induction-coil of toroidal form, wherein the invention has been incorporated, Fig. 4 being taken on the line *x x* of Fig. 5 and Fig. 5 on the line *y y* of Fig. 4.

The diagrams Figs. 1, 2, and 3 each indicate a repeating induction-coil I, having separate windings *i j*. When connected in a telephone-circuit or interposed between two telephone-circuits, as shown in Fig. 1, either winding at any particular moment may be the primary and either the secondary, this being determined by the direction of transmission at such moment.

In Fig. 1, *L* and *L*² are telephone-circuits extending from telephone instruments *T t* at stations *A* and *B*, respectively, to an intermediate station *C*, where both are associated with the repeating-coil I, the circuit *L* being connected with winding *i* and circuit *L*² with winding *j*. The repeating-coil is shown as being provided with three conducting-shields *s*, *s*², and *S* and two condensers *K* and *k*. The shield *s* surrounds the winding *i* and is conductively connected with the outer terminal thereof at 2, being thereby also in conductive relation to circuit *L*. The shield *s*² in like manner is placed round the winding *j* and attached at 4 to a terminal thereof, preferably the one having the greater capacity to the shield, being thus brought into conductive connection with circuit *L*², while an outer shield *S*, grounded at *E* and having a middle partition *S*², surrounds both of the windings with their shields *s s*² and screens them from

each other. The condenser K is connected between the shield S and the terminal 3 of winding i to balance the capacity between shields s and S, thus making the direct capacity between shield S and each of the winding-terminals the same, and the condenser k is introduced to balance in the same way the capacity between the inner shield s^2 and the outer shield S, being connected between winding j at the point 5 and the said outer shield S. A repeating-coil shielded in this manner is perfectly balanced howsoever unsymmetrical may be the distribution of the resistance, inductance, and capacity or the mutual inductance between the two windings, and a coil of such construction introduced into or connected in any circuit divides the same and is itself divided into two sections, either of which will maintain its balanced condition absolutely irrespective of what may occur upon the other section. The shields should be constructed of some good conducting material and are to be suitably insulated from one another. In apparatus embodying this invention which has been made and used shields of sheet-copper have proved satisfactory; but tin-foil may be employed and is in every respect appropriate material. Figs. 4 and 5 illustrate the practical application of these shields in the manner diagrammatically indicated by Fig. 1 to a repeating induction-coil of preferred toroidal form and show, respectively, concentric and diametric sections of such coil. In these figures the conductors of windings i and j are shown as being wound over an iron core D, made of iron wire or iron otherwise divided or laminated in a plane normal to the direction of magnetization and formed into a closed magnetic circuit, the winding i being innermost or nearest to said core. Between the two windings i and j three layers of sheet metal or metal foil are in-folded, and a fourth layer surrounds the outer winding j externally. The sheet nearest to the winding i constitutes the shield s , the second one forms the intermediate partition S^2 of the external shield S, and the third and fourth together form the shield s^2 of the winding j and, as shown at y , Fig. 4, are in conductive connection with one another. These shields are insulated from each other by interposed layers of cloth or other suitable non-conducting fabric, a layer n being interposed between the innermost and second coatings of metal s and S^2 and a layer n^2 between the said metal coatings S^2 and s^2 , while a layer n^3 also overlaps the external or fourth metallic coating. Surrounding the entire repeating-coil is an iron case which serves as the outer or inclosing shield S. Apertures z are provided on one side u of the said iron case, through which the ends of the windings i and j are brought for attachment to their terminal clips h h^2 h^3 h^4 , said clips being mounted in pairs upon non-conducting blocks o o^2 within

conducting - housings s^3 s^4 , supported upon other non-conducting blocks v v^2 , and thereby insulated. Outer conducting-housings S^3 S^4 are also furnished, these being in conductive connection with the iron casing-shield S and inclosing the housings s^3 s^4 , the terminal clips contained therein, and the non-conducting blocks o and v . The outer and inner ends of the inner winding i brought out through aperture z are attached to the terminal clips h and h^2 , respectively, and to these clips the wires d and e of the external circuit L, entering through suitable openings in the housings S^3 and S^4 , are also secured. The conductive connection between the outer end of winding i and the shield s , mentioned in describing Fig. 1 as occurring at the point 2, is established by the short conductor 22, which passing through the block o unites the clip h with the conducting base-plate p of the housing s^3 , which is itself directly connected with the inner layer of sheet metal forming the said screen s . The connection through the condenser K from the inner terminal of winding i at the point 3 to the exterior and inclosing shield S is formed by conductor 33, which unites one terminal of the condenser (which is fixed in one of the corners of said shield) to the terminal clip h^2 and conductor 34, which unites the other terminal of said condenser to the substance of the shield S at h^3 . The middle layer of sheet metal forming the middle partition S^2 of the casing-shield S is connected directly to said casing at the edge of the aperture z . The terminal connections of the outer winding j , its shield s^2 , and its external circuit-conductors in the double housing S^4 s^4 are quite similar. The conductors f and g of the second external circuit are attached, respectively, to the terminal clips h^3 h^4 , to which are secured also the ends of the winding j , which have passed through the aperture z^2 , the non-conducting blocks v^2 and o^2 , and the base-plate p^2 of the inner housing s^4 . The connection of one end of winding j through the condenser k to the casing-shield S is formed by the wire 55, which extends from the clip h^4 at point 5 to one side of the condenser, and the wire 56, extending from the other side of the condenser to the point h^3 of attachment to shield S, and the connection mentioned in describing Fig. 1 as existing between a terminal of winding j and its shield s^2 at point 4 is provided for by the conductor 44, extending from such point 4 to the base-plate p^2 of the inner housing s^4 , and by conductively uniting said base-plate to the outermost of the three layers of metal sheet or foil which are between the windings and to the fourth coating thereof, which overlaps the outside of winding j . The wire w serves to perfect or complement the required intimate electrical connection between the middle layer of metal sheet or foil S^2 and the iron casing, which together form the shield S, and in the same manner the wire w^2 looks to the perfecting of con-

