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O. J. LODGE.

TELEGRAPH AND LIKE CABLES.

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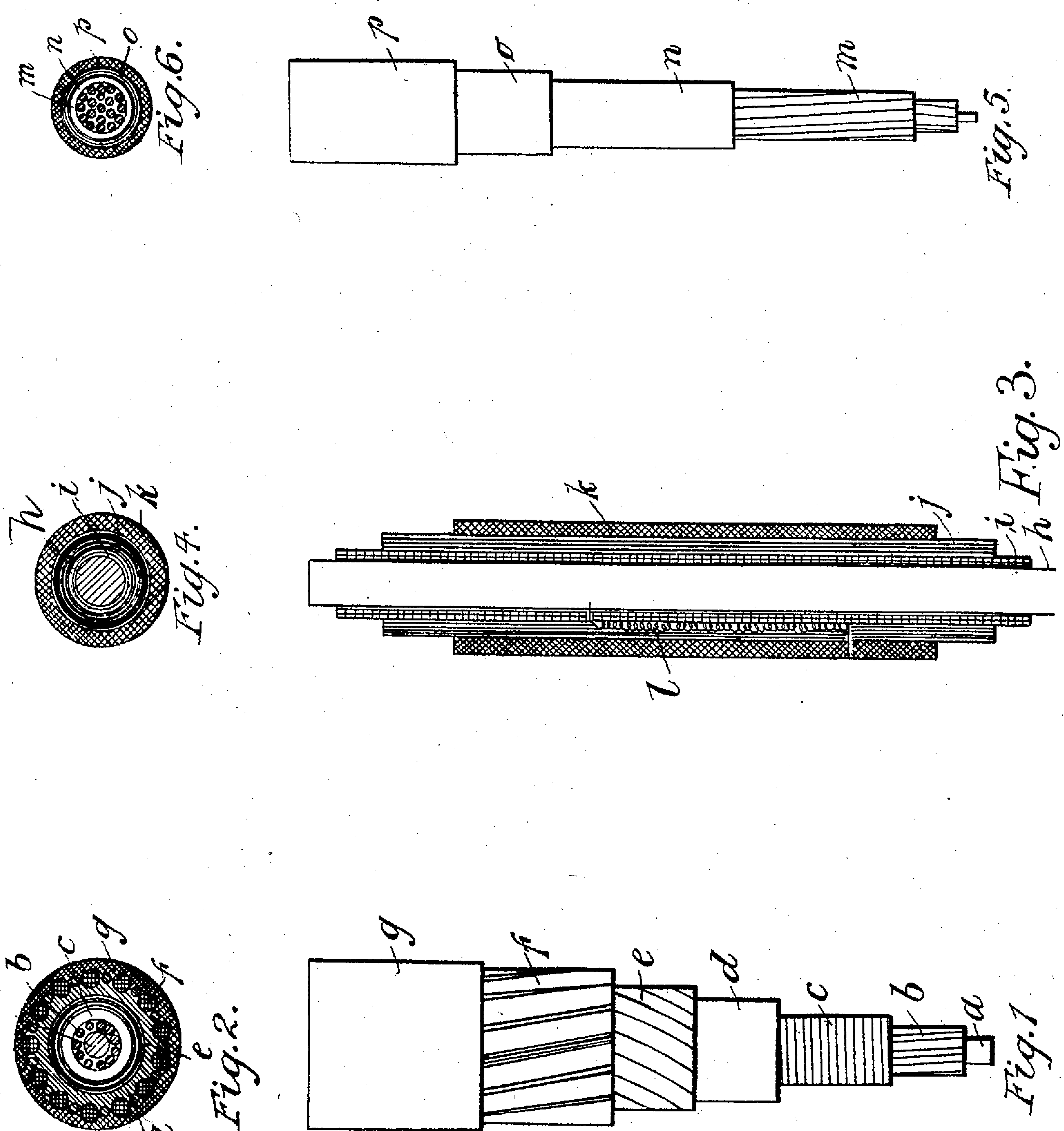

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TELEGRAPH AND LIKE CABLE.

No. 795,402. Specification of Letters Patent. Patented July 25, 1905.

Application filed December 9, 1904. Serial No. 236,229.

To all whom it may concern:

Be it known that I, Oliver Joseph Lodge, Knt., principal of the University of Birmingham, a subject of the King of Great Britain and Ireland, residing at Mariemont, Edgbaston, in the city of Birmingham, England, have invented new and useful Improvements in and Relating to Telegraph and Like Cables, of which the following is a specification.

