(No Model.)

2 Sheets—Sheet 1.

W. S. SMITH & W. P. GRANVILLE.

ELECTRIC CABLE.

No. 597,790. Patented Jan. 25, 1898.

Fig. 1.

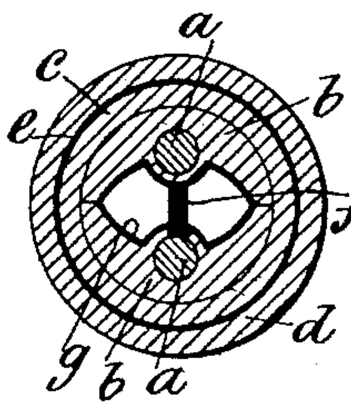


Fig. 2.

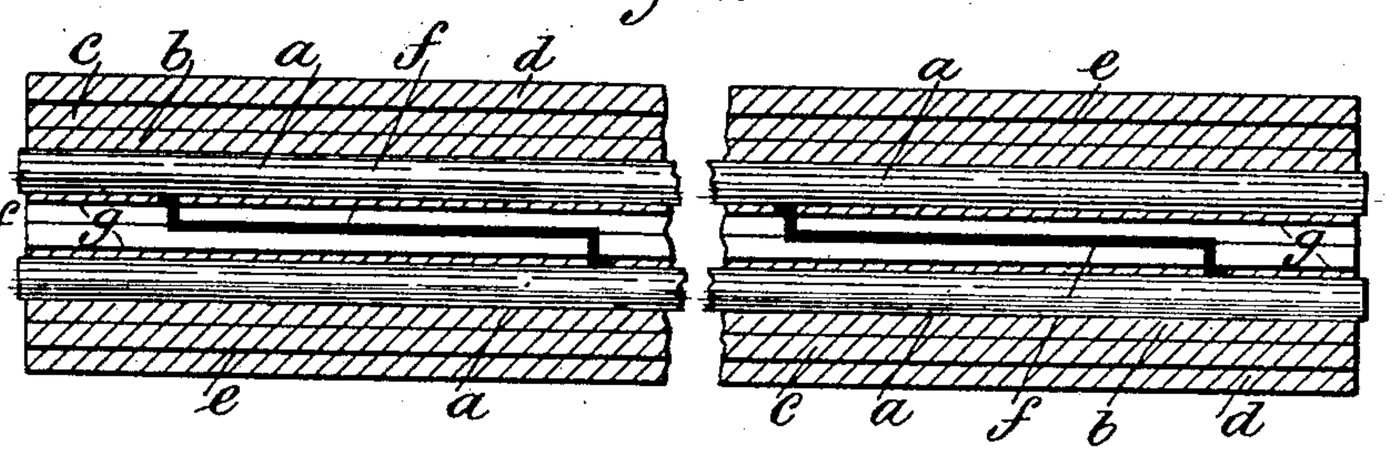


Fig. 3.

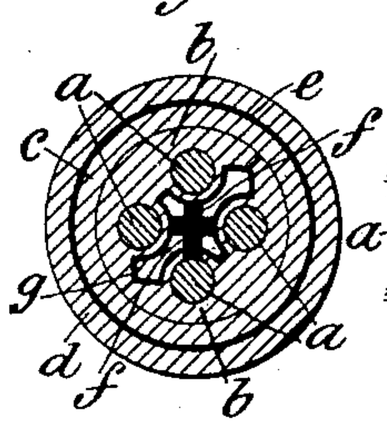


Fig. 4.

