Feb. 26, 1957 E. E. THIESSEN 2,783,171

INSULATING METHOD AND APPARATUS

Filed Oct. 12, 1955

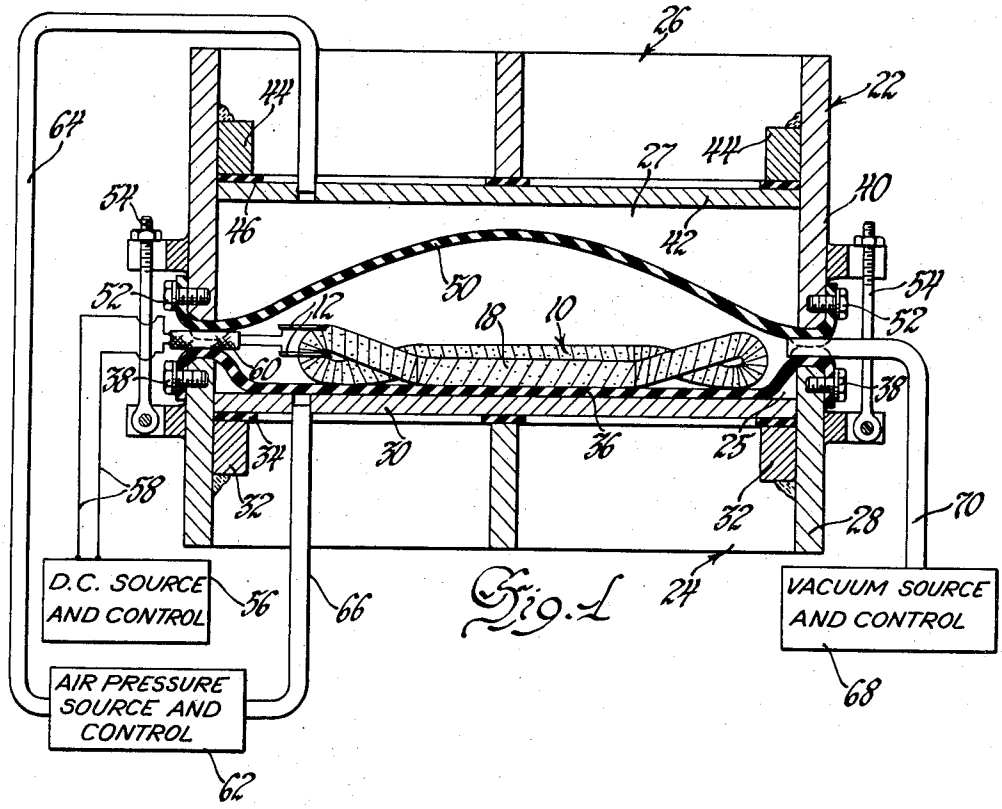


Fig. 1

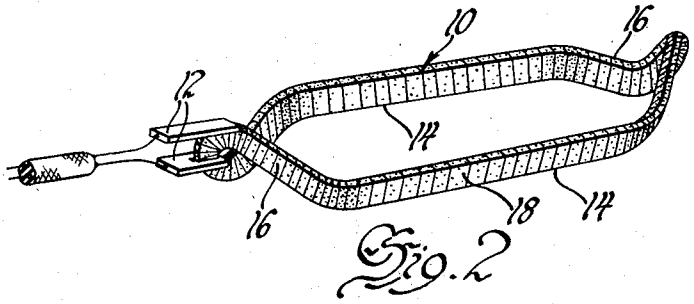


Fig. 2

INVENTOR
Elmer E. Thiessen
BY
E. W. Christen
ATTORNEY

United States Patent Office 2,783,171 Patented Feb. 26, 1957

2,783,171

INSULATING METHOD AND APPARATUS

Elmer E. Thiessen, La Grange, Ill., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application October 12, 1955, Serial No. 539,986

6 Claims. (Cl. 154—2.26)

This invention relates to the insulation of electrical coils and more particularly to a method and apparatus for the manufacture of insulated electrical coils. The invention is especially well suited for applying insulating systems to irregularly shaped electrical coils for dynamoelectric machines.

The insulation system of dynamoelectric machines imposes a limit upon the power output rating of the machine because the insulation is subject to deterioration at high temperatures. It is desirable, therefore, in an insulation system to achieve a high rate of heat dissipation from the insulated conductors. A number of insulating materials are known which are particularly well suited to high temperature operation because of excellent thermal stability and relatively high thermal conductivity. A notable example is silicone rubber insulating material.

