April 16, 1940. R. W. ATKINSON 2,197,544

ELECTRIC CABLE

Filed Aug. 5, 1938

Fig. 1.

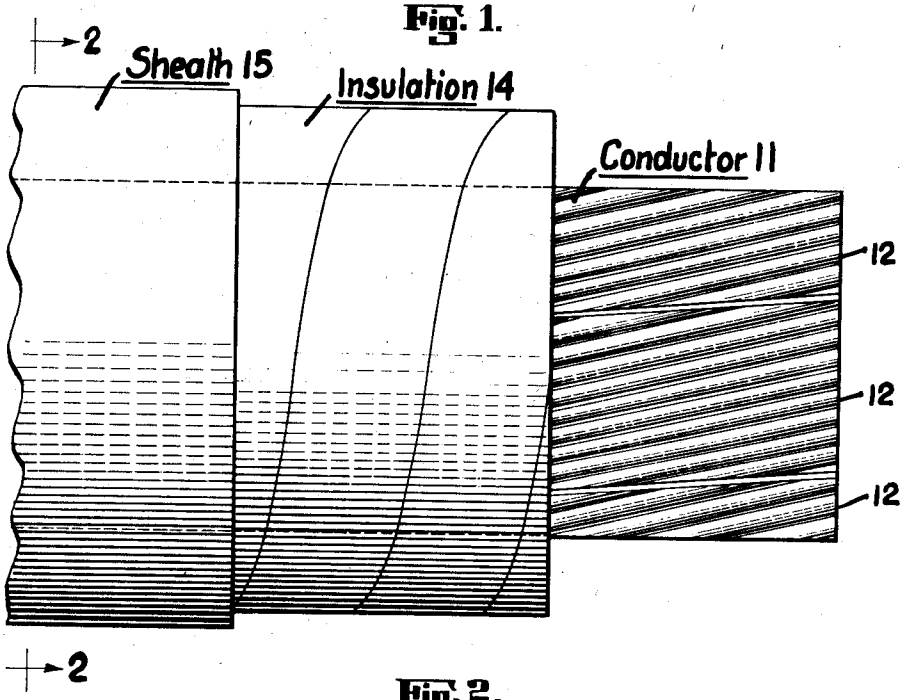
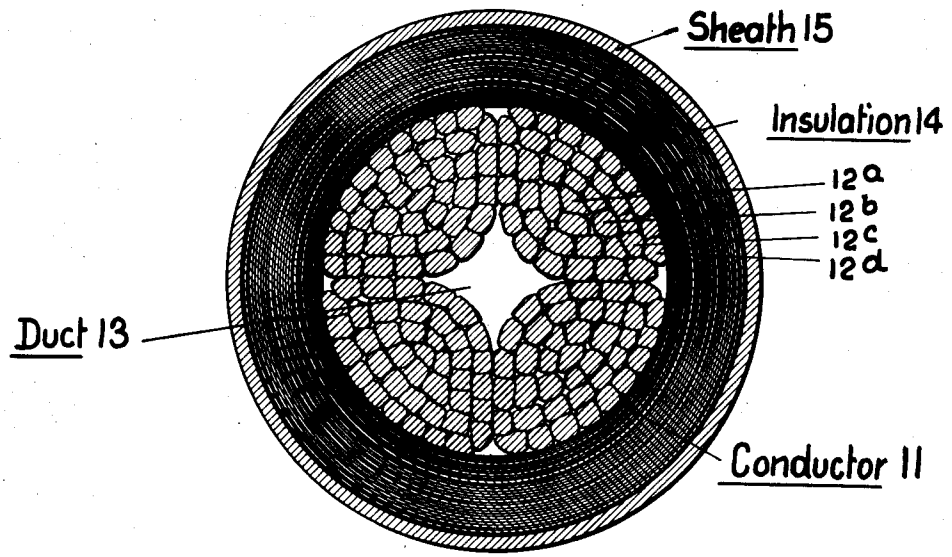


Fig. 2.



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ELECTRIC CABLE

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Application August 5, 1938, Serial No. 223,143

10 Claims. (Cl. 174—25)

The present invention relates to electric cables, and more particularly to cables comprising large, hollow core conductors having reduced skin effect and otherwise improved electrical characteristics. The present application is a continuation-in-part of my copending application Serial Number 681,022, filed July 18, 1933, patented August 9, 1938, No. 2,125,869, and all that is disclosed in that application with respect to a segmental construction for reducing skin effect, intersegmental insulation, character of wire lay or formation, valley fillers, shielding, insulation and the like may be considered, so far as pertinent and consistent, as applicable to the present invention. The improvement provided by the present invention over the invention disclosed in the said application resides principally in the provision of a construction in which the flow of oil or other fluid insulation is better accommodated, particularly the flow longitudinally of the cable. It is an object of the invention to provide an improved hollow core conductor. It is a further object of the invention to provide an improved fluid-filled cable. Other objects and advantages of the invention will appear hereinafter.