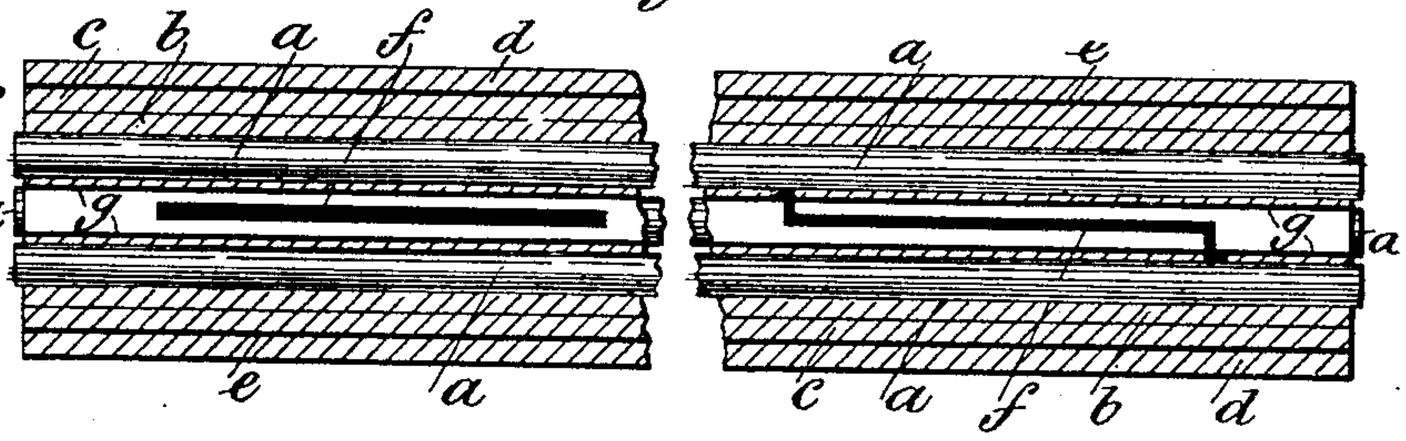


Fig. 5.

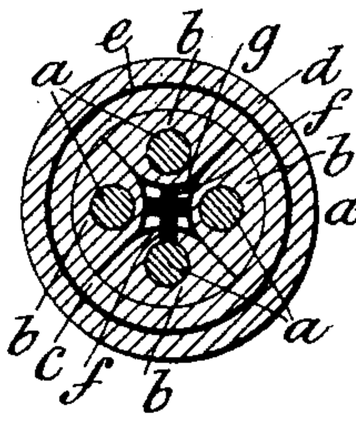


Fig. 6.

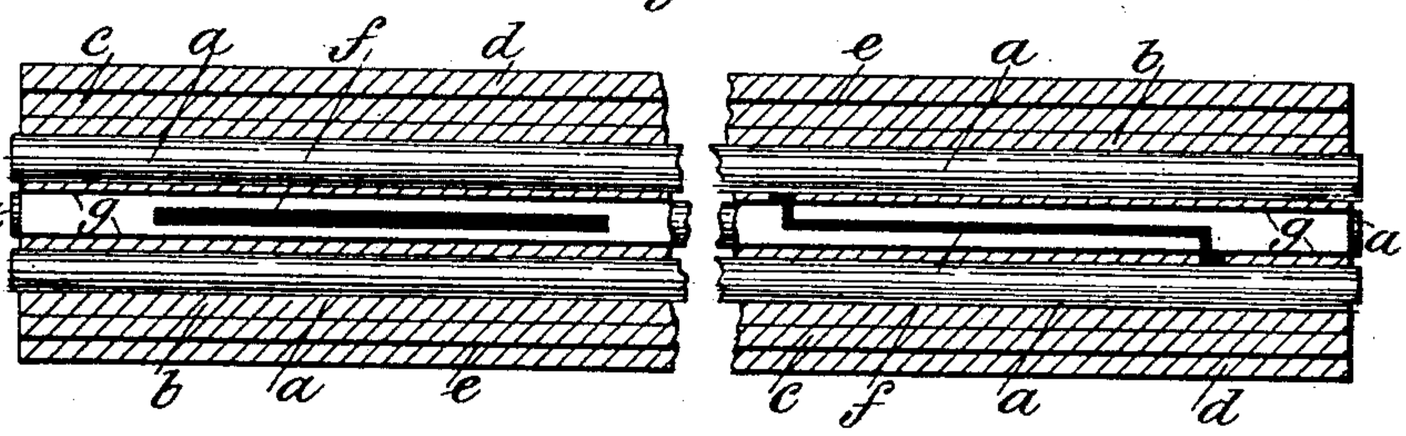


Fig. 7.

