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J. J. GILBERT

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CONDUCTOR

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Fig. 1

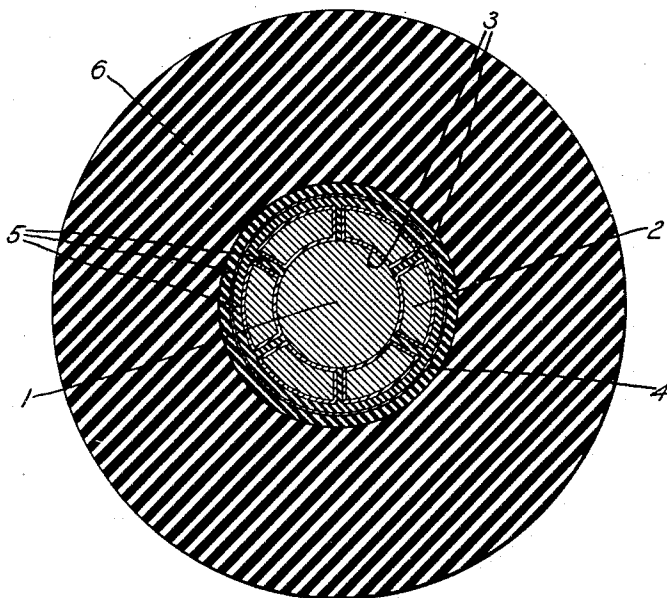
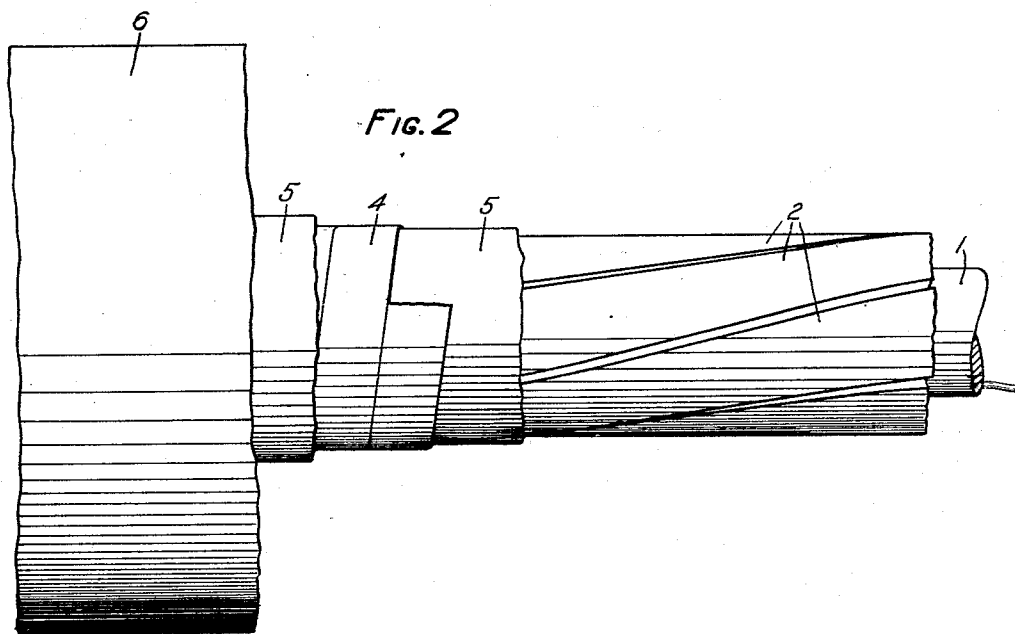


Fig. 2



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## UNITED STATES PATENT OFFICE

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## CONDUCTOR

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In a submarine cable conductor of the ordinary type either solid, or the stranded type consisting of a central core with surrounds in the form of flat spiraled copper strips, the "skin effect" results in the effective resistance being increased as the frequency increases. This occurs because the current tends to concentrate in the outer portion of the conductor.

An object of this invention is to lessen the increase of resistance with increased frequency of current. This is accomplished by increasing the impedance of the outer layers or surrounds of the conductor as compared to the impedance of the central core.

To attain the desired result, in accordance with one method the surrounds of a stranded conductor are individually loaded to counteract the skin effect, whereby a portion of the current will be forced from the surrounds into the central strand or strands. In this manner the overall resistance is reduced and the inductive reactance increased.

