H. M. KROFT

VACUUM IMPREGNATION PROCESS

Filed June 16, 1949

INVENTOR
Herbert M. Kroft.

ATTORNEY
Frederick Shapo
This invention relates to the vacuum impregnation of porous members with fluid compositions.

In treating members having pores, crevices or other fine voids, hereinafter designated "porous members," with a fluid composition so as to impregnate the pores of the members thoroughly and completely with the fluid composition, it is well known that considerable difficulty is experienced in securing such complete impregnation. Even with the benefit of a preliminary evacuation of the porous members, it has been found in many cases that the fluid compositions fail to penetrate to the innermost portions of the pores and spaces of porous members.

Thus in the manufacture of electrical coils, it is desirable to thoroughly saturate the fibrous insulation, such as paper, cloth, silver, or felt, commonly applied both to the conductors and the coil with an insulating varnish. To this end electrical coils are placed in vacuum tanks wherein they are evacuated to a low absolute pressure to withdraw air, moisture and other volatiles from the interstices of the coils, and thereafter the coils are flooded with insulating varnish composition, and pressures above atmosphere are then applied to the varnish composition to drive it into the interstices of the coil. In many cases, particularly with the larger coils wrapped with many layers of tape, the varnish does not completely penetrate the entire insulation. The innermost layers often have very little impregnant present. Likewise, in impregnating electrical members with insulating oils, it has been found that the penetration of the oil has been unsatisfactory even with the assistance of a vacuum. This incomplete impregnation is particularly prevalent where the member being treated has extremely fine pores or crevices some of which have been found to be unimpregnated with the oil even after prolonged evacuation and impregnation under pressure. It appears as if the fine pores resist the flow of the varnish or oil therethrough, the residual gases in the pores are not displaced by the impregnant but rather are compressed by the entering fluid and thereby this prevents the complete impregnation of the members.

It has been discovered that, if members being treated with liquid compositions are heated by infra-red radiation to temperatures of above 80° C. while subjected to a high vacuum and flooded with fluid compositions and the temperature maintained during the flooding, until bubbling indicating escaping residual gas ceases, unexpectedly rapid and substantially complete penetration of the pores of such members is accomplished by the fluid compositions.

The object of this invention is to provide for enabling the rapid and thorough impregnation of porous members with fluid compositions by subjecting the members to simultaneous evacuation and heating by infra-red radiation previous to impregnation.

A further object of this invention is to provide for more completely impregnating porous members with insulating fluid compositions by evacuating them to a pressure of less than five inches of mercury and heating them with infra-red radiation to a temperature to at least 80° C., then covering the members with a fluid composition and continuing heating in the presence of the fluid composition to at least 80° C.

Other objects of the invention will, in part, be obvious and will, in part, appear hereinafter.

For a better understanding of the nature and objects of the invention, reference should be had to the following detailed description and drawing in which the single figure is a vertical cross section through an impregnating tank, illustrating the practice of the invention.

It has been discovered that the impregnation of porous members by fluid compositions may be greatly expedited and rendered more complete by subjecting the porous members to simultaneous evacuation to a low pressure and irradiation with infra-red radiation to heat the members to at least 80° C., covering the members with the fluid composition while evacuated, and heating the covered members while so covered to bring them up to a temperature of at least 80° C., so that residual gases will be almost entirely driven off at a rapid rate, as evidenced by extensive bubbling, and finally applying pressure on the composition after the bubbling substantially ceases. Heating members by infra-red radiation has been found to be unusually effective in the process of this invention providing for the vacuum impregnation of porous members. Other advantages are that the infra-red radiation may be conducted without heating any extraneous parts of the vacuum equipment and it enables the heating of the porous members to be accomplished rapidly. Nearly all insulating oils and insulating varnish compositions, with the exception of heavily pigmented compositions, through which infra-red radiation will not penetrate, effectively, are relatively transparent to infra-red radiation so that efficient heating of
the members may be carried out while covered by such fluid compositions.