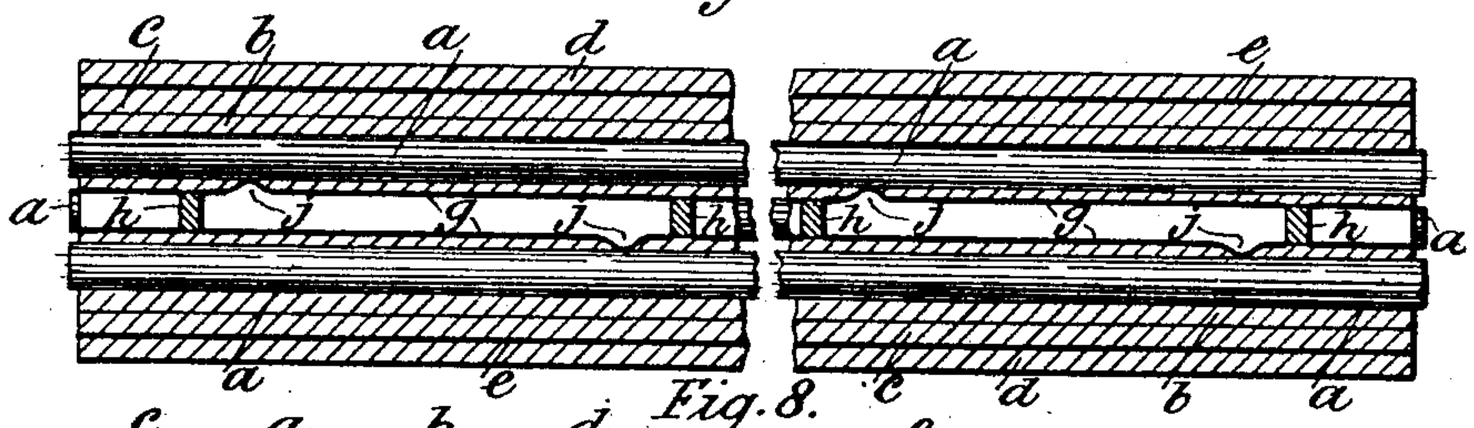
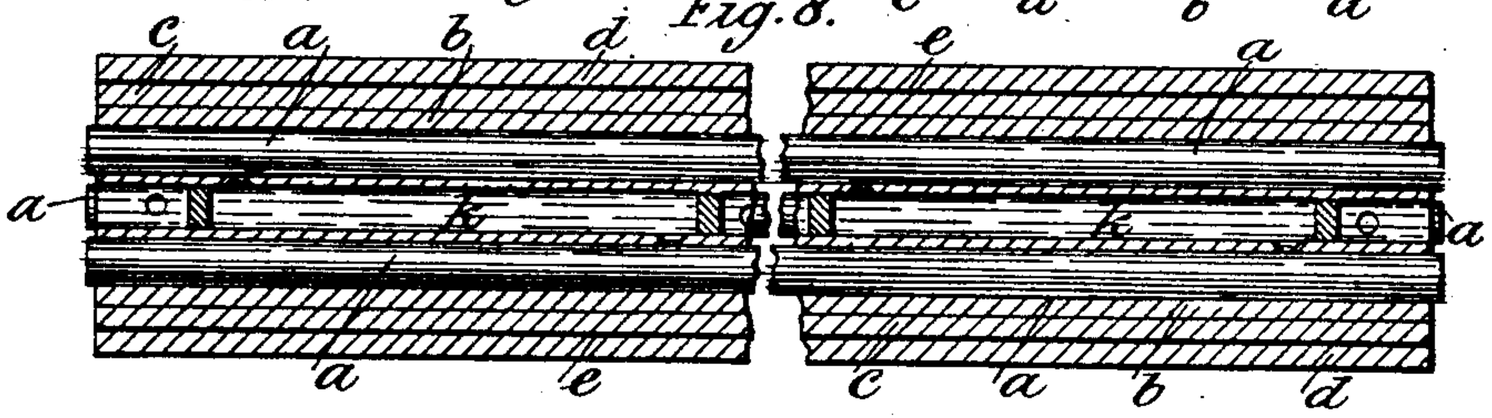


Fig. 8.



