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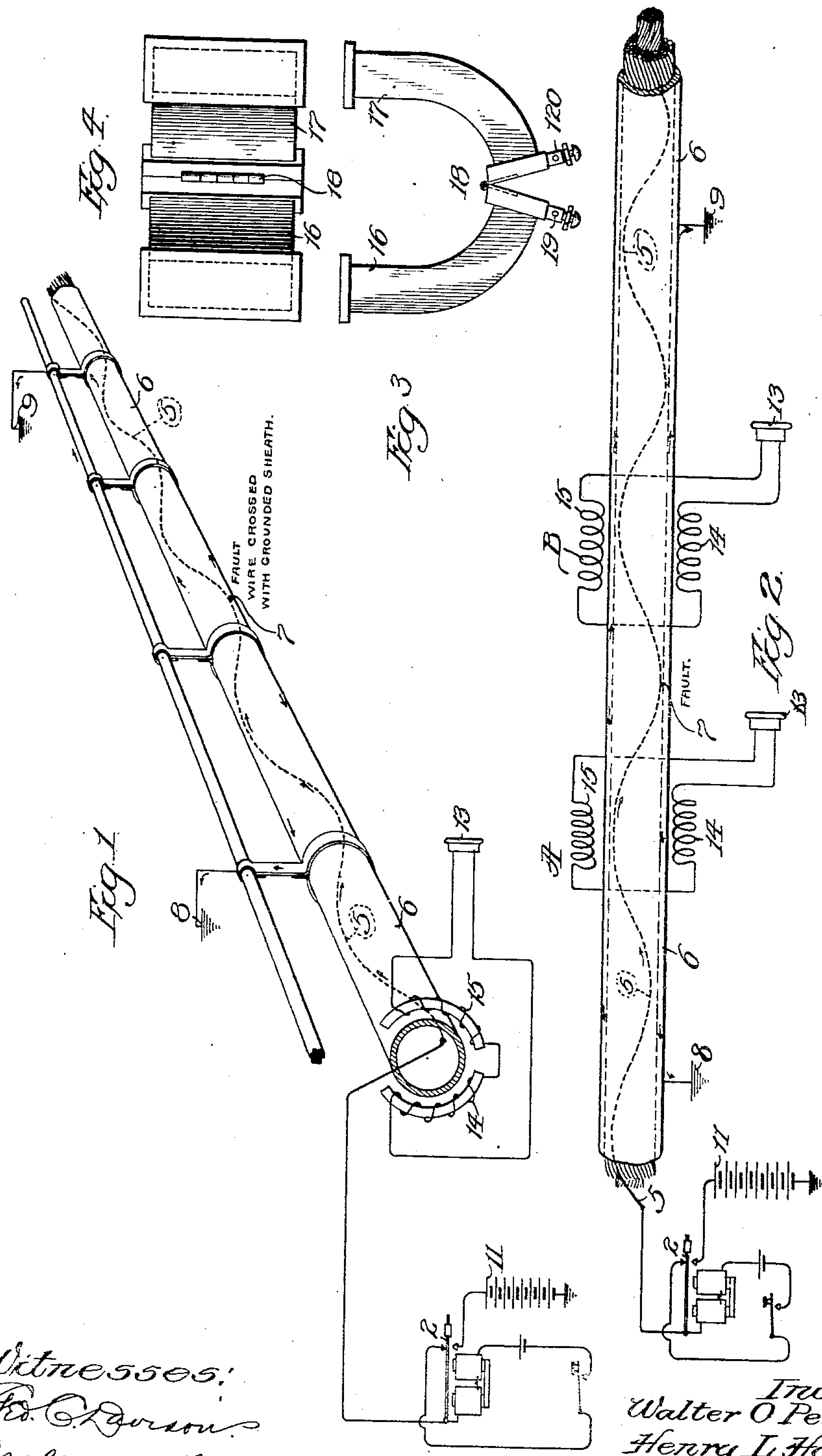
FAULT LOCATOR FOR ELECTRIC CABLES.

APPLICATION FILED MAY 8, 1908.

925,594. Patented June 22, 1909.



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UNITED STATES PATENT OFFICE.

WALTER OTIS PENNELL AND HENRY LOUIS HOFFMANN, OF KANSAS CITY, MISSOURI.

FAULT-LOCATOR FOR ELECTRIC CABLES.

No. 925,594. Specification of Letters Patent. Patented June 22, 1909.

Application filed May 8, 1908. Serial No. 431,690.

To all whom it may concern:

Be it known that we, WALTER OTIS PENNELL and HENRY LOUIS HOFFMANN, citizens of the United States, residing at Kansas City, in the county of Jackson and State of Missouri, have invented a certain new and useful Improvement in Fault-Locators for Electric Cables, of which the following is a full, clear, concise, and exact description.

Our invention relates to a method of and apparatus for locating faults in electric cables, and its object is to provide means for securing greater accuracy in testing operations of this character.