The invention will be best understood from the following description when read in the light of the accompanying drawing showing an illustrative embodiment of the invention and wherein:

Fig. 1 is an elevation of a short length of insulated and sheathed cable, the parts being broken away progressively greater distances to disclose the construction more clearly; and

Fig. 2 is a cross section through the cable of Fig. 1, the view being taken substantially on the line 2—2 of Fig. 1.

As disclosed in my copending application referred to above, when an electric conductor is carrying alternating current there is a tendency for the current to concentrate in the outer portion of the conductor. This increase in current density near the surface of the conductor may be considered to be a result of the fact that that portion of the flux generated by the current and lying within the conductor itself generates counter-electromotive forces in the conductor which are greater in the center of the conductor than adjacent the surface thereof. This concentration of current near the outer surface of the conductor, commonly known as skin effect, results in an increase in the effective resistance of the conductor to the flow of alternating current longitudinally of the conductor.

In conductors of small cross-section this increase in effective resistance of conductors is small for currents of the usual power frequencies. However, as the size of the conductor increases, the increase in the effective resistance of the conductor due to skin effect rises rapidly.

According to my copending application there is provided a segmental conductor in which the skin effect is greatly reduced, as compared to what it would be in a comparable sized concentric stranded conductor, particularly in large size conductors, so that the cables may be used economically for high voltages without substantial increase in the overall size of the conductor, and with a minimum danger of failure in the cable insulation adjacent the surface of the conductor.

According to the present invention there is shown, by way of example, a single conductor power cable in which the conductor 11 comprises a plurality of conducting segments 12, there being four of these segments in the illustrative embodiment. Desirably, the segments 12 are approximately sector-shaped so that when they are cabled together they form a substantially round conductor. Each of these conducting segments comprises a plurality of conducting wires stranded together, and preferably each segment 12 is built up in a plurality of overlying layers with the wires stranded helically so that each wire follows a sinuous course longitudinally of the conductor, first approaching the center of the conductor 11 and then approaching the outer surface thereof.

In this manner the resistance of each wire of the conductor to the flow of alternating current longitudinally of the conductor may be made approximately equal to the resistance of every other wire of the conductor, depending upon the completeness in transposition of the wires.

The segments 12 are in one way or another insulated from each other. The oxide coatings normally present on the wires may serve in whole or in part as the insulation.

The segments desirably will be formed as compressed stranded sectors as by the method disclosed in the patent to Edgar W. McKnight, No. 1,943,086, granted January 9, 1934. Such sectors are illustrated in Fig. 5 of the copending application referred to and are illustrated in the present drawing. They comprise a core strand 12*a* and overlying layers 12*b*, 12*c*, 12*d* of helically laid strands, each layer being compressed to the desired shape and smooth outer surface before the next layer is applied. By such a method the sectors may be given practically any cross-sectional shape desired.

According to the present invention the sectors have imparted to them such a shape that they have substantially parallel sides lying along radii of a circle, and arcuate outer surfaces which together form a substantially perfect circle. Small valleys between segments at the outer surface of the conductor are shown in the drawing, but it will be understood that the shape of the segments may be such as practically to eliminate these valleys. If any appreciable valleys are left they may be filled by insulators or conductors and shielded in the manner disclosed in my copending application, referred to hereinabove.

Interiorly the segments 12 are shaped to form an axial channel or duct 13. This channel preferably is of substantial size whereby to accommodate a rapid flow of a large volume of oil or other fluid. The duct is preferably formed in such shape as to minimize friction and obstructions which would impede the flow of oil. The duct shown approximates a square in cross section, but if some other shape is found to produce less hindrance to the flow of oil longitudinally of the cable, the method of formation of the segments obviously will permit the fabrication of the segments in a manner to modify materially the shape of the channel, even to making it round.

The compressed sectors provide a further advantage. Being relatively smooth exteriorly they allow the oil to flow with a minimum of surface resistance, in spite of the fact that the helical wire strands are disposed in part transversely or circumferentially with respect to the length of the duct.