Witnesses
E. A. Bellock.
Guy E. Davis.

Inventors
Willoughby Statham Smith and
William Ruddicombe Granville.
By their Attorneys Baldwin Davidson & Wright

(No Model.) 2 Sheets—Sheet 2.

W. S. SMITH & W. P. GRANVILLE.

ELECTRIC CABLE.

No. 597,790. Patented Jan. 25, 1898.

Fig. 9.

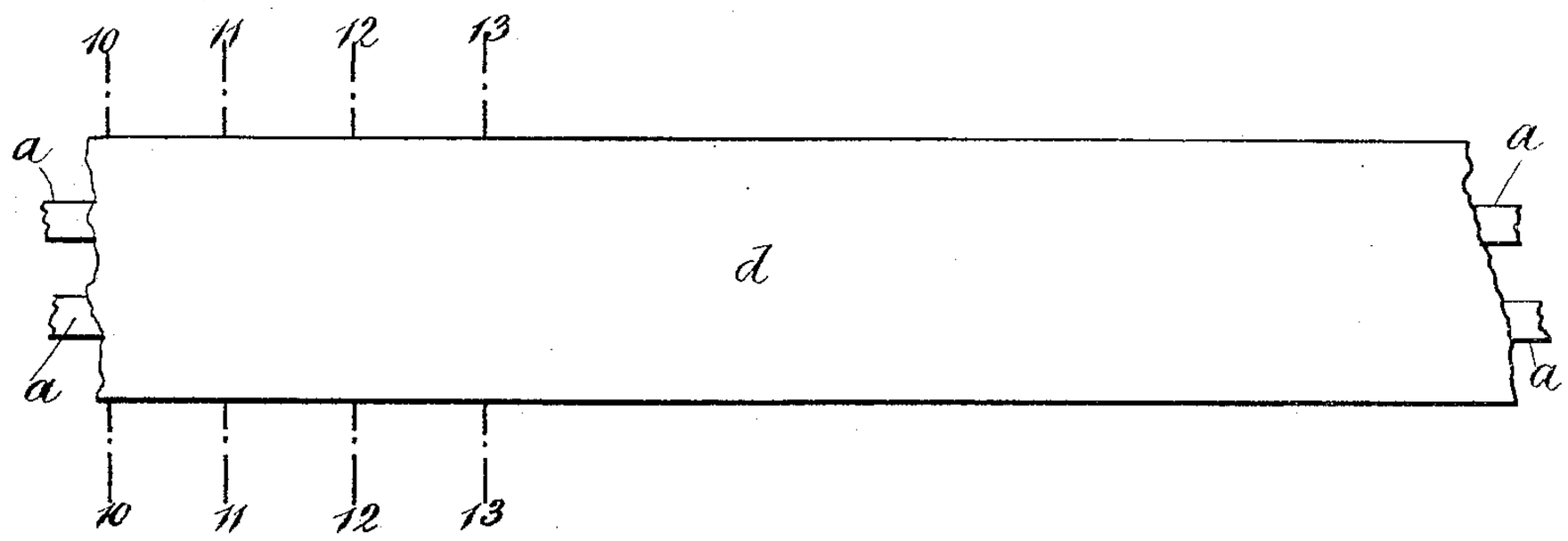


Fig. 10.

