

June 29, 1965

W. W. ERBE

3,192,305

FLUID COOLING OF ELECTRICAL CONDUCTORS

Filed Sept. 18, 1961

Fig. 1.

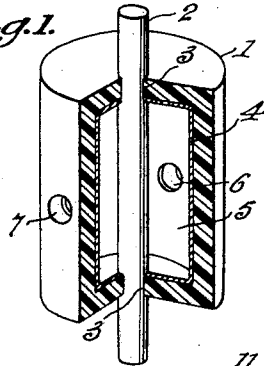


Fig. 2.

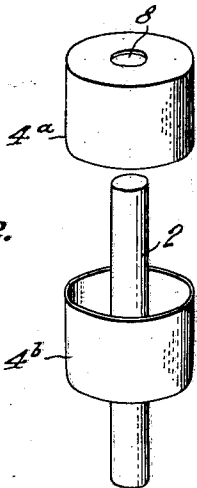


Fig. 4.

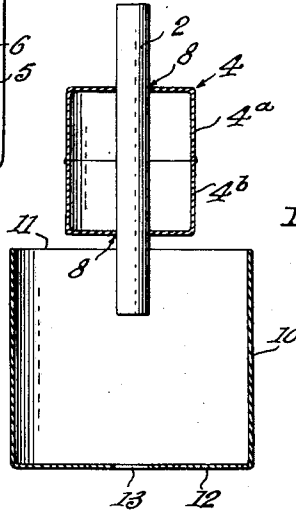


Fig. 3.

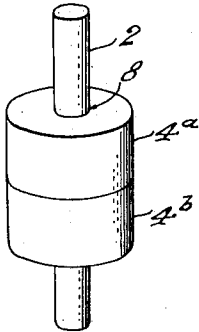


Fig. 5.

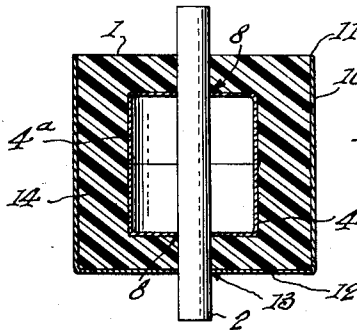
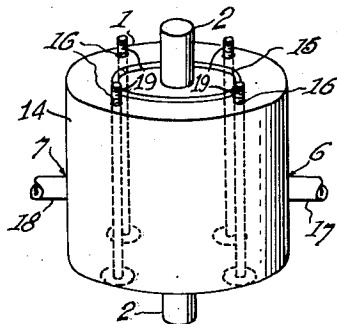


Fig. 6.



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FLUID COOLING OF ELECTRICAL CONDUCTORS
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Filed Sept. 18, 1961, Ser. No. 139,013

5 Claims. (Cl. 174-15)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

The present invention relates to systems for cooling electrical conductors more particularly to a jacket which carries fluid for cooling a conductor, a method of manufacturing that jacket, and an electrode equipment with a modification of that jacket intended for use where the conductors pass through a wall of a chamber.

In many situations electrical conductors subjected to large currents or high voltages must be cooled by artificial means. Coils and jackets of various kinds have been designed for circulating liquids around the exterior of conductors. Ineffectiveness, complexity of design, difficulties in fabrication and relatively high cost of manufacture have limited the value of systems and devices previously designed.

The present invention was conceived in solving problems arising from overheating of electrodes in an evaporation coating machine. In such a machine one or more pairs of electrodes are needed to conduct a large current from an external source into a vacuum chamber to the piece of metal which is to be vaporized. The object to be coated, such as an optical mirror, is placed in the vacuum chamber where vaporized metal will be deposited on it. The electrical current required for this process, in the order of 500 amperes at 12 volts, causes the relatively small electrodes used to become heated. Unless this heating is controlled, the seal which surrounds each electrode at the point where it enters the vacuum chamber may "gas" and so contaminate the metallic coating.

