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H. R. LORCH ET AL

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ELECTRIC HEATING CABLES

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Fig. 1.

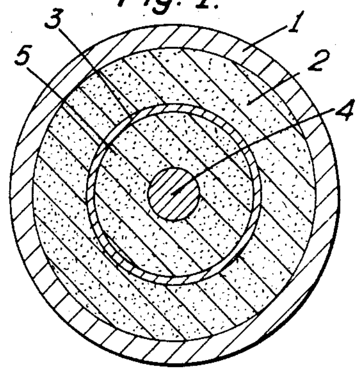


Fig. 2.

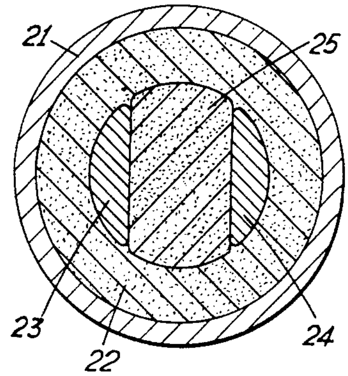


Fig. 3.

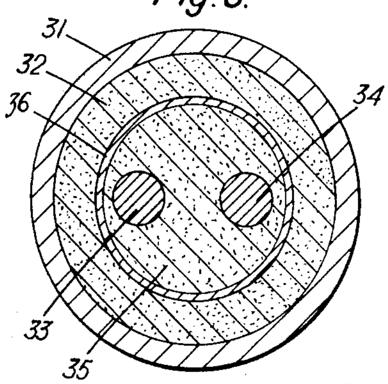


Fig. 4.

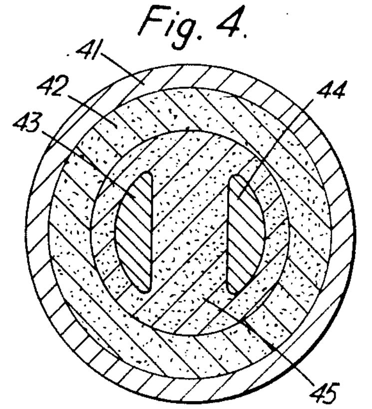
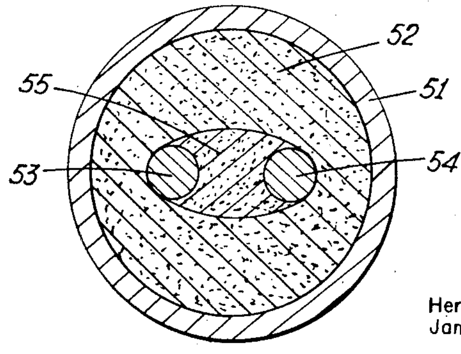


Fig. 5.



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ELECTRIC HEATING CABLES

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Claims priority, application Great Britain January 17, 1956

4 Claims. (Cl. 338—224)

This invention relates to electric cables for use, in long or short lengths, as electric heaters. The cable in accordance with this invention comprises at least two conductors separated from one another by semi-conducting inorganic material, the whole being enclosed within a surrounding layer of pulverulent mineral insulating material and an outer metal sheath. The insulating material may be, for instance, magnesium oxide or talc.

There may be two conductors, comprising an inner wire and a tubular conductor filled with the semi-conducting material within which the wire is disposed. Alternatively there may be two conductor wires extending in spaced relationship. In this alternative arrangement the two wires may be separated from one another and in some cases also surrounded, by semi-conductive material and separated from the surrounding sheath by mineral insulating material. In yet another arrangement the two wires may be separated from one another and from a tubular conducting intersheath by semi-conducting material, the intersheath being insulated from the outer sheath by mineral insulating material.

The cable will preferably be of circular cross-section. Where, in such a circular form, there is one inner wire surrounded by a tubular conductor, the latter will usually be of circular section with the inner wire extending along its axis. Where there is an intersheath surrounding two inner wires, the intersheath will usually be of circular section with the wires spaced apart from it and from one another symmetrically about the cable axis. The inner wires will be similarly arranged where there is no intersheath.