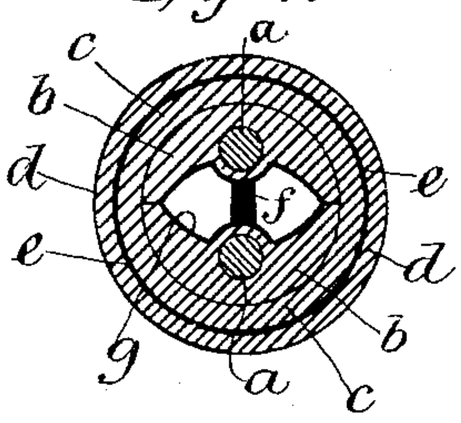


Fig. 11.

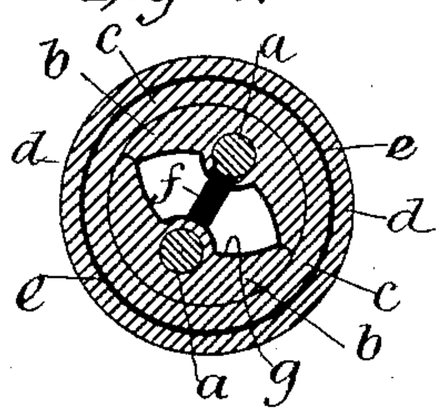


Fig. 12.

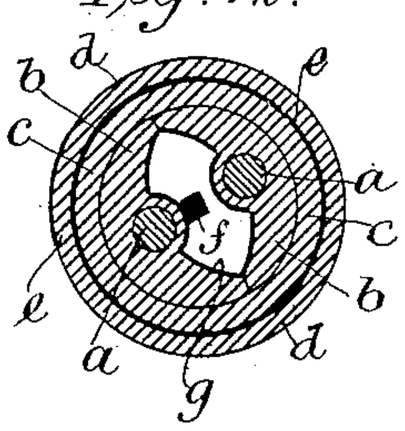
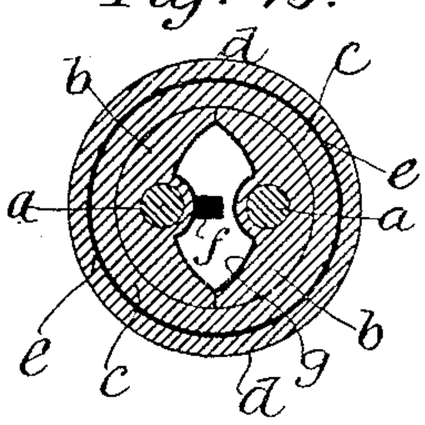


Fig. 13.



Witnesses.
A. H. Parkins.
E. A. Pallock.

Inventors
W. S. Smith & W. P. Granville,
By their Attorneys
Baldwin, Davidson & Wright

UNITED STATES PATENT OFFICE.

WILLOUGHBY STATHAM SMITH AND WILLIAM PUDDICOMBE GRANVILLE,
OF LONDON, ENGLAND.

ELECTRIC CABLE.

SPECIFICATION forming part of Letters Patent No. 597,790, dated January 25, 1898.

Application filed November 1, 1897. Serial No. 657,073. (No model.) Patented in England April 30, 1895, No. 8,573.

To all whom it may concern:

Be it known that we, WILLOUGHBY STATHAM SMITH, telegraphic engineer, residing at 13 Courtfield Road, South Kensington, and WILLIAM PUDDICOMBE GRANVILLE, electrician, residing at 36 Oakfield Road, Stroud Green, London, in the county of Middlesex, England, subjects of the Queen of Great Britain, have invented certain new and useful Electric Cables, (for which we have obtained Letters Patent in Great Britain, No. 8,573, dated April 30, 1895,) of which the following is a specification.

This invention relates to the manufacture of hollow cables.

Figures 2, 4, 6, 7, and 8 are enlarged longitudinal sections of cables made according to this invention. Figs. 1, 3, and 5 are transverse sections of the cables shown in Figs. 2, 4, and 6. Fig. 9 is a side elevation, and Figs. 10, 11, 12, and 13 transverse sections on the line 10 10, 11 11, 12 12, and 13 13, of a modification of the cable shown in Fig. 1.