However, in high temperature insulating systems, particularly those using built-up jackets of plural layers or the like, heat transfer and dissipation is impaired by the occurrence of voids or air spaces in the insulating jacket. As a result the optimum performance is not realized in practice. The voids or air spaces occur because of failure to achieve a good bond or adhesion between adjacent layers of insulating material or between the insulating material and the conductor material. In the application of vulcanizable insulating materials, pressing the insulation layers together and against the conductor material contributes to improved adhesion or bonding. Heretofore difficulty has been encountered in applying uniformly distributed and controlled pressure over the entire surface extent of the insulating material simultaneously to insure proper adhesion or bonding during the vulcanization. This difficulty is especially pronounced in the production of electrical coils of irregular shape, such as alternator coils and the like.

Accordingly, it is an object of this invention to provide a method and apparatus for applying uniformly distributed pressure over the entire surface extent of an insulating jacket on an irregularly shaped coil.

A further object is to provide a method and apparatus for applying a uniformly distributed pressure to the entire insulating jacket of an electrical coil during vulcanization or curing of the insulating jacket.

A further object of the invention is to provide apparatus for the simultaneous application of controlled pressure and vulcanizing temperature while removing the evolved gases from the insulating material of an electrical coil.

An additional object of the invention is to provide apparatus which is of simple construction and operation and which permits a high rate of production of electrical coils having a void free, uniformly bonded insulating jacket.

In the accomplishment of these objects there is provided an elastic member adapted to enclose an insulated electrical coil and which is disposed within a fluid-tight chamber. Means are provided for admitting fluid pressure to the chamber to cause the elastic member to conform to the configuration of the coil and transmit pressure thereto. Exhaust means communicate with the interior of the elastic member to insure close conformity thereof to the coil and for removal of evolved gases. Additionally, electrical conductors extend into the interior of the elastic member for resistance heating of the coil to accomplish vulcanization of the insulating material.

A more complete understanding of the invention may be had from the detailed description which follows taken with the accompanying drawings in which:

Figure 1 is a sectional view illustrating the inventive apparatus;

Figure 2 is a perspective view of a typical electrical coil provided with an insulating jacket.

Referring now to the drawings, the inventive apparatus is shown in an illustrative embodiment adapted for the manufacture of armature coils for alternators. The drawings of the apparatus are somewhat diagrammatic in the interest of clarity.

In Figure 2 there is shown an alternator coil 10 which is typical of a variety of electrical coils for which the method and apparatus are suited. As is well known to those skilled in the art, this type of coil may be formed of plural turns of conductor material such as copper bar or strap terminating in coil leads 12. The coil turns are formed to provide substantially parallel side or slot sections 14 and end or diamond portions 16 having a bight or loop portion therein. The slot sections may be somewhat inclined with respect to each other to permit the completed coil to conform to the cylindrical configuration of the stator of the electrical machine. The completed coil is quite irregular in shape which results in angular and relatively inaccessible portions.

An insulation system or jacket 18 is applied to the formed coil 10 and may take a variety of forms. A preferred insulation system for high temperature service comprises plural layers of silicone rubber insulating material. For example, the insulating material is applied in tape or sheet form which may comprise a glass cloth backing impregnated and coated on one side with partially vulcanized silicone rubber. The rubber is partially vulcanized or cured only sufficiently to prevent adhesion between layers on the supply rolls. A specific silicone rubber tape and sheet which may be applied is that sold under the trademark "Silastic R" by the Dow Corning Corporation. A typical insulating jacket may comprise plural layers of sheet insulating material wrapped on the slot sections 14 and plural layers of tape material wrapped on the diamond sections 16. The junction of the two wrappings may be blended together to avoid irregularity and an outer wrapper of tape is applied in overlapping fashion. Thus the insulation system or jacket 18 on the coil 10 is built up of plural layers of heat vulcanizable insulating material. It remains to simultaneously vulcanize and press the entire insulation system in order to obtain a completed insulating jacket on the coil.