Where the cable includes two inner conductors extending longitudinally within the insulating body and spaced apart symmetrically about its axis, the two wires may be each of substantially D-shaped cross-section arranged with their convex sides outwards and their other sides facing the cable axis. Within the term "D-shaped cross-section" there is included semi-circular and crescent-like cross-sections, the wires of such sections being arranged with their flat or concave sides facing the cable axis. Such inner conductors are separated by a body of the semi-conductive material which, in combination with them, forms a substantially circular or elliptical cross-sectional shape.

All the conductive elements of the cable will be of high conductivity and high melting point metal, for example copper or aluminium. The inner conductors are preferably single wires. Where there is a tubular conductor or an intersheath, this may be a seamless metal tube, or a metal tape folded longitudinally or wrapped helically into the form of a tube.

The semi-conductive material may be any suitable pulverulent inorganic composition which will serve for the generation of heat on the passage of current through it. Suitable compositions are mixtures of magnesium oxide with powdered carbon, or with other metallic oxides or metal titanates which mixtures have a semi-conductivity appropriate for required heat generation.

The cables may be made by assembling the metal components in relatively short lengths of increased cross-sectional area in the appropriate relationship and filling the intermediate spaces with the appropriate semi-conductive and insulating compositions, usually in the form of dry powders. After filling, the complete structure is then reduced to the required cross-sectional dimensions by rolling, swaging or drawing or any combination of these operations, with or without drying and annealing stages. Alternatively one or both of the non-metallic components may be applied by extrusion in the form of paste which is afterwards dried, or with some constructions both may be so applied either simultaneously or consecutively, with or without a final drawing down to consolidate the non-metallic layers.

Several forms of the improved cable will now be described by way of example and with reference to the accompany diagrammatic drawings, wherein:

Figure 1 represents a view in cross-section of a cable which incorporates two concentric conductors;

Figure 2 represents a view in cross-section of a cable which incorporates two parallel conductors of D-shaped section;

Figure 3 shows in cross-section a cable having two parallel circular section conductors surrounded by a conducting intersheath;

Figure 4 illustrates in cross-section another form of cable which includes two parallel D-shaped conductors, and

Figure 5 illustrates a modification of the arrangement shown in Figure 2, the conductors in this case being circular section wires.

Referring first of all to Figure 1, there is shown a circular section copper tube 1, which constitutes an outer sheath, fitting closely on an annular insulating body 2 of pulverulent magnesium oxide. The annular insulating body 2 encloses a tubular copper conductor 3, which is of circular section and is concentric with a central copper conductor wire 4, the wire 4 and tubular conductor 3 being separated from one another by a filling of semi-conductive material 5. The latter is a mixture of magnesium oxide and powdered carbon. This cable is made by drawing down an assembly of appropriately arranged component parts, each of which is shorter than the finished cable and of cross-sectional dimensions which are correspondingly larger than in the finished cable. In this process, a circular section copper rod which is to comprise the central conductor 4, is placed centrally within, and in fixed relation to, a circular section copper tube which is to provide the tubular conductor 3. The powdered semi-conductive material 5 is now packed within the annular space between the tube and the rod. The resulting assembly, which may or may not be first drawn down, is then placed, and held, centrally within a circular section copper tube which is to provide the outer sheath 1 and the annular space within the tube is packed with the pulverulent insulating material 2. The whole assembly is afterwards drawn down to the required dimensions. In an alternative method, a circular section copper tube, which is to provide the tubular conductor 3, is placed centrally within, and in fixed relation to, another circular section copper tube which is to provide the outer sheath 1. The annular space within the two tubes is then packed with the pulverulent insulating material 2 by means of a hollow ram. The bar is now removed and a circular section copper rod, which is to provide the central conductor 4, is placed centrally within and in fixed relation to the inner tube. The annular space around the copper rod is then packed with the pulverulent semi-conductive powder and then the complete assembly is drawn down to the required dimensions.

