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A.D. 1880, 6th APRIL. N° 1407.  
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Electrical Conductors, &c.

LETTERS PATENT to Oliver Heaviside, of No. 3, Saint Augustine's Road, in the County of Middlesex, for an Invention of "IMPROVEMENTS IN ELECTRICAL CONDUCTORS, AND IN THE ARRANGEMENT AND MANNER OF USING CONDUCTORS FOR TELEPHONIC AND TELEGRAPHIC PURPOSES."

PROVISIONAL SPECIFICATION left by the said Oliver Heaviside at the Office of the Commissioners of Patents on the 6th April 1880.

OLIVER HEAVISIDE, of No. 3, Saint Augustine's Road, in the County of Middlesex. "IMPROVEMENTS IN ELECTRICAL CONDUCTORS, AND IN THE ARRANGEMENT AND MANNER OF USING CONDUCTORS FOR TELEPHONIC AND TELEGRAPHIC PURPOSES."

When a number of wires run parallel to one another, either suspended or otherwise, any change in the current flowing in one wire causes currents in all the rest by induction, and the effect may be so great as to seriously interfere with the working of telephonic circuits, and to a less degree of ordinary telegraphic circuits also.

It is a common practice to complete the circuit by means of a second wire instead of the earth, and it is well known that the inductive interference is thereby reduced in magnitude, the induced electro-motive forces in one wire cancelling those in the other to a certain extent. The nearer the wires are brought together the less does the inductive interference become, but it cannot be altogether eliminated in this way, because the axes of the two wires cannot be made to coincide so that they shall be both at the same distance from any disturbing wire.

My improvements have for object to obtain perfect protection, and to render a circuit completely independent under all circumstances of external inductive influences. For this purpose I use two insulated conductors for the circuit, and place one of them inside the other; thus, one conductor may be a wire, and the other a tube or sheath, thus forming a compound conductor consisting of a central wire surrounded by an insulating covering, which is in its turn surrounded by a conducting tube or sheath, which must also be insulated. When the tube and inner wire are electrically connected at both ends of the line, as through apparatus in the usual manner, the circuit as thus described is completely independent of other circuits, and any number of such circuits, each containing an insulated tube

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and inner wire, may be laid side by side and worked without any mutual inductive interference, and without interference from other wires worked in ordinary manners.

I also render circuits mutually independent in the following way, which does not require the use of an insulated tube or sheath for the return current:—I employ 5 two wires for each circuit, one of which serves for return wire instead of the earth. If 1 and 2 are the two wires forming one circuit, and 3 and 4 those forming the other, I place the wires 1 and 2 at any convenient distance apart, and the wires 3 and 4 in any positions relative to 1 and 2, such that the induction according to known laws between the circuits 1, 2, and 3, 4, is *nil*. There are many ways of 10 doing this, of which the following is one of the simplest:—The four wires are placed parallel to one another, so that their centres are situated at the four corners of a square upon a plane perpendicular to the axes of the wires, and the two wires at the opposite ends of one diagonal are paired to form one circuit, and the remaining two wires are paired to form another. In consequence of the relative positions of 15 the four wires, and of the manner of pairing them, there will be no induction between the two circuits.

It is not necessary for the centres of the four wires to form a square in the manner described, for the circuits may have any other positions that make their mutual induction *nil*. For instance, if the four wires 1, 2, 3, and 4 are placed parallel to 20 one another, and 1 and 2 are placed at any distance apart and paired to form one circuit, while 3 is placed equidistant from 1 and 2, and 4 also equidistant from 1 and 2, and 3 and 4 are paired to form a second circuit, then the mutual induction, both static and dynamic of the two circuits 1, 2, and 3, 4, is *nil* as regards the complete circuits. (The two wires 3 and 4 may be worked separately, using the 25 earth to complete their circuits, and they will be independent of the circuit 1, 2, though not of one another. Similarly 1 and 2 may be worked separately, while 3 and 4 are paired).

The four wires may be suspended separately, and when there are a large number of wires they may be arranged in groups of four, the four wires in every group 30 having proper positions, and being properly paired, as above described; or the four wires may be insulated in any manner and laid side by side in proper positions, preferably so that they form a square, and bound together for convenience, or covered with a jacket, thus forming a cable containing four wires to be properly paired to form two mutually independent circuits. The cables thus formed may be 35 suspended in the ordinary way.

SPECIFICATION in pursuance of the conditions of the Letters Patent filed by the said Oliver Heaviside in the Great Seal Patent Office on the 6th October 1880.