Referring to Fig. 1 of the drawing, there is illustrated one form of apparatus for the practice of the invention. A hermetically sealed vessel 10 is provided with a cover 12 provided with a window 14 relatively transparent to infra-red radiation. Numerous classes for this purpose are known. The vessel 10 is provided with a conduit 16 for introducing and withdrawing fluid compositions with which members are to be impregnated. A pipe 18 connected to a suitable source of vacuum (not shown), such, for example, as a vacuum pump, enables the vessel 10 to be evacuated to any desired degree. The pipe 18 may also be connected to a source of air, carbon dioxide or other gas under pressure, if necessary, for building up pressures above atmospheric, or else the pipe 18 may be opened to the atmosphere to break the vacuum. Within the vessel 10 is disposed a horizontal support 20 provided with a plurality of bars 22 on which porous members 24 to be impregnated may be placed, arranged so that the fluid composition may readily penetrate between the bars 22. It will be appreciated that the bars 22 may be replaced by their equivalent, such as the grating, wire screen or the like. Exterior of the vessel 10 is located one or more infra-red lamps 26 constituting a source of infra-red radiation. While lamps have been shown, it will be understood that electrically heated resistance elements and other infra-red means, preferably with focusing shields, may be employed. In some cases we have placed the infra-red lamps within the vessel 10 itself, though it is more convenient to accommodate the focusing of the lamps 25 to the number and disposition of the members 24 within the vessel if the lamps are exterior of the tank. In addition, the heat from the lamps other than the directed radiant heat is more conveniently removed, if the lamps are not within the vessel 10.

After the porous members 24, which may be electrical coils or any other electrical devices requiring impregnation with a fluid composition, are disposed in suitable manner on the bars 22, the cover 12 is applied to the vessel and the vessel hermetically sealed. It has been found that the best results are obtained if the members 24 are disposed in a single thickness to form a horizontal layer on the bars 22. Likewise, if the member has openings or pores extending to one side only, as, for example, in vibration pickups, it is preferable that the porous side be placed uppermost. The vessel 10 is evacuated through the pipe 18 to a suitable low absolute pressure, generally below five inches of Hg absolute. For best results, we have evacuated to an absolute pressure of below 10 mm. Hg. The pressures are exemplary and for very viscous fluids the absolute pressure may be much lower. The evacuation removes air, moisture and other volatile material from the porous members 24. In some cases a substantial amount of gas and other volatile substances will remain in the fine interstices and pores. Thus, we have found that coils wrapped with eight to ten layers of mila and waxed paper retains a substantial amount of gas in the innermost layers thereof, which is not removed even with drastic vacuum treatment.

Soon after evacuation is started, the infra-red lamps 26 are focused on the porous members 24 and put in operation so that infra-red radiation is applied to the members 24 to cause them to heat up. A temperature of at least 80° C. has been found to give the best results in combination with a suitable low vacuum. The combination of infra-red heating and the vacuum has been found to result in the expedient elimination of all but traces of gases and volatile matter in the porous members 24. Inasmuch as infra-red radiant heating is capable of transmitting energy to the members at an extremely high rate, the members may be heated in a very short period of time, usually a few minutes is adequate. This is advantageous securing prompt and thorough degassing. After the members 24 have been heated and evacuated adequately, a fluid composition may be introduced through the conduit 16 so as to cover the members 24. In the practice of the invention, the height of the fluid composition 28 is adjusted to barely cover the members 24. This insures the maximum absorption of the infra-red radiation by the members 24 and also that the least amount of the fluid composition is heated unnecessarily. Upon contact of the hot members 24 with the fluid composition 28, they will be cooled considerably since ordinarily the fluid composition is not as hot as they are. Particularly in the case of heat reactive insulating varnishes, preheating of the composition 28 would be undesirable since it would cause premature gelation and poor storage life of the composition.

Radiation of the members by the infra-red radiation means is continued during the immersion of the members in the composition 28 until the members are at a temperature of at least 80° C. in the case of varnish compositions. Much higher temperatures may be employed if the members 24 are to be impregnated in an insulating oil, such as transformer oil or a silicone oil. Bubbles of gas are given off by the porous members as they are heated.