In accordance with this invention as illustrated in Figure 1, the vulcanizing fixture 22 includes a fixed compartment 24 and a relatively movable compartment 26. The fixed compartment 24 is of box-like structure defining a chamber 25 and comprises a continuous side wall 28. The chamber 25 is closed at the bottom by a plate 30 which is seated upon the internal support shoulder 32. A suitable sealing gasket 34 is interposed between the plate 30 and shoulder 32 to provide a substantially air-tight closure. The chamber 25 is closed at the top or upper end by a diaphragm 36 formed of elastic and flexible sheet material such as silicone rubber or neoprene. The diaphragm 36 is secured at its outer periphery to

the compartment 24 by a plurality of screw-threaded fasteners 38.

The movable compartment 26 is similarly of box-like structure defining a chamber 27 and comprises a continuous side wall 40. The chamber 27 is closed at the top by a plate 42 which is seated against the internal shoulder 44 and suitably sealed by a gasket 46 to provide an air-tight closure. The chamber 27 is closed at its lower end by a diaphragm 50 secured to the compartment 26 at its peripheral edge by screw-threaded fasteners 52. The diaphragm 50 may be identical in structure to the diaphragm 36.

The compartment 26 is disposed in vertical alignment with the compartment 24 and is secured thereto by suitable clamping devices 54. The clamping devices 54 urge the side walls 40 and 28 toward engagement compressing the peripheral edges of the diaphragms 36 and 50 therebetween to form a peripheral air-tight seal. In this condition, the diaphragms form a bladder which is adapted to surround or enclose the coil 10.

In order to supply vulcanizing heat to the insulating jacket 18 when the coil 10 is disposed between the diaphragms 36 and 50, there is provided an electrical current source 56 having associated therewith a suitable control instrumentality for regulating the current supply. The current source 56 is electrically connected by conductors 58 to the coil terminals 12. A suitable bushing 60 is provided at the peripheral seal of diaphragms 36 and 50 to accommodate the passage of conductors 58 without impairing the seal.

The chambers 25 and 27 are adapted to receive fluid pressure from an air-pressure source 62 having associated therewith suitable control devices of conventional type for regulation of the delivered pressure. The air pressure source 62 is connected by a conduit 64 to the chamber 27 in compartment 26 and by the conduit 66 to the chamber 25 in compartment 24. In order to exhaust the space between the diaphragms 36 and 50, there is provided a vacuum source and control apparatus 68. A conduit 70 extends from the vacuum source through the peripheral seal of the diaphragms 36 and 50 to the space therebetween.

In operation, the upper compartment 26 is removed and the coil 10 having the heat vulcanizable insulating jacket 18 thereon is placed on the diaphragm 36 which is supported in the distended condition by the bottom plate 30. The electrical conductors 58 are connected to the coil leads 12. The upper compartment 26 is replaced to the position shown and the clamping devices 54 are tightened to urge the peripheral edge of the diaphragm 50 into sealing engagement with the diaphragm 36. In this condition, the space between the diaphragms 36 and 50 is evacuated by energization of the vacuum source 68 which removes the entrapped air and gases through conduit 70. Following the energization of the vacuum source, the air-pressure source 62 is energized and air pressure is admitted to the chamber 27 within compartment 26 through conduit 64 and to the chamber 25 within compartment 24 through conduit 66. The combined action of the fluid pressure in the chambers 25 and 27 and the evacuation of the space between the diaphragms 36 and 50 causes the diaphragms to conform closely and uniformly over the entire surface extent of the insulating jacket 18 on the coil 10. Thus, the fluid pressure within the chambers 25 and 27 is transmitted through the diaphragms to the insulating jacket and effectively presses the plural layers of the jacket into engagement with each other and against the conductor of the coil. For application of an insulating system of the type previously described, it has been found that fluid pressure values in the range of 80 to 100 pounds per square inch are effective to produce a well bonded insulating jacket. Vulcanization of the insulating material is accomplished by energization of the current source 56 which delivers current through the conductors 58 and the conductor turns of coil 10 during the application of pressure. The current flow through the turns of the coil 10 produces electrical resistance heating therein which provides a uniform temperature distribution throughout the coil body. This internally generated heat is transmitted to the insulation system primarily by conduction thus effecting the vulcanization or cure of the entire system simultaneously. The heat transfer from the conductor of the coil to the inner layer of insulation and thence to the outermost layer of insulation is enhanced by the application of pressure because of the absence of voids which would otherwise act as thermal barriers. The value of current to be used depends, of course, upon the particular coil being processed and the insulating material. In the application of an insulating system of the type previously described using silicone rubber, most satisfactory results have been obtained by heating the insulating material to the vulcanizing temperature of approximately 210° C. within a period of approximately seven minutes. In a specific application this required a current through the coil of approximately 600 amperes. The continued operation of the vacuum source 68 during the heating interval promotes improved bonding and curing of the insulation by removal of gases evolved from the insulating material during vulcanization. Upon completion of the vulcanization period, the operation of the current source 56, the air pressure source 62 and the vacuum source 68 is terminated and the coil 10 is removed from the fixture. The insulating jacket 18 is bonded layer-to-layer and to the conductor material and is substantially void free. The insulated coil may be subjected to subsequent processing such as baking to develop optimum properties in the insulation material.