In the form of heater cable shown in Figure 2, the outer sheath 21 is again a circular section copper tube which fits closely on an insulating body 22 of pulverulent magnesium oxide. The insulating body 22 is of substantially annular cross-section, and its central cavity is filled by two inner parallel copper wires 23, 24 and an intermediate body 25 of a pulverulent semi-conductive mixture of magnesium oxide and powdered carbon. The two inner copper wires 23, 24 extend longitudinally within the insulating body 22 and are spaced apart symmetrically about its axis. The cross-sectional shape of each of the wires 23, 24 is a segment of a circle and they are arranged one on each side of the cable axis with the flat sides of the segments facing one another and their convex sides in contact with the insulating body 22. The inner wires 23 and 24 are separated by the body 25 of semi-conductive material which, together with the wires, forms a substantially circular cross-sectional shape. This cable is made by a process similar to those described in connection with Figure 1. There is placed within, and in fixed relation to, a copper tube, which is to become the outer sheath 21, a central circular section core member consisting of two segmental copper rods, which are to become the inner wires 23 and 24, separated by a removable spacer bar. The powdered insulant 22 is packed within the space between the core and the tube wall by means of a hollow ram. The spacer bar is then removed, leaving the copper rods in place. The semi-conductive powder 25 is now packed into the remaining central space by means of a ram having a cross-sectional shape corresponding substantially to that formed by the flat sides of the segmental rods and the remaining surfaces of the packed insulant 22. After this space is filled, the ends of the assembly are closed and the whole is drawn down in the usual manner.

The wires 23 and 24 of the cable shown in Figure 2 may be of semi-circular or crescent-like cross-section, arranged with their flat or concave sides facing the cable axis. In the process of manufacture, therefore, the initial copper rods may also be of corresponding semi-circular or crescent-like cross-section with their flat or concave surfaces separated by a removable spacer bar of correspondingly appropriate cross-section. Alternatively, the body of semi-conductive material with the wires 23 and 24 may have an elliptical cross-sectional shape. In such case, the core member used in the process of manufacture and comprising the copper rods and spacer bar, will also be of the appropriate elliptical section.

In Figure 3, the outer circular section tubular sheath 31 of copper is a close fit on an annular body 32 of pulverulent magnesium oxide. This, in turn, is packed about a copper intersheath 36, which is a circular section tube concentric within the outer sheath 31. Within the intersheath 36 there extend, longitudinally and in parallel spaced relationship, two single copper conductor wires 33 and 34 of circular section. The wires 33 and 34 are symmetrical about the cable axis, with their axes in a plane through the cable axis. The intersheath 36 is packed with a body 35 of semi-conductive material, comprising a mixture of magnesium oxide and powdered carbon, in which the wires 33 and 34 are embedded and by which they are separated from one another and from the intersheath 36. In the use of this cable as a heater, the heating current will flow through the semi-conductive body 35 from one wire to the other directly, and also indirectly along paths which include the intersheath.

The arrangement shown in Figure 4 is generally similar to that of Figure 2, in that it comprises an external tubular copper sheath 41 enclosing an annular body 42 of pulverulent insulating material which in turn encloses two segmental copper wires 43 and 44 which are separated by a body 45 of a semi-conductive mixture of magnesium oxide and powdered carbon. In this case, however, the semi-conductive body 45 is of circular section with its cylindrical surface in complete contact with the outer insulating body 42, and the wires 43 and 44 are completely embedded in the semi-conductive body 42 so as to be separated by it from one another and from the insulating body 42.

The two cables shown in Figures 3 and 4 may be made by methods similar to those described in connection with Figures 1 and 2.