Relatively light loading is required and the outer strands may be loaded by electrolytic deposition of magnetic material upon them. Alternatively, the magnetic material may be applied by sputtering or by the Schoop's pistol.

Where there are several layers of surrounds each layer may be loaded and the loading increased towards the outer layer to counteract the increasing skin effect.

Alternatively, the desired inductive reactance may be had by serving the unloaded surrounds with a given number of turns per unit length of conductor. In this case it might be desirable to subdivide the central conducting core in order to reduce the losses due to eddy currents set up in this core by the solenoidal field of the surrounds.

Fig. 1 is a cross section of a cable core embodying the features of the invention; and

Fig. 2 is a side view of the same cable core with the various layers cut away at different points in order to illustrate the several components thereof.

The details of a representative structure involving the invention may be understood from the following description taken in connection with the accompanying drawings

which are purely diagrammatic and not intended to represent relative dimensions of a practical structure.

In the drawings the central core 1 is surrounded by the usual flat strands or surrounds 2. The strands 2 are individually loaded by electro-deposition upon them or by other suitable application thereto of magnetic materials such as nickel-iron alloys of high permeability, nickel-iron-cobalt alloys or other similar magnetic materials, illustrated at 3. Surrounding the outer strands is the usual magnetic loading material 4. For telephone cables of considerable length the loading material 4 may consist, for example, of a composition of 45% nickel, 25% cobalt, 23% iron, and 7% molybdenum, heat treated to develop high constancy of permeability in a range of low magnetizing forces as is well known, the molybdenum content in such a composition serves to give it a high resistivity of the order of 85 microhm-cms. In a practical structure the entire conductor and loading material will be surrounded by a viscous semi-liquid pressure equalizing substance 5 of a kind well known in the art, i. e. bitumen or "Chatterton's compound". The conductor thus prepared is surrounded with gutta percha or similar insulating material 6 to form a core.

For a deep sea submarine cable conductor of the usual dimensions it will be appropriate to cover the surrounds with high permeability material to a thickness of about 0.001 inch (0.025 m. m.). The hysteresis and eddy current losses in this thin layer of material will be very small.

A conductor having the outer strands loaded in the manner thus described is advantageous in that the impedance of the outer strands is increased, which tends to force more of the current into the central core or the inner strands, thereby compensating in part, at least, for the skin effect. Loading the surrounds makes the phase angle of the currents in the inside and outside parts of the conductor more nearly equal, or entirely equal depending upon the frequency and degree of loading. In an ordinary conductor the skin effect has the appar-

ent result of making the ratio of reactance to resistance lower in the outside part of the conductor than in the inside and this ratio is increased by individually loading the surrounds.

What is claimed is:

1. A loaded conductor for submarine telephone communication comprising a central portion surrounded by closely fitting surrounding strands, each strand having its inductance increased by a thin layer of high permeability magnetic material substantially completely covering the external surface of the strand.

2. A submarine cable conductor composed of several strands some of which lie nearer the exterior of the conductor than others, characterized in this that the extreme outer layers of the individual exterior strands have magnetic material substantially completely surrounding them.

3. A submarine cable conductor having a plurality of strands part of which are individually substantially completely covered upon their external surfaces by a thin layer of magnetic material composed principally of nickel and iron heat treated in a manner to make it of high permeability.

4. A composite electrical conductor having a plurality of strands, some of which lie externally of the others and have as their outer layer a layer of magnetic material of the order of 0.001 inch in thickness.

5. A composite electrical stranded conductor in which certain strands are individually substantially completely surrounded by magnetic material and the entire conductor as a whole is surrounded with other magnetic material.

6. A submarine cable having a conductor in accordance with claim 5, characterized in this, that the cable is insulated with a tough solid insulating material of the character of gutta percha and that the strands of the conductor and the other magnetic material are completely surrounded by a viscous or semi-liquid pressure equalizing substance.

7. A composite electrical conductor for high frequency submarine cable communication having a conductor composed of a central portion and closely fitting surrounding strands in which the inductance of the closely fitting surrounding strands as compared to the inductance of the central portion, is increased by magnetic loading material, characterized in this that the loading material is high permeability, high resistivity material in thickness of the order of 0.001 inch.

In witness whereof, I hereunto subscribe my name this 26th day of February, 1929.

JOHN J. GILBERT.