Inasmuch as the specific inductive capacity of air is considerably less than that of any known insulating material it is for many purposes of great advantage to construct an electric cable with an air space or spaces along its interior, especially when currents of rapid variation are used, since the speed of variation of the current is effected largely by the capacity. Several methods have before been used for forming cables with such interior air-spaces, all having more or less attendant disadvantages.

According to this invention we construct an electric cable of gutta-percha or like insulating material with a central longitudinal air-space and with two or more wires embedded at distances apart in the gutta-percha near to the inner surface of such tubular cable. We do this by forming two or more crescent-shaped strips *b* of gutta-percha, each having embedded within it near to its concave or inner side one or more conducting-wires *a*. Afterward we bring together the crescents *b*, so that they together form a tube, and around the exterior of this tube we form an outer tube *c* of gutta-percha or like material by an ordinary covering-machine, the crescent-shaped pieces *b* being sufficiently strong to retain their form while this outer covering *c* of gutta-percha is being put around them.

In order to obtain as large an air-space as practicable and yet keep the crescent-shaped strips *b* of sufficient strength to allow of an outer tubular covering *c* of gutta-percha being formed around them after they have been brought together, we in some cases, as shown in Fig. 1, make each strip thicker along the middle than at its side edges, and if a single wire *a* only is embedded in each strip it is embedded in this thicker portion near its inner concave surface, and the gutta-percha where it surrounds the wire may bulge inward somewhat into the air-space, so that the cross-section of the interior of the tubular cable becomes somewhat of an oval form, with a slight inward projection along the center of each of its flatter sides.

If desired, more than two segments *b* may be used, as shown in Fig. 5, more especially if there are to be more than two wires *a* in the cable.

When the cable contains, say, two wires *a* only, it will be less flexible in the plane in which the wires lie than in a plane at right angles thereto. In cases where this is likely to be prejudicial we make each of the strips or segments *b* in the form of a helical coil in place of straight. This we do by twisting the strips *b* as they are brought together and before the outer covering is put on, as shown in Figs. 10 to 13. The same applies to cables in which three or more wires are used. It is also well known that the possible speed of transmission is increased by having one or more leaks connecting the two parts of the circuit. For the purpose of producing an artificial leak or leaks we in some cases take advantage of the longitudinal air-space, using it as a convenient receptacle for inclosing the leak-producing apparatus, which leak apparatus may consist of a length of fine wire or ribbon *f*, either straight or coiled, and if coiled either with or without an iron axis and and having the necessary electrical resistance, one end of the leakage wire or ribbon being connected to one wire *a* of the circuit and the other end to the other wire *a* of the circuit; or for the same purpose we coat the outside of the insulation of each conductor

with some bad conductor *g*, Fig. 7, such as plumbago, and also make holes *j* in it, exposing the conductors *a* alternately at points some distance apart.

The number and dimensions of the leakage resistances inserted in the air-space conduit may, even for cables of one and the same length and conductor resistance, vary within large limits, it being well understood that, although the definition of the signals is improved by increasing the number of distributed leaks, the signals are diminished in amplitude. The possible number of distributed leaks will depend, therefore, not only upon the resistance and electrostatic capacity of the cable, but also upon the sensitiveness of the receiving instrument intended to be used.

In the case of an air-space cable having two conductors used as a metallic circuit without "earth" then, if we suppose the cable to be two thousand nautical miles in length, having a total resistance for the whole circuit of eight thousand ohms, we may insert at equal distances in and along the air-space conduit two hundred leakage wires or ribbons, or leakage connections by plumbago or the like with or without stops between each leakage connection, the resistance of each leakage-circuit being, say, two hundred and fifty thousand ohms.

If the cable, instead of having only one pair of conductors, has two or more pairs, each pair being used as a metallic loop, then each pair of conductors is provided with its own separate and distinct series of leakage resistances, it being convenient to insert the leakage resistance of each pair in rotation in and along the air-space conduit.

In the case of a cable having more than one circuit stops *h*, Fig. 7, are placed between the bared points in different circuits, and this may be done in all cases.

