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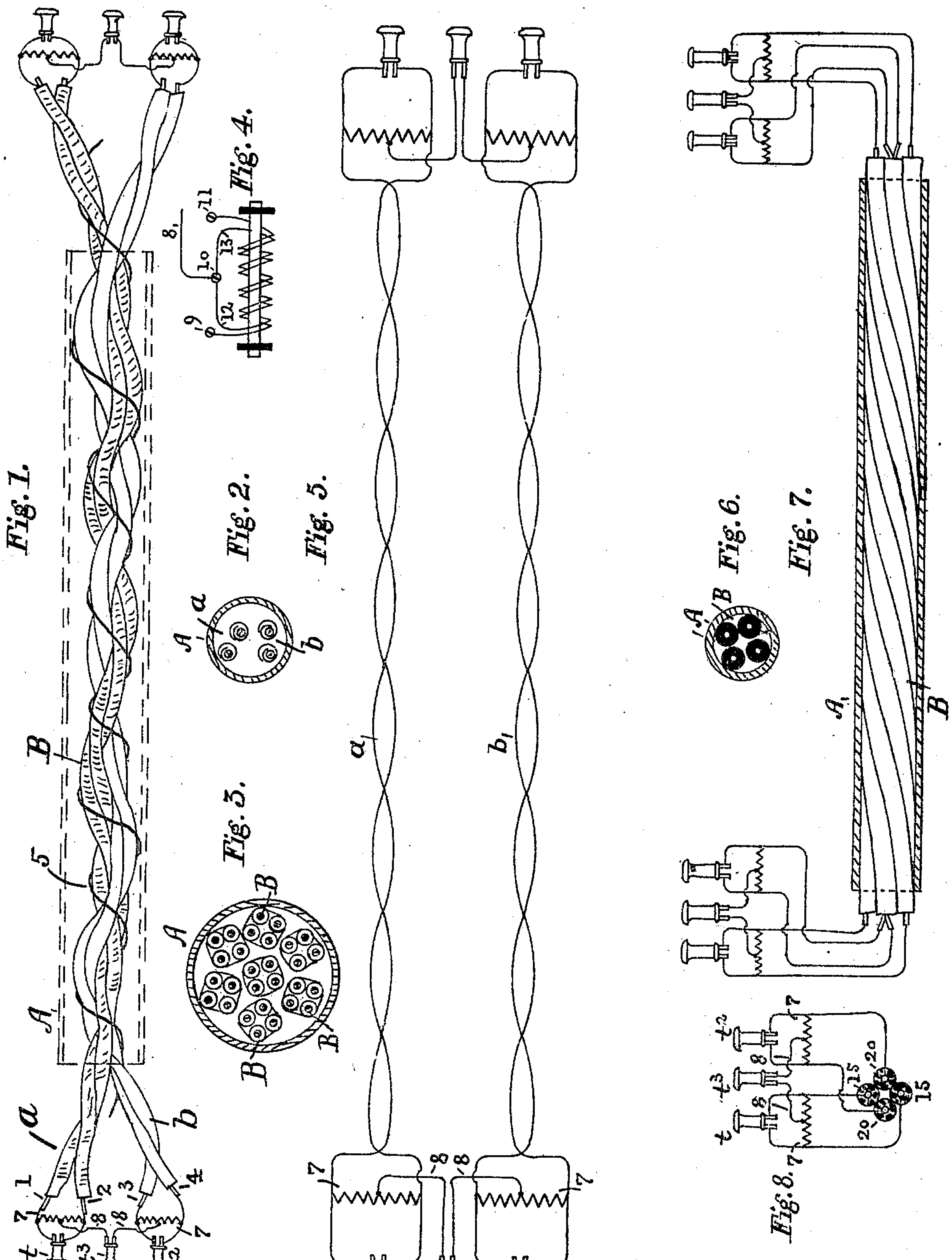
TELEPHONE CIRCUIT.

(Application filed July 2, 1901.)

(No Model.)



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UNITED STATES PATENT OFFICE.

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TELEPHONE-CIRCUIT.

SPECIFICATION forming part of Letters Patent No. 706,308, dated August 5, 1902.

Application filed July 2, 1901. Serial No. 66,932. (No model.)

To all whom it may concern:

Be it known that ISAIAH H. FARNHAM, deceased, formerly residing at Wellesley, in the county of Norfolk and State of Massachusetts, did invent certain Improvements in Telephone-Circuits, of which the following is a specification.