A usual practice, when one of the conductors in a telephone cable is crossed with the grounded metallic sheath of the cable, is to connect one end of such conductor to an interrupted or varying source of electrical potential, the other pole of which is connected to earth; and then to present to the outside of the cable at different points along its length an "exploring coil" the terminals of which are connected to a telephone receiver. The theory is that the electromagnetic induction between the conductor and the coil of wire will cause a sound in the telephone until the place where the conductor is grounded is passed, and that beyond this point no sound will be heard. But as a matter of fact, considerable difficulty has been experienced in locating faults in this manner because the sounds in the telephone would continue to be heard after the exploring coil had passed some distance beyond the fault. The reason for this difficulty we have found to be as follows:—The supporting strand and sheath of an aerial cable are usually bonded and grounded at intervals, and the sheaths of underground cables are also grounded at intervals. When a conductor of the cable becomes crossed with the sheath, the interrupted current, after passing from the conductor to the sheath, will divide, and part will flow back through the sheath to the nearest ground and then to the interrupter, and the remainder will flow ahead on the sheath to the nearest ground, and thence back to the interrupter. This current flowing in the metal sheath is the source of the error in locating the fault, because it acts inductively upon the exploring coil in the same manner as does the current flowing in the faulty conductor, so causing a noise in the telephone after the exploring coil has passed beyond the fault.

In accordance with our invention, we provide an apparatus by which the effect of current flowing in the metallic sheath will be neutralized and only the current flowing in the faulty conductor will produce an effect in the telephone receiver. This is accomplished by providing the exploring coil with two windings connected differentially, and placing these windings symmetrically with respect to the cable, so that the inductive effects in the two portions due to the current in the sheath are equal and opposite and neutralize each other, producing no sound in the telephone. The conductors in the cable, however, being laid spirally, are not symmetrical with respect to the sheath, but will vary in position, being in some places nearer to one side of the cable and in other places nearer to the other side. The interrupted current flowing in the faulty conductor will thus produce an unequal magnetic inductive effect upon said windings, and thus cause the characteristic sound in the telephone, until said windings reach the point where the fault is located, at which point the noise will cease. The source of error is thus eliminated, and the location of the fault accurately determined.

We will describe our invention more particularly by reference to the accompanying drawings, in which—

Figure 1 is a diagram representing an aerial cable in which one of the conductors is crossed with the lead sheath at a point intermediate between two places where the sheath is grounded, the diagram also indicating the apparatus of our invention for locating the fault; Fig. 2 is a somewhat similar diagram representing an underground cable together with the exploring apparatus of our invention shown in two different positions. Fig. 3 is a detail view of one form of mounting for our exploring coil in which the two cores carrying the differential windings are hinged together; Fig. 4 is a plan view of the exploring coil shown in Fig. 3.

Like parts are indicated by similar characters of reference throughout the several views.

In Fig. 1, one of the conductors of the cable is indicated by the dotted line 5, and this conductor is supposed to be crossed with the lead sheath 6 of the cable at the point 7. The sheath is bonded to earth at the points 8 and 9, in accordance with the usual practice. To locate the fault 7 we have shown one end of the conductor 5 connected to an interrupter 2. This interrupter is adapted intermittently to connect the end of said conductor 5 to the free pole of a grounded battery 11. The exploring coil as shown consists of two windings 14 and 15, which are connected in circuit with a telephone receiver 13. Said windings are arranged to be placed symmetrically one on either side of the cable, and they are wound and connected so that varying currents flowing in a conductor equally distant from each of them will produce equal and opposite inductive effects in said windings.

The flow of intermittent current from the battery 11 through the conductor 5 in the cable is indicated by arrows. This current passes at the fault 7 from the wire 5 to the sheath 6, and thence flows in opposite directions through the sheath to the grounds 8 and 9. As the exploring coil is passed along the cable between the points 8 and 9, the interrupted current flowing in the sheath and in the suspension wire bonded thereto will produce equal and opposite inductive effect upon the windings 14 and 15, and as these effects neutralize each other, the current in the sheath will produce no noise in the telephone 13. The conductor 5, however, being wound spirally through the cable is not symmetrically located with respect to the two windings 14 and 15, but at some places is nearer to one of said windings and at other places is nearer to the other. The current in said wire will thus produce a greater effect upon one of the windings than upon the other, and this will result in the production of a noise in the telephone receiver. This noise will continue to be heard as the exploring coil is moved along the cable, until the point is reached at which the wire 5 is crossed with the sheath, after which no further noise will be heard, since the current now flowing in the sheath toward the ground 9 will produce equal and opposite effects upon the symmetrically-located windings 14 and 15. At some places along the cable the wire in trouble may lie symmetrically with respect to the two windings of the exploring coil, but, owing to the spiral or otherwise eccentric disposition of the wire, this condition will only exist for a short distance.