OLIVER HEAVISIDE, of No. 3, Saint Augustine's Road, in the County of 40 Middlesex. "IMPROVEMENTS IN ELECTRICAL CONDUCTORS, AND IN THE ARRANGEMENT AND MANNER OF USING CONDUCTORS FOR TELEPHONIC AND TELEGRAPHIC PURPOSES."

When a number of wires run parallel to one another, either suspended or otherwise, any change in the current flowing in one wire causes currents in all the rest 45

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by induction, and the effect may be so great as to seriously interfere with the working of telephonic circuits, and to a less degree of ordinary telegraphic circuits also.

It is a common practice to complete the circuit by means of a second wire instead of the earth, and it is well known that the inductive interference is thereby reduced in magnitude, the induced electro-motive forces in one wire cancelling those in the other to a certain extent. The nearer the wires are brought together the less does the inductive interference become, but it cannot be altogether eliminated in this way, because the axes of the two wires cannot be made to coincide so that they shall be both at the same distance from any disturbing wire.

My improvements have for object to obtain perfect protection and to render a circuit completely independent under all circumstances of external inductive influences. For this purpose I use two insulated conductors for the circuit and place one of them inside the other. Thus, one conductor may be a wire and the other a tube or sheath, thus forming a compound conductor consisting of a central wire surrounded by an insulating covering, which is in its turn surrounded by a conducting tube or sheath which must also be insulated.

A suitable method of carrying out this part of my Invention is shewn in Figure 1 of the Drawing, which represents an enlarged section of the compound conductor. *a* is the conducting wire coated with gutta percha, india rubber, or other insulating material in the usual manner, as shewn at *b*. The core thus formed is then coated with a thin layer of brass-tape, tin-foil, copper-foil, or a sheathing of lead or other suitable conducting material *c*. The resulting sheathed core is then covered with gutta-percha, india-rubber, or other insulating material to a convenient thickness, as shewn at *d*. If found desirable a wrapper may be added for protection against injury. When the tube and inner wire are electrically connected at both ends of the line, as through apparatus in the usual manner, the circuit as thus described is completely independent of other circuits, and any number of such circuits, each containing an insulated tube and inner wire may be laid side by side and worked without any mutual inductive interference and without interference from other wires worked in ordinary manners. Figures 2, 3, and 4 are diagrams showing the ways of joining up. In Figure 2 the compound or sheathed conductor (shewn in section) is used for the whole distance, the wire *a*, sheath *c*, and terminal apparatus *e, e*, forming a closed circuit excluding the earth. But when only one end of a line is exposed to induction only that part need be protected therefrom, as shewn in Figure 3, the unprotected portion being an ordinary wire *f*, and the circuit completed by earthing either the wire *a* or sheath *c* at one end of the single portion, and earthing the apparatus at the other end. In Figure 4 both ends of the line are shewn protected, while the intermediate portion *f* is not protected, earth connection being made to either wire or sheath at both ends of *f*, the Figure shewing earth connection to sheath.

I also render circuits mutually independent in the following way, which does not require the use of an insulated tube or sheath for the return current:—I employ two wires for each circuit, one of which serves for return wire instead of the earth. If 1 and 2 are the two wires forming one circuit, and 3 and 4 those forming the other, I place the wires 1 and 2 at any convenient distance apart, and the wires 3 and 4 in any positions relative to 1 and 2, such that the induction according to known laws between the circuits 1, 2, and 3, 4, is *nil*. There are many ways of doing this, of which the following, shewn in section in Figure 5, is one of the simplest:—The four wires 1, 2, 3, 4, are placed parallel to one another so that their centres are situated at the four corners of a square upon a plane perpendicular to the axes of the wires, and the two wires 1 and 2 at the opposite ends of one diagonal are paired to form one circuit, as shewn by the dotted lines, and the remaining two wires 3 and 4 are paired, as shewn by the dotted lines, to form another circuit. In consequence of the relative positions of the four wires and of the manner of pairing them, there will be no induction between the two circuits.

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It is not necessary for the centres of the four wires to form a square in the manner described and shewn in Figure 5. For instance, if the four wires 1, 2, 3, and 4 are placed parallel to one another, as represented in Figure 6, and wires 1 and 2 are placed at any distance apart, and paired to form one circuit, while wire 3 is placed equidistant from 1 and 2, and 4 also equidistant from 1 and 2; and 3 and 4 are paired to form a second circuit, then the mutual induction, both static and dynamic, of the two circuits 1, 2, and 3, 4, is *nil* as regards the complete circuits.