Owing to the facility with which they could be constructed, the early telephone-lines were constructed like the telegraph-lines by using the ground as the return-circuit and were scarcely disturbed by the inductive effects of the existing telegraph-lines, which were the only circuits then in existence employing electric currents upon poles. Upon the extension of the telephone-lines to longer distances and the rapid introduction of electric light, power, and railway service it soon became necessary to substitute metallic circuits for grounded circuits and to transpose the conductors upon the pole-lines relatively to one another to avoid the inductive effects of the power-currents, and as the same troubles occurred in the overhead and underground telephone-cables it became necessary to arrange their conductors so that these disturbing effects should be eliminated. As the art of telephony broadened out composite circuits were devised in which telegraphic and telephonic services were performed upon the same circuits and also composite circuits were arranged for telephone service whereby the conductors of two telephone-circuits were employed as the limbs of a third telephone-circuit, which are known as "phantom circuits."

In the large towns and cities the overhead pole-lines and house-top supports for telephone-wires have become obnoxious in many ways, and the circuits are being rapidly placed in conduits underground. The conductors are bundled together in insulated twisted pairs and inclosed in a protecting covering or sheath, which is usually of lead. The pairs of conductors within the sheath are arranged in reverse layers—*i. e.*, a certain number of pairs twisted to the right constitute one layer, and over the layer is another layer of pairs having a turn to the left, and so on, to constitute, say, a cable having thirty pairs of conductors, denominated a "thirty-pair" core-cable. Such cables have certain specified relative electrical properties, such as resistance and electrostatic capacity, and at the present time the soft-copper conductors are covered with paper insulation.

The invention described in this specification relates to telephone-cables and telephone-circuits of novel construction. The cable preferably consists of a plurality of pairs of insulated conductors separated from each other to as great an extent as the diameter of the covering or sheath will admit. The insulated conductors are twisted in pairs, and then each two pairs are also twisted together in a reverse direction to the conductors, forming the single pairs, and the length of the twist of each pair and also that of each two pairs in practice is made about three inches. Each set of two pairs when twisted are bound with a thread of some distinctive color in order to more easily identify the pairs, and the whole of the conductors when thus arranged in two twisted pairs are formed into a core within the sheath in reverse layers. Each two pairs of twisted conductors constitute a unit, which when the cable is in place is adapted to form three independent circuits—*i. e.*, the two metallic circuits and a third or phantom circuit in which the conductors of each metallic circuit are employed as one limb or conductor—and in a thirty-pair core-cable there will be fifteen such units and fifteen phantom circuits. By means of the invention it is possible to greatly increase the circuit capacity of a cable and obtain completely-balanced circuits in each of the said units in their relations with one another and in relation to the powerful foreign currents conveyed upon conductors strung in proximity to the cable.

The foregoing describes the preferable form of cable employed; but there may also be used a cable made up of units of four conductors, forming two metallic circuits, which are all twisted together and several of such units placed within a sheath or covering, all of which will now be more fully described, and pointed out in the appended claims.

In the accompanying drawings, which illustrate the invention, Figure 1 is a diagrammatic view of one unit of the improved cable.

Fig. 2 is an end view of the same. Fig. 3 is an end view of a cable having a plurality of such units. Fig. 4 is a diagram of an impedance or inductance coil. Fig. 5 is a diagram of circuit connections. Fig. 6 is an end view of a modified cable, and Figs. 7 and 8 are diagrams of the circuit connections of Fig. 6.

Fig. 1 shows in a simple way the invention with one unit B composed of the two pairs *a* and *b* of paper-insulated conductors in a lead sheath A. (Shown in dotted lines.) Each pair, consisting of two conductors 1 2 and 3 4, respectively, are first twisted together with a right-handed twist, and the two circuits *a* and *b* are then twisted to each other with a left-handed twist. If desired, the twists may be reversed—*i. e.*, *a* and *b* may each be twisted to the left and then the two twisted to the right. The twisted unit B has wound around it a cord or thread 5 to hold the conductors together, usually of a distinctive color. At each end of the cable the conductors are represented as connected to the poles of the telephones t and t^2, respectively. Between the conductors of each of the two metallic circuits is bridged an impedance-coil 7, and from the center 10 of the coil-windings wires 8 extend to the poles of the telephone t^3 to form a third or phantom circuit, of which the pair *a* form one side or limb and the pair *b* the other side.

Fig. 4 represents in diagram the windings of the impedance-coils 7, the helices of which are wound on in parallel, and the outer ends 9 and 11 are connected to binding-posts, while the inner ends 12 and 13 are connected to the bridging-post 10, and the circuit from 9 is from the binding-post 10 by one winding and from said post to 11 by the second winding. In operation the currents from the signaling instruments t in, say, the circuit *a* circulate through the helices of the coil-winding in series and have an inductive effect upon the core of the coil, while the currents from the signaling instruments t^3 circulate by the connecting branch 8 to the center of the helices of the coils and thence through the said helices differentially to the circuits *a* and *b* and have no inductive effect upon the cores. The coils are thus wound so that a perfect balance is obtained between the two conductor metallic circuits *a* and *b* and the third or phantom circuit *c*.