My invention relates to improvements in the construction of cables for telegraph and telephone purposes, and has for its object the construction of cables of a character approaching the distortionless cable, the theory of which has been given by Oliver Heviside. Theoretically a distortionless cable is one that will transmit waves or impulses communicated to it attenuated in intensity, but preserving their shapes or characteristics, and will transmit waves of all frequencies at the same speed. Freedom from distortion in a telegraph-cable renders possible increase in the rapidity and distinctness of the signaling, and, indeed, a sufficient approximation to a true distortionless cable would enable telephonic speech to be transmitted provided the attenuation were not too great for audibility. Taking the four chief electrical properties possessed by cables—viz., resistance, capacity, inductance, and leakance—the distortionless condition is attained if the four are proportioned to one another in such a way that the product of the inductance and leakance is equal to the product of the conduction resistance and capacity, and it is desirable that this proportion should hold not only for the cable as a whole, but for every part of it—that is to say, that the leakance and inductance shall be distributed uniformly along the length of the cable just as the resistance and capacity are at present. If the inductance for the whole cable be expressed in henries, the leakance in hmos, the conduction resistance in megohms, and the capacity in microfarads, then both the above products, which have to be approximately equal, will for the whole cable be expressed in seconds of time. The velocity with which sudden impulses or the fronts of waves will be transmitted by such a cable is the reciprocal of the geometric mean of its self-inductance and capacity per unit length.

The attenuation of an ordinary cable is divisible into two parts, one depending on resistance compared with self-induction and the other on leakance compared with capacity; but in the case of a distortionless cable these two causes of attenuation are equal, and in that case the attenuation-index, whereby the logarithm of the received amplitude falls below the logarithm of the transmitted amplitude is simply the square root of the product of the conduction resistance to the leakance for the whole cable.

I am aware that it has been proposed by various devices to increase the inductance of a cable and in some cases to equate the inductance to the capacity, which is impossible, in order to increase the rate of transmission and reduce distortion. It has also been proposed separately to provide an ordinary cable with leakance only; but none of these proposals have succeeded in doing more than slightly improving the rate of transmission. The efforts have not been directed to truly distortionless conductors.

The first part of my invention consists in constructing a cable in which provision is specially made for increase of both inductance and leakance, the conduction resistance and the capacity being both kept low.

The second part of my invention consists in special means hereinafter described for increasing the self-inductance of the cable in a way favorable to rapid signal transmission.

The third part of my invention consists in providing the required leakage to satisfy the condition indicated above by reducing the insulation of the dielectric, while maintaining its water-tight character. One way of doing this is by incorporating a fine powder—say a suitable form of carbon, such as plumbago—in the insulating material. Another way is by keeping any permitted coating of high insulation, such as gutta-percha and rubber, very thin, and over that to lay a considerable thickness of a compound having inferior insulation. Another way is by introducing special high-resistance wire spirals reaching from core to sheath at regular intervals.

In carrying my invention into effect I employ a central copper conductor having a resistance as low as is practicable, and for the purpose of increasing the self-inductance of the copper core I surround it with iron, preferably subdivided in concentric rings, the iron being carefully selected for low hysteresis and high permeability under small magnetizing forces. This iron should be in practically immediate contact with the copper, that being the most valuable space for the purpose. In order to keep the capacity low, I employ a substantial thickness of dielectric, while to introduce leakage of proper amount to satisfy the condition indicated above I prefer to use a dielectric of only very moderate insulating power, but of a completely water-tight character, so as to preserve the core from contact with sea-water, but at the same time to allow electricity to escape from the core as fast as it accumulates, because its accumulation would introduce distortion by opposing and deflecting the front of a wave impulse.

In a true wave it is necessary that the magnetic and electric energy shall be equal, while in a cable the electric energy is apt to overpower the magnetic unless the surplus electricity is drained away by leakage or unless the magnetic energy is sufficiently increased, as suggested by the use of iron surrounding the copper core.

Referring to the accompanying drawings, Figure 1 is a view showing the various layers of a cable constructed according to one modification of my invention, Fig. 2 being a transverse section of the same. Fig. 3 is a longitudinal section, and Fig. 4 is a transverse section, of another modification. Fig. 5 is an elevation showing the various layers of another modification, while Fig. 6 is a transverse section of the same.