An object of this invention is to provide an improved jacket to encase part of an electrical conductor through which cooling fluid may flow.

Another object is to provide a simple, economical method of manufacturing such a jacket.

Another object is to provide a particular electrode with a jacket adapted to cooling the electrode at the point where it enters a chamber.

Briefly, the invention consists of a jacket made of an epoxy resin, or of a material having like characteristics, which encases part of an electrical conductor. The jacket has at least two openings through which fluid can enter and leave and so cool the conductor by direct contact. The invention includes a method of casting the jacket directly on the conductor utilizing an inner mold form, an outer mold form, and a material such as certain epoxy resins. When the conductor and mold forms are properly positioned, the material is poured into the mold and thereafter cures into a durable jacket which can be drilled and machined as necessary.

The specific nature of the invention as well as other objects and advantages will appear from the following description and accompanying drawings in which:

FIG. 1 is a perspective view, partly in section, showing a jacket and a conductor, in this case an electrode;

FIG. 2 is a view of an electrode with the inner mold form partly in place;

FIG. 3 is a view of an electrode with the inner mold form completely in place;

FIG. 4 is a vertical, partial cross-sectional view of an electrode, with the inner mold form in place, about to be inserted into the outer mold form;

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FIG. 5 is a vertical, partial cross-sectional view of an electrode and jacket, after casting, before the outer mold form has been removed; and

FIG. 6 is a perspective view of an electrode and jacket adapted for use at a wall.

Referring now to FIG. 1 which shows the jacket in its preferred cylindrical form, the jacket 1 encases part of electrode 2, fitting tightly at surfaces such as 3 where the jacket contacts the electrode. In the particular jacket illustrated, the inner mold form 4 used in the manufacture has been left in place and bounds the hollow space 5 in which fluid circulates around the electrode. Of course, the jacket may be manufactured by methods which do not involve leaving an inner mold form in place. A plurality of holes 6 and 7 are provided for the entrance and exit of the cooling fluid. The material of which the jacket is made must have good electrical insulating properties and a heat distortion point such that it will retain its form at expected operating temperatures. A heat distortion point of about 200° F. or greater is desirable. A number of epoxy resins familiar to persons versed in the plastics art have these characteristics.

FIGS. 2 through 5 illustrate the preferred method of making one of the jackets in a cylindrical shape. The inner mold form 4 consists of two cylindrical cups 4a and 4b made of heavy metal foil, such as aluminum foil; each cup is closed at one end and open at the other. There is a hole 8 in the closed end of each cup; this hole corresponds in size and shape to the cross section of the electrode. The two cups 4a and 4b are slipped over the electrode with their open ends toward each other. Beeswax or like material is used to seal the joint where the cups contact each other. If the fit between the electrode and holes 8 is not snug, beeswax may be used to seal any open space. The outer mold form 10 which is made of heavy metal foil is cylindrical in shape, closed at its bottom end 12 and open at its top end 11, the bottom end of the outer mold form has a hole 13 centered in it corresponding in size and shape to the cross section of electrode 2. The electrode bearing the inner mold form is placed in the outer mold form with the bottom of the electrode passing through the hole 13. If the fit between the electrode and the bottom of the outer mold form is not snug, beeswax may be used at this point. The electrode with its attachable inner mold form is centered and supported by any suitable means within the outer mold form.

In making a jacket according to the preferred method, the epoxy resin, or other material, employed should be one which can be poured at moderate temperatures and one which does not require pressure in the casting process. The liquid epoxy resin is poured into the space 14 between the outer mold form and inner mold form until the resin is level with the top of the outer mold form. When the epoxy resin cures, it tends to grip the electrode forming leakproof joints where the electrode passes through the jacket. The outer mold form 10 thereafter may be stripped away and the jacket is ready for holes to be drilled in it, as was done to the jacket illustrated in FIG. 1, also for further machining and working to adapt it to any specific purpose.