When the radial thickness of the sectors is appreciably less than the V-gauge depth of the sectors, the V-gauge depth being the radius of the circular conductor in the present instance, that is, when the oil duct is relatively large, there will be large areas of the sectors exposed interiorly to oil pressure. This will tend to force the sectors outward and spread them apart thus permitting oil to be forced between them. The oil then tends to form an insulating film or separating layer between the sectors.

This action also assists in the passage of oil to the outer portions of the assembly. The outflow of oil is also facilitated by the small spaces between the spiral strands of the sectors. Even when the sectors are compressed and made relatively smooth there will still be very small spaces or valleys between strands which are usually sufficient to accommodate radial flow of oil.

The outer coverings may be the same as those disclosed in my copending application above referred to. However, for simplicity only a single layer 14 of permeable material such as laminated paper, cambric or the like is illustrated. Over this an impermeable covering such as a lead sheath 15 may be placed.

If necessary for supporting the sectors during assembly or thereafter in order to obtain or maintain a round section, a supporting structure such as a wire helix core may be employed, though this ordinarily will not be used when it can be dispensed with because of its obstruction to the flow of oil. Alternatively, if desired, the segments may be shaped to have interlocking side walls to avoid inward collapse of any segment.

It will thus be seen that the present invention provides a cable adapted for the transmission of large currents with a greatly reduced skin effect loss, as compared to a comparable sized concentric stranded conductor, and one which permits rapid passage of oil or other fluid longitudinally as well as radially in the cable.

It will be understood that the present invention may be variously modified and embodied within the scope of the subjoined claims.

I claim:

1. A segmental electric conductor having reduced skin effect loss, comprising a plurality of conducting segments cabled together, said segments each comprising a plurality of wires stranded together, the radial thickness of the segments being less than the radius of the conductor so as to form an axial duct within the conductor.

2. A segmental electric conductor having reduced skin effect loss, comprising a plurality of conducting segments cabled together, said segments each comprising a plurality of wires stranded together, the segments being substantially in contact with each other at their outer surfaces and being spaced apart interiorly to form an axial oil duct.

3. A segmental electric conductor having reduced skin effect loss, as set forth in claim 2, which further comprises means to maintain the segments in proper position to avoid inward displacement of any of the segments.

4. A segmental electric conductor having reduced skin effect loss, comprising a plurality of conducting segments cabled together, said segments each comprising a plurality of wires stranded together, the segments being substantially in contact with each other along extended surfaces on their sides and being spaced apart interiorly to form an axial oil duct.

5. A segmental electric conductor having reduced skin effect loss, comprising a plurality of conducting segments cabled together, said segments each comprising a plurality of wires stranded together, the segments being sector-shaped with arcuate outer surfaces and substantially radial side surfaces, the segments being foreshortened interiorly to form an axial oil duct.

6. A segmental electric conductor having reduced skin effect loss, comprising a plurality of stranded conducting segments cabled together, the segments each being formed of a plurality of helical strands compressed to form substantially sector-shaped elements with relatively smooth surfaces, the outer surfaces being arcuate, the side surfaces being substantially radial, and the segments being foreshortened interiorly to form an axial oil duct.

7. A segmental electric conductor having reduced skin effect loss, comprising a plurality of conducting segments cabled together, said segments each comprising a plurality of wires stranded together, the segments being substantially in contact with each other at their outer surfaces and being spaced apart interiorly to form an axial oil duct, a permeable insulating layer over the conductor, and an impermeable jacket enclosing the entire assembly.

8. A fluid-filled cable comprising a plurality of sector-shaped, stranded conducting segments cabled together to form a single conductor having an axial duct for the flow of fluid, said segments each comprising a plurality of wires stranded together, a laminate wall of insulating material enclosing the conductor, an impermeable protective sheath surrounding the insulation, and a body of fluid insulating material filling the duct and permeating the laminate wall.

9. An oil-filled cable comprising a plurality of

stranded, sector-shaped conducting segments cabled together to form a hollow, cylindrical conductor, said segments each comprising a plurality of wires stranded together, an inclosing wall of oil-permeable insulation, an impermeable protective sheath surrounding the insulation, and a body of insulating oil filling the conductor and permeating the wall of insulation.

10. A segmental electric conductor having reduced skin effect loss, comprising a plurality of sector-shaped, conducting segments cabled together, said segments each comprising a plurality of wires stranded together to effect transposition of the wires radially within the conductor, the radial thickness of the segments being less than the V-gauge depth of the segments.

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