In Fig. 2, the exploring coil is shown in two positions. At the position A, the wire 5 lies nearer to the winding 15 than to winding 14, and this unbalanced condition causes a noise in the telephone. But when the exploring coil reaches position B, the sound ceases, because the wire 5 at this point carries no current, and the current in the sheath produces equal and opposite effects in both windings 14 and 15, which neutralize each other. In the case of an aerial cable, the supporting strand also carries a part of the return current, and the exploring coil should be held so that its two windings are equally distant from said supporting strand. It is not necessary for both the differential windings to be upon the same core, nor that they should be mechanically mounted together, and in Fig. 2, we have indicated the two windings as separate coils. In Fig. 3 and Fig. 4, however, we have indicated a form of mounting which will be found convenient in practice. The two cores 16 and 17 are in this instance hinged together at 18 so that the two halves can be adjusted like a caliper upon the cable, the symmetrical disposition of the two windings with respect to the sheath being thus assured. The two windings may have their inner terminals connected through the hinge, and their outer terminals connected respectively to binding posts 19 and 20, to which the terminals of the flexible cord leading to the telephone receiver may be connected. It will be understood, however, that our invention is not limited to any such specific form of exploring coil as that shown.

While we have referred to a telephone receiver as the preferred instrument for detecting the currents inductively produced in the exploring coil, it will be apparent that any electrical current detecting device of sufficient sensitiveness can be employed.

We claim:—

1. The method of locating a fault in an electric cable conductor, which consists in causing a varying current to flow through said conductor by way of the fault, causing said current to induce a current in the circuit of a detecting instrument, and rendering the circuit of said instrument neutral with respect to varying current flowing in the sheath of said cable.

2. The method of locating a fault in an electric cable conductor having a metallic sheath, which consists in causing a varying current to flow through the conductor by way of the fault, causing said current to induce a current in the circuit of a detecting device, and neutralizing said detecting device with respect to any portion of said varying current that may flow through the metallic sheath of said conductor.

3. The method of locating a fault in a conductor having a metallic sheath, which consists in causing varying current to flow through said conductor by way of said fault, causing the current flowing in said conductor to induce unequal currents in the circuit of a detecting device, and causing the portion of the varying current that flows over the metallic sheath after passing through the fault to induce equal and opposing currents in the circuit of said detecting device.

4. The method of locating a fault in a conductor of a cable having a metallic sheath, which consists in causing varying current to flow through the conductor by way of the

fault by connecting one pole of the generator of said varying current to one end of said faulty conductor and the other pole to earth, causing the varying current flowing in said conductor to induce unequal currents in two differential windings of an exploring coil by presenting said windings to said conductor at unequal distances therefrom, and causing the varying current that flows through the metallic sheath of the cable to induce equal and opposing currents in the two differential windings of said coil by disposing said windings at equal distances from said sheath.

5. The method of locating a fault in a telephone cable, which consists in causing varying current to flow through the faulty conductor by way of the fault, and causing the varying current flowing in the faulty conductor to induce unequal currents and the varying current flowing in the sheath of the cable to induce equal and opposite currents in the differential windings of an exploring coil.

6. The method of locating a fault in a conductor eccentric with respect to its metallic sheath, which consists in causing a fluctuating current to flow through said conductor as far as the fault and then by way of the metallic sheath, causing the fluctuating current in the conductor to induce a current in an exploring coil brought into inductive relation with said conductor, and neutralizing the inductive action produced in said coil by current flowing in the sheath when the coil is presented beyond the fault.

7. Apparatus for locating faults in electric cables, comprising means for establishing a varying current in the faulty conductor of the cable, and two coils arranged to be placed symmetrically with respect to the cable sheath at different points along its length, said coils being connected differentially in circuit with a current-detecting device.

8. A fault locating device comprising two cores hinged together, a winding upon each of said cores, said winding being differentially connected in circuit with a telephone receiver.

9. The combination with two conductors, one lying within the other and eccentric thereto, of means for producing a flow of varying current in said conductors, a connection between said conductors at some point along their length, and a device for determining the location of said connection, said device comprising a current-detector and two differential windings connected in circuit therewith, said windings being adapted to be so presented to such conductors that the currents produced in said windings are equal and opposite with respect to the outer conductor, and unequal with respect to the inner conductor.

10. A fault-locating-apparatus for electric cables having spirally-laid conductors inclosed in a metallic sheath, such apparatus comprising a telephone receiver and two windings connected in circuit therewith, said windings being balanced with respect to the induction of current flowing in said metallic sheath, and unbalanced with respect to current flowing in the conductors of the cable.

11. A fault-locating apparatus for metal-sheathed cables comprising a current detector, a winding in circuit therewith adapted to be inductively responsive to fluctuating current flowing in a conductor of the cable, and means for balancing and neutralizing the inductive action in said winding arising from fluctuating currents flowing in the sheath of the cable.

In witness whereof, we hereunto subscribe our names this fifth day of May A. D., 1908.

WALTER OTIS PENNELL.
HENRY LOUIS HOFFMANN.

Witnesses:
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