It will be understood that the jacket and its interior cavity may not only be cylindrical but they may be made in any convenient shape. Furthermore the inner mold form need not be in two parts. Nor is it necessary that the mold forms be made of heavy aluminum foil. Because neither pressure nor high temperatures are used in the casting process, and because it is unnecessary for the shape of the jacket to be geometrically precise, any thin easily-shaped material capable of containing the epoxy resin without leaking or becoming excessively deformed may be used.

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FIG. 6 shows a jacket 1 cast on an electrode 2 which has been adapted to be passed through the wall of a chamber. A circular groove 15 has been cut in the top of the jacket to accommodate an O-ring. Holes 16 are drilled completely through the jacket parallel to the axis of the electrode. Securing means, such as bolts 19, are used to locate the electrode in an operative area. Fitting 17 inserted in hole 6 and fitting 18 in hole 7 serve as connections to the pipes which bring fluid in and out of the jacket. When the jacket and electrode shown in FIG. 6 are used with a vacuum chamber such as an evaporation coating machine, an O-ring is placed in groove 15, the part of the electrode extending from the top of the jacket is inserted through a hole in the base of the evaporation coating machine to the point where the top of the jacket is seated against the said base, the O-ring forming an airtight seal. The jacket is secured to the base of the evaporation coating machine by bolts through the holes 16 and through the said base. In an evaporation coating machine, two or more jacketed electrodes are mounted on the base in the aforesaid manner and their fluid fittings are coupled together and to a source of water so that the water flows from the source to each jacket in succession and from the last jacket to a drain. Of course, means other than bolts may be used for fastening the jacketed electrodes to the evaporation coating machine. Jacketed electrodes similar to the one shown in FIG. 6 having copper electrodes $\frac{3}{4}$ inch in diameter have been used in an evaporation coating machine to carry currents of 500 amperes at 12 volts for periods of 24 hours or longer. With cooling water flowing at the rate of 1 gallon per minute, the electrodes have not become excessively hot.

As stated previously, the cooling jacket shown in FIG. 1 can be adapted to a wide range of uses. At relatively low voltages, water may be used as the cooling fluid. At higher operating voltages, it might be desirable to use oil or some other nonconducting fluid as a coolant otherwise there may be grounding through the fluid.

The embodiments shown and the method of manufacture described herein are illustrative only and may be departed from in many respects without departing from the scope of the invention.

I claim:

1. In combination, an electrical conductor having an electrode end and a power source end, a cooling jacket means having a cylindrical body and first and second disc-shaped end means, first aperture means centrally located in each of said first and second end means in sealed relationship with said conductor, said first disc-shaped end

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means located nearer said electrode end than is said second disc-shaped means, each of said end means having fluid tight connection to said cylindrical body, said cylindrical body being spaced from said conductor, said jacket means having a pair of second aperture means and enclosing said conductor, a cooling fluid source, means conducting said cooling fluid into one of said second aperture means and out of the other of said second aperture means whereby said conductor is cooled by direct contact with said fluid and means for securing said first disc-shaped end to a support.

2. A combination as recited in claim 1 wherein said first and second disc-shaped end means have planar end surfaces, one of said planar end surfaces having a groove therein surrounding said conductor, a sealing ring seated in said groove and a plurality of aligned openings through the opposite planar end surfaces for receiving said securing means whereby said electrical connector may be secured to a structure to be supplied with electrical energy with the sealing ring in contact with a surface of the structure.

3. A combination as recited in claim 1 wherein said cooling jacket means comprises a metallic inner cylindrical member enclosed by an outer plastic cylindrical member.

4. The combination as recited in claim 3 wherein said metallic inner cylindrical member includes a pair of cup-shaped members, each of said cup-shaped members having a central aperture at a closed end thereof and an opposite open end, said cup-shaped members being joined at their open ends to form said inner cylindrical member.

5. The combination as recited in claim 3 wherein the material of said outer cylindrical member is an epoxy resin having a heat distortion point of not less than 200° F.

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