Although the description of this invention has been given with respect to a particular embodiment, it is not to be construed in a limiting sense. Many variations and modifications within the spirit and scope of the invention will now occur to those skilled in the art. For a definition of the invention, reference is made to the appended claims.

I claim:

1. Apparatus for simultaneously heating and pressing an insulating jacket on an electrical coil said apparatus comprising a fixture defining a closed chamber, an elastic bladder adapted to enclose the insulated electrical coil and disposed within the chamber, electrical conductors extending from the exterior of the chamber to the interior of the bladder adapted to conduct current through the coil to provide electrical resistance heating thereof, a venting conduit extending from the interior of the bladder to the exterior of the chamber to permit escape of entrapped gases, and a conduit extending into the chamber for admission of fluid pressure to cause the bladder to conform to the configuration of the insulated coil.

2. Apparatus for applying a uniformly distributed pressure to the surface of an irregularly shaped, insulated, electrical coil said apparatus comprising a pair of fluid-tight compartments each defining a chamber, an elastic diaphragm disposed over each of the chambers, said diaphragms being disposed in face-to-face relation and adapted to receive an insulated electrical coil therebetween, means urging said diaphragms together adjacent the periphery thereof to form a peripheral fluid-tight seal, a venting conduit extending through said seal to permit entrapped gases to escape from between the diaphragms, and means for admitting fluid pressure to said chambers to cause the diaphragms to conform to said coil for transmitting pressure thereto.

3. Apparatus for processing electrical coils having an insulating jacket thereon of heat vulcanizable insulating material said apparatus comprising a pair of compartments each defining a chamber having an open side, an elastic diaphragm disposed over the open side of each chamber and secured to the respective compartment, said diaphragms being disposed in face-to-face relation and

adapted to receive an electrical coil therebetween, means urging said compartments together to pass the peripheral edges of the diaphragms together to form a fluid tight seal, electrical conductors extending through the seal and adapted to be connected to the terminals of the coil for electrical resistance heating thereof, a source of vacuum, an exhaust conduit extending from the source of vacuum through the seal to permit evacuation of the space between the diaphragms, a source of fluid pressure, and a pressure conduit extending from the source of fluid pressure to each of the chambers for applying pressure to the surface of the coil through said diaphragms.

4. In the process of manufacturing insulated electrical coils, the steps of wrapping a conductor coil with a heat vulcanizable insulating material, enclosing the coil in an elastic bladder, venting the interior of the bladder, applying fluid pressure to the exterior of the bladder to cause conformation thereof to the coil configuration whereby the fluid pressure is transmitted to the surface of the insulating material, passing an electric current through the coil to effect vulcanization of the insulating material, relieving the fluid pressure, and removing the coil from the bladder.

5. In the process of manufacturing electrical coils, the steps of wrapping a conductor coil with plural layers of heat vulcanizable insulating material, enclosing the coil in an elastic bladder, and simultaneously applying fluid pressure to the exterior of the bladder, evacuating the interior of the bladder, and passing electric current through the coil to provide a bonded void-free insulating jacket.

6. In the process of manufacturing electrical coils of irregular shape, the steps of wrapping a conductor coil with a heat vulcanizable insulating material, enclosing the coil in an elastic bladder, applying greater than atmospheric fluid pressure to the exterior of the bladder to cause conformation thereof to the coil configuration and to transmit the fluid pressure to the surface of the insulating material, passing a current through the conductor of the coil to effect rapid vulcanization of the insulating material, and evacuating the interior of the bladder to remove entrapped air and evolved gases.

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