The usual way of making up telephone-cables whose conductors are insulated by paper is, as has been referred to hereinbefore, to twist the pairs of conductors together and then arrange them in reverse layers within the cable-sheath. In the experiments that were made previous to this invention it was found impossible to obtain quiet phantom circuits between the pairs of metallic circuits thus arranged, as there would in all cases be more or less "cross-talk;" but by the formation of two pairs of such metallic circuits into units it has been found that phantom circuits connected between the pairs of such units are quiet and without perceptible cross-talk or disturbances of any kind.

Fig. 2 is an end view of the unit shown in Fig. 1, and Fig. 3 is an end view to show a plurality of units in a sheath.

Fig. 5 shows a similar circuit to that shown in Fig. 1 in diagram. The two circuits *a* and *b* are supposed to be twisted to each other with a reverse twist, to which each are separately twisted, but for the illustration are not so shown.

In Figs. 6, 7, and 8 the sheath A incloses a unit of two pairs of conductors, all of which are wound together, and the opposite conductors 15 15, forming the circuit *a*, are connected with the telephone t, and the opposite conductors 20 20, forming the circuit *b*, are connected with the telephone t^2, and the coils 7, bridged between the conductors of the circuits, are connected from their centers to the telephone t^3 to constitute the phantom circuit.

Having described the invention, what is claimed is—

1. A plurality of pairs of paper-insulated conductors, the conductors of each pair evenly and equally twisted together throughout their length, and each twisted pair evenly and equally twisted with another twisted pair, the said two pairs that are twisted together being insulated from any other conductor.

2. A plurality of pairs of paper-insulated conductors, the conductors of each pair evenly and equally twisted together throughout their length, and each twisted pair evenly and equally twisted with another twisted pair, but in a direction reverse to that of the individual pairs, the said two pairs that are twisted together being insulated from any other conductor.

3. An electric cable composed of a suitable covering or sheath, and a plurality of inclosed pairs of insulated conductors, the conductors of each pair evenly and equally twisted together throughout the length thereof, and each twisted pair equally twisted with another twisted pair, the said two pairs that are twisted together being insulated from any other conductor.

4. An electric cable composed of a suitable covering or sheath, and a plurality of inclosed pairs of insulated conductors, the conductors of each pair evenly and equally twisted together throughout the length thereof, and each twisted pair equally twisted with another twisted pair, but in a direction reverse to that of the said pairs, the said two pairs that are twisted together being insulated from any other conductor.

5. A plurality of pairs of electric circuits, the conductors of each pair evenly and equally twisted together throughout their length, and each twisted pair evenly and equally twisted with another twisted pair; with an impedance-coil at the terminals of each twisted pair and in a bridge between the conductors thereof dividing the circuit into sections, one

section provided with signaling instruments, with a connecting branch between the centers of the impedance-coil windings of two circuits adapted to contain signaling instruments.

6. A plurality of pairs of electric circuits, the conductors of each pair evenly and equally twisted throughout their length, and each twisted pair evenly and equally twisted with another twisted pair; with an impedance-coil at the terminals of each twisted pair and in a bridge between the conductors thereof dividing the circuit into sections, one section provided with signaling instruments, with a connecting branch between the centers of the impedance-coil windings of two circuits to constitute a third circuit, the said branch adapted to contain signaling instruments.

7. A plurality of pairs of electric circuits, the conductors of each pair evenly and equally twisted throughout their length, and each twisted pair evenly and equally twisted with another pair; with an impedance-coil at the terminals of each twisted pair and in a bridge between the conductors thereof dividing the circuit into sections, one section provided with signaling instruments, current from which is adapted to circulate in the helices of the said coil-winding in series, with a connecting branch between the centers of the impedance-coil windings of two circuits to constitute a third circuit, the said branch containing signaling instruments, current from which is adapted to circulate in the helices of the coil-windings of the two circuits differentially.

8. A plurality of pairs of electric circuits, the conductors of which are evenly and equally twisted together throughout their length; with an impedance-coil at the terminals of the conductors and in a bridge between the conductors of each pair dividing the circuit into sections, one section provided with signaling instruments, with a connecting branch between the centers of the impedance-coil windings of two circuits adapted to contain signaling instruments.

9. A plurality of pairs of electric circuits, the conductors of which are evenly and equally twisted together throughout their length; with an impedance-coil at the terminals of the conductors and in a bridge between the conductors of each pair, dividing the circuit into sections, one section provided with signaling instruments as telephones, with a connecting branch between the centers of the impedance-coil windings of two circuits to constitute a third circuit the respective conductors of each pair of circuits forming the limbs thereof, the said branch adapted to contain signaling instruments as telephones.

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