The arrangement shown in Figure 5 is similar to that of Figure 2 in that it comprises an external tubular copper sheath 51 of circular section which fits on an insulating body 52 of pulverulent magnesium oxide and this in turn includes a central cavity filled by two parallel copper wires 53 and 54 and an intermediate body 55 of a pulverulent semi-conductive mixture. In this case, however, each of the wires 53 and 54 is of solid circular cross-section and also the central assembly, comprised of the wires and the semi-conductive material 55 has a cross-section substantially in the shape of an ellipse. The ellipse is symmetrical about the cable axis, and the two wires 53 and 54 are arranged towards the ends of the major axis of the ellipse so that at the ends of that axis the surfaces of the wires are in contact with the insulating body 52.

Alternatively, some or all of the cables shown in the drawings may be made by extrusion processes. For instance, the cable shown in Figure 1 may be made by extruding the semi-conductive material 5 in the form of a paste upon the central wire 4 and thereafter applying the tubular conductor 3 in the form of a metal tape folded or wrapped about the paste. Thereafter the insulating material 2 is extruded as a paste about the tubular conductor 3 and then the sheath 1 is applied as an extruded tube. The structure is subjected to drying temperatures at an appropriate stage or stages in the process and may or may not be finally drawn down to consolidate the non-metallic parts. In the case of the cable shown in Figure 3, the method of manufacture may be similar, the semi-conductive material 35 being extruded as a paste about the two conductor wires 33 and 34. In both constructions, the inner part can conveniently be subjected to drying after the application of the inner tubular member 3 or 36, since the moisture can escape between the edges of the tape of which the member is formed. After the insulant 2 or 32 has then been extruded as a paste, this may be wrapped with metal foil tape (not shown) to form both a pervious layer to permit the escape of steam during drying and a protective layer to retain the insulant in place before the outer sheath 1 or 31 is applied. The outer sheath may be applied, before the final drying operation, with sufficient clearance, between it and the pervious layer, to permit steam to escape longitudinally along the cable during drying, the cable being thereafter subjected to drawing down to remove that clearance and consolidate the powders.

Although the metal components of the cables shown in the drawings have been described as being of copper, some or all of them may be of aluminum. Similarly the semi-conductive material may be a mixture of magnesium oxide and other metallic oxides or metal titanates such that the mixture has a semi-conductivity appropriate for the required heat generation, and the insulant may be talc or any other pulverulent mineral insulating material. The conductor wires are preferably single solid wires, but they may be stranded conductors particularly in the constructions shown in Figures 1 and 2 and where the method of manufacture involves only a light drawing down operation.

What we claim as our invention is:

1. An electric heater cable comprising a tubular metal sheath, a body of pulverulent mineral insulating material enclosed by and in contact with the sheath and, surrounded by that body, at least two metal conductors which extend parallel with the cable axis, and a semi-conductive body of pulverulent inorganic material separating said conductors from each other.

2. An electric heater cable comprising a tubular metal

sheath, a body of pulverulent mineral insulating material enclosed by and in contact with the sheath, and, surrounded by that body, a tubular metal conductor and at least one other conductor enclosed thereby, said conductors extending parallel with the cable axis, and a semi-conductive body of pulverulent inorganic material separating said conductors from each other.

3. An electric heater cable comprising a tubular copper sheath, a body of pulverulent magnesium oxide enclosed by and in contact with the sheath, and, surrounded by that body, a tubular copper conductor and a copper conductor enclosed thereby, said conductors extending parallel with the cable axis, and a semi-conductive body of a pulverulent mixture of magnesium oxide with a titanate of a metal separating said conductors from each other.

4. An electric heater cable comprising a tubular metal sheath, a body of pulverulent mineral insulating material enclosed by and in contact with the sheath, and, surrounded by that body, two conductor wires each of D-shaped cross-section which extend parallel with and symmetrically one on each side of the cable axis with the convex side of the D-section outermost from that axis and a semi-conductive body of pulverulent inorganic material separating said conductor wires from each other.

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