ductive continuity between the inner housing s^1 and the metal layers which form the shield s^2 . A similar purpose is subserved by the contact-springs m, m^2, m^3 , and m^4 . For the avoidance of any interference with the mutual induction to be exercised between the two windings the layers of metal sheet or foil which are interposed between said windings are preferably made circumferentially discontinuous. This is indicated in Fig. 5, where the three interposed layers are shown as being applied each in two half-sheets with overlapping edges at M and N. The edges at M are in metallic contact, whereas the opposite edges of each layer at N are held apart from one another by any appropriate means, as by placing a thickness of insulating fabric between them. HH are blocks of wood, with which, if desired, the opening through the middle of the toroidal coil may be filled to give support and stability to the parts and solidity to the appliance as a whole.

A modified electrical arrangement of the shields is illustrated by Fig. 2, which shows the shields s, s^2 , which envelop the windings i and j , respectively, as being each divided into two conductively distinct parts 12 13 and 14 15. The ends of winding i , adapted for connection with circuit-wires d and e , are united at points 2 and 3 with the said separated parts 12 and 13 of shield s , and similarly the ends of winding j , adapted to connect with the circuit-conductors f and g , are united at points 4 and 5 with the separated parts 14 and 15 of shield s^2 . The outer shield, as in Fig. 1, has a partition S^2 between the two winding-shields s, s^2 and is grounded at E. By this arrangement the capacity of each of the inner shields s, s^2 to the outside shield S is equally divided between the two terminals of the shielded winding, and the need of special balancing condensers is so greatly diminished that in many instances they may be altogether dispensed with or, in any event, reduced to extremely small size.

Fig. 3 shows a second modification to be followed when one of the windings—say j —is centrally split, so that, if desired, some other appliance in a manner well understood is to be connected between its two halves. The windings i and j and the entire coil have separate shields s, s^2 and S and the latter a central partition S^2 ; as in the previous examples, the winding i being balanced by the condenser K^2 , connected between one of its ends at 3 and the external shield S and being in conductive connection at its other end with its own shield s . The two sections j^2, j^3 of winding j each have one end free from contact with either the inner shield s^2 or the outer shield S , and these ends passing through openings in the said shields are respectively united to the conductors f and g of the external circuit. The other ends of said sections are, however, connected to one another at the middle of the

winding and with the shield s^2 at the point 6 by the branch conductor 16. The outer shield, as usual, is grounded at E. In order to insure the complete balancing of this modification, it is required that the mutual impedance between the undivided winding and each of the two halves of the split winding shall be equal and that the impedance of the two halves of the said split winding shall be the same.

When both windings of the repeating-coil are split, they will be each shielded in the same manner as is the winding s^2 in Fig. 3, each of the windings being connected at its middle to its own shield, and in such a case in order that a perfect balance may be obtained it will also be necessary that the impedance of each of the two halves of the split windings shall be the same and that the mutual impedance between each of the halves of each split winding and the halves of the other shall be equal.

I claim—

1. A repeating induction-coil composed of two insulated conductors wound over an iron core; a conducting-shield for each winding; and an outside conducting-shield surrounding both windings and their associated shields; substantially as set forth.

2. In a repeating induction-coil having two windings designed for connection respectively with two working circuits or sections of circuits, the combination with said windings; of a conducting-shield for each; an external conducting-shield surrounding both windings and their respective shields but having no conductive connection with either; and means for balancing the capacity between the said inner shields respectively and the said external shield; substantially as described.

3. The combination in a repeating or other induction coil, with the two windings of said coil adapted for connection respectively in different working circuits or circuit-sections; of a separate or individual conducting-shield for each winding, conductively united to one terminal thereof; an exterior conducting-shield surrounding both windings and their associated shields; and a condenser for each winding, connected between the remaining terminal thereof and the external shield; substantially as described.

4. In a repeating-coil or transformer, the combination of the two concentrically-disposed windings of said coil adapted for connection in different circuits or sections of circuits respectively; of a separate or individual conducting-shield for each winding; an exterior conducting-shield inclosing both windings and their associated shields and separating each from the other; and a condenser associated with each winding; the shield of the inner winding being conductively united to the outer terminal thereof; the shield of the outer winding being in like manner united to that terminal of its winding whose capacity to said

shield is the greater; and the condensers being respectively connected between the remaining terminals of their associated windings and the exterior shield; substantially as set forth.

- 5 5. The combination in a repeating or other induction coil of toroidal form with the closed magnetic circuit-core; and the two insulated conductors wound and concentrically disposed thereover; of three layers of metal sheet or
10 foil interposed between the said concentrically-disposed windings and insulated from said windings and from one another; and a metal casing inclosing the whole; the said inner and outer metallic layers being each con-
15 ductively connected with a terminal of the inner and outer winding respectively and constituting conducting-shields therefor; and the metal casing being conductively connected

with the middle metallic layer to constitute an exterior conducting-shield for the said in- 20 duction-coil with a partition separating the two shielded windings thereof; substantially as hereinbefore described.

6. In apparatus of the character described, the combination of a plurality of coils of in- 25 sulated wire, a conducting-shield for each such coil, and an external conducting-shield for all said coils.

In testimony whereof I have signed my name to this specification, in the presence of two sub- 30 scribing witnesses, this 5th day of October, 1904.

GEORGE A. CAMPBELL.

Witnesses:

THOMAS D. LOCKWOOD,
GEO. WILLIS PIERCE.