When cables having air-spaces are employed in deep water, the pressure is apt to collapse the air-space, and to prevent this we surround the tube with one or more metallic ribbons *e*, or we fill the air-space with wax, gum, resin, or other liquid or solid material *k*, Fig. 8, of low specific inductive capacity. When the material has a low melting-point, as is preferred, this may be done by liquefying the material and pumping it into the cable while the latter is in a warm chamber. Magnetic substances may also be mixed with the materials.

It is well known that many liquid or semi-liquid substances—such as Stockholm tar, carbolic acid, and alcohol—have the property of decreasing the electrical resistance of gutta-percha, and we therefore in some cases use them for filling the space or interstices, as above described.

It is found that gutta-percha and like material attract or exude moisture, forming a more or less conductive surface, and in order to render the low inductive capacity of air-space cables more permanent we coat the surface of the insulation of the conductor in the air-space with insulating and non-hygroscopic varnish or wax *g*, and where a badly-conducting coating is used this varnish is preferably applied over it. In Fig. 7 these two coatings are shown as one and are marked *g*.

What we claim is—

1. An electric cable of insulating material formed with a central longitudinal air-space and with two or more wires embedded at distances apart in the insulating material near the inner circumference.

2. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment.

3. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment such segments being twisted as they are brought together and before the outer covering is formed around them.

4. An electric cable of insulating material formed with a central longitudinal air-space and with two or more wires embedded at distances apart in the insulating material near the inner circumference the wires forming a circuit being connected together by conductors of high resistance.

5. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment the wires forming a circuit being connected together by conductors of high resistance.

6. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment such segments being twisted as they are brought together and before the outer covering is formed around them, the wires forming a circuit being connected together by conductors of high resistance.

7. An electric cable of insulating material formed with a central longitudinal air-space and with two or more wires embedded at distances apart in the insulating material near the inner circumference the insulation of the wires in the air-space being covered with a non-hygroscopic and non-conducting coating.

8. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment, the insulation of the wires in the air-space being covered with a non-hygroscopic and non-conducting coating.

9. An electric cable composed of a tubular case inclosing a cylinder which is built up of

two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment such segments being twisted as they are brought together and before the outer covering is formed around them the insulation of the wires in the air-space being covered with a non-hygroscopic and non-conducting coating.

10. An electric cable of insulating material formed with a central longitudinal air-space and with two or more wires embedded at distances apart in the insulating material near the inner circumference, the insulation of the wires in the air-space being covered with a conducting material of high resistance connected with the wires such covering being coated with non-hygroscopic and non-conducting material.

11. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment, the insulation of the wires in the air-space being covered with a conducting material of high resistance connected with the wires such covering being coated with non-hygroscopic and non-conducting material.

12. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment such segments being twisted as they are brought together and before the outer covering is formed around them, the insulation of the wires in the air-space being covered with a conducting material of high resistance connected with the wires such covering being coated with non-hygroscopic and non-conducting material.

13. An electric cable of insulating material formed with a central longitudinal air-space and with two or more wires embedded at distances apart in the insulating material near the inner circumference, the insulating material having around it a helically-wound metallic ribbon.

14. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment the tubular case containing a helically-wound metallic ribbon.

15. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment such segments being twisted as they are brought together and before the outer covering is formed around them the tubular case containing a helically-wound metallic ribbon.

16. An electric cable of insulating material formed with a central longitudinal air-space and with two or more wires embedded at distances apart in the insulating material near the inner circumference the air-space being afterward filled with a solid or liquid.

17. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment the air-space being afterward filled with a solid or liquid.

18. An electric cable composed of a tubular case inclosing a cylinder which is built up of two or more segments and has a longitudinal central hollow air-space and also has one or more wires embedded in each segment such segments being twisted as they are brought together and before the outer covering is formed around them the air-space being afterward filled with a solid or liquid.

WILLOUGHBY STATHAM SMITH.
WILLIAM PUDDICOMBE GRANVILLE.

Witnesses:
ROBERT B. RANSFORD,
FRED. C. HARRIS.