In the modification shown in Figs. 1 and 2 I provide a stout copper core *a*, surrounded by a number of copper strands *b*, packed closely together, the whole forming a core of, say, three-eighths of an inch diameter, for the cable of very low resistance. The core is surrounded by a covering *c* of selected iron strip—say one-sixteenth of an inch square section—bound directly on the copper as nearly as possible at right angles to the core, this covering being covered by layers of waterproof sheathing *d*. The sheathing *d* is covered with a layer of hemp *e* and a layer of steel or iron wires or of alternate hemp and steel or iron wires *f* to give the cable the necessary longitudinal strength or tenacity and the whole is covered with any suitable waterproof coating *g*.

Figs. 3 and 4 show a modification in which the solid copper core *h* is surrounded with an iron layer either wound or braided or in the form of washers *i*. This layer is covered by waterproof sheathing *j* and a protecting covering *k* without any strengthening iron or steel. The iron layer may be in the form of a double layer of strip winding. An artificial leak is shown diagrammatically in Fig. 3, consisting of a spiral of wire *l* of high resistance connecting the core *h* with the outer sheath or with the sea-water if no outer conducting-sheath is used. The artificial leak may consist of a spiral of wire of high resistance wound round the cable inside part of the waterproof sheathing. I prefer, however, to obtain the necessary leakage by using coverings of poor insulating quality, and I only provide the artificial leak at intervals of, say, a mile along the cable in cases where the leakage through the insulating-sheathing is insufficient.

Figs. 5 and 6 show a modification with a copper core *m* stranded throughout and coated with an iron sheathing *n* in the form of a continuous tube, which may be deposited electrically on the copper or otherwise squeezed on, so as to give longitudinal strength. The iron coating is covered with a waterproof sheathing *o* and outer covering *p*, as before.

In the above-described modifications I have described various methods of surrounding the copper core with iron; but the ideal arrangement is to thread the iron on the copper core in the form of thin washers, circumferentially continuous, which would become concentrically magnetized and demagnetized by longitudinal currents in the core, and the winding of a strip of iron above described is an approximation to this form.

The outer coatings may consist of, first, a water-tight composition, such as gutta-percha or india-rubber, surrounding the iron and forced on in a continuous coating, and over that a layer of some thickness of a compound of inferior insulation, this material being selected for permanence, but not for high insulating qualities. The other coating or covering of the cable can be hemp or other usual materials, together with any iron or steel necessary for mechanical strength, this outer iron not being magnetically serviceable. Preferably I should dispense with iron armor in the deep-sea portion of the cable and obtain the necessary strength by adding to the thickness of the copper core, surrounding that with carefully-selected iron, and then sheathing the whole in water-tight material of poor insulation and preferably of low inductive capacity to as great a bulk as is permissible in practice.

The insulation as a whole must be of such a character that it will permit the required amount of leakage, and in cases where the leakage through the insulating-coating is insufficient I provide spirals, as described with reference to Fig. 3, these spirals having a resistance comparable to a megohm and being placed at suitable short intervals—say a mile apart. It is important, however, that the leakage should be kept as low as is consistent with the approximation to the distortionless character of the cable, and it is desirable to keep the leakage less than the theoretical amount and never greater, because when the leakage is too great the attenuation is uselessly increased, as then both attenuation and distortion increase together. It is vitally essential in all cases to keep the conduction resistance of the cable as low as possible.

Having now described my invention, what

I claim as new, and desire to secure by Letters Patent, is—

1. A substantially distortionless cable, having a core of low resistance, iron divided longitudinally surrounding said core, and a waterproof sheath of low insulating quality, as and for the purposes described.

2. A substantially distortionless cable having a core of low resistance, iron divided longitudinally surrounding said core, and a waterproof sheathing with means whereby leakage is allowed between the core and the outside of the cable, as and for the purposes described.

3. A substantially distortionless cable having a core of low resistance, means surrounding said core for increasing the self-induction, a waterproof sheathing of poor insulating quality and of considerable thickness, as and for the purposes described.

4. A substantially distortionless cable, having a core of low resistance, iron wound spirally round said core and a waterproof sheathing of poor insulating quality and considerable thickness as and for the purposes described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

OLIVER JOSEPH LODGE.

Witnesses:
ALFRED BRISCOE,
HENRY HERBERT OLIVER.