It will be understood that the two wires 3 and 4 may be worked separately, using the earth to complete their circuits, and they will be independent of the circuit 1, 2, though not of one another. Similarly 1 and 2 may be worked separately, while 3 and 4 are paired.

The four wires may be suspended separately, and when there is a large number of wires they may be arranged in groups of four, the four wires in every group having proper positions and being properly paired, as hereinbefore described.

Or the four wires may be insulated in any manner, and laid side by side in proper positions, preferably so that they form a square, and bound together for convenience, or covered with a jacket *g*, thus forming a cable containing four wires, to be properly paired to form two mutually independent circuits. The cables thus formed may be suspended in the ordinary way. In Figure 7, 1, 2, 3, 4, are the wires to be paired, as shewn by dotted lines, in one insulating covering *h*, surrounded by wrapper *g*; and in Figure 8 the wires are separately insulated, *h* being a central yarn.

It will be understood that I do not confine myself to the employment of four wires. Any four wires in a cable suitably situated may be paired in this manner, or there may be any number of groups of fours.

By my improvements besides the neutralization of induction the advantage of immunity from earth currents and leakage, caused by imperfect earth connections and imperfect conductivity of the earth, is obtained.

Having thus described the nature of my said Invention, and the best means with which I acquainted for carrying the same into effect, I wish it to be understood that I do not confine myself to the precise details herein laid down, as the same may be varied without departing from the peculiar character of my Invention, but what I do claim is,—

The improvements in electrical conductors, and in the arrangement of and manner of using conductors for telephonic and telegraphic purposes, substantially as hereinbefore described.

In witness whereof, I, the said Oliver Heaviside, have hereto set my hand and seal, this Fourth day of October, in the year of our Lord One thousand eight hundred and eighty.

OLIVER HEAVISIDE. (L.S.)

Witness,
G. F. REDFERN,
Patent Agent,
4, South St.,
Finsbury.

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FIG. 1.

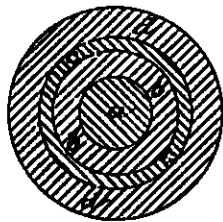


FIG. 2.

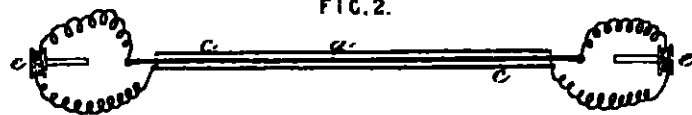


FIG. 3.

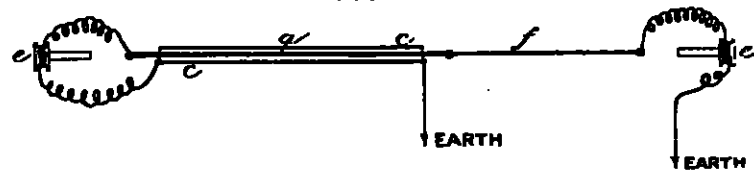


FIG. 4.

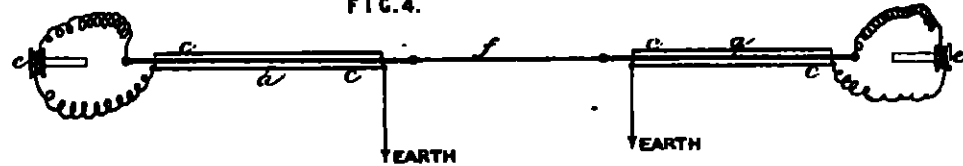


FIG. 5.

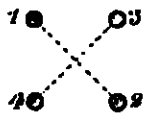


FIG. 6.

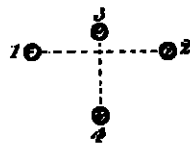


FIG. 7.

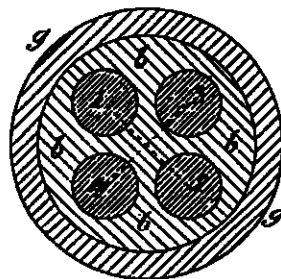
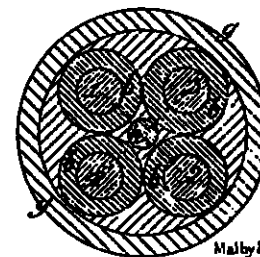


FIG. 8.



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