To secure the best impregnation results, after the members have been immersed, heated to at least 80° C. and bubbling has ceased, the vacuum should now be broken and either atmospheric pressure is applied or a pressure much higher than atmospheric pressure, may be imposed upon the fluid composition 28 by connecting the pipe 18 to a suitable source of gas under pressure. Pressure of as much as 100 pounds per square inch may be applied to the fluid composition 28 to cause the composition to be forced into the finest and innermost interstices in the members 24. Within a short period of time, usually a few minutes, the members 24 will be completely and thoroughly saturated with the fluid composition, and the fluid composition may be withdrawn through conduit 16 to uncover the members 24. The members may be permitted to remain on the bars 22 for superficial drainage of residual composition. After suitable drainage, the members may be removed and processed further. If an insulating oil is applied, for example, to impregnate a vibration pickup, the pickup may be sealed while covered with oil and the sealed unit need only be wiped to be ready for use. Electrical coils impregnated with an insulating varnish will be removed and put in a baking oven or otherwise heated to cure the varnish therein.

Unexpectedly good results have been secured by the combination of infra-red heating and evacuation. It has been found that members, as, for example, a vibration pickup, cannot be completely and thoroughly saturated with an
insulating oil without any appreciable amount of gas or moisture being left, by the use of vacuum alone. Furthermore, the treatment without the use of heat was more than three times as long with less satisfactory results than secured by a short treatment using infra-red heating combined with the vacuum treatment.

Numerous varnish compositions may be employed in the practice of the present invention for impregnating coils. It is preferable that the compositions be relatively transparent to infra-red radiation thereof. This requirement may be dispensed with if the members are barely covered with the fluid composition, that is, not over a fraction of an inch of the composition is over the surface of the members. Examples of suitable varnishes for the practice of the invention are alkyd varnishes, phenolic resin varnishes, melamine resin varnishes, polyester compositions embodying an unsaturated alkyd resin and a vinyl monomer. Specific examples of such polyester resins are disclosed in Patent No. 2,414,525. Examples of suitable oils are transformer oil, castor oil, silicone oil and chlorinated diphrenyl.

Since certain obvious changes may be made in the above procedure and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In the process of impregnating a porous member with a fluid composition, the steps comprising subjecting the member to a vacuum at an absolute pressure of less than 5 inches of Hg to withdraw air, moisture and other volatiles from the pores thereof, irradiating the member with infra-red radiation to cause its temperature to rise above 80° C. while still subjected to the vacuum, immersing the member with an amount of a fluid composition barely covering the upper surface of the member while the member is maintained under vacuum, the fluid composition being relatively transparent to infra-red radiation, continuing heating the member with the infra-red radiation while it is so covered with the fluid composition until the member again reaches a temperature of at least 80° C. and continuing such heating until bubbling ceases, and withdrawing the impregnated member from the body of the fluid composition.

2. In the process of impregnating a porous member with a fluid composition, the steps comprising subjecting the member to a vacuum at an absolute pressure of less than 5 inches of Hg to withdraw air, moisture and other volatiles from the pores thereof, irradiating the member with infra-red radiation to cause its temperature to rise above 80° C. while still subjected to the vacuum, barely covering the member with a fluid composition selected from the class consisting of insulating varnishes and dielectric liquids while the member is maintained under vacuum, the fluid composition being relatively transparent to infra-red radiation, continuing heating the member with the infra-red radiation while it is so covered with the fluid composition until all gas bubbling from the member ceases, and then applying pressure to the fluid composition about the member to cause it to penetrate into the member, and withdrawing the impregnated member from the body of the fluid composition.

3. In the process of impregnating a porous member with a varnish, the steps comprising placing the member in a hermetically sealable vessel, evacuating the vessel to an absolute pressure of below 5 inches of Hg to withdraw air, moisture and other volatiles from the member, irradiating the member with infra-red radiation to cause its temperature to rise above 80° C. while being subjected to the vacuum, immersing the member in a varnish relatively transparent to infra-red radiation while being irradiated and under vacuum, breaking the vacuum when the impregnated member reaches a temperature above 80° C. and ceases to give off gas bubbles, applying a pressure equal to at least atmospheric pressure to the varnish to force it into the member, removing the varnish impregnated member from the vessel and baking it to cure the applied varnish.

4. In the process of impregnating a plurality of members with a fluid composition, the steps comprising placing a single thickness of the members in a single horizontal layer of a hermetically sealable vessel, evacuating the vessel to an absolute pressure of below 5 inches of Hg to withdraw air, moisture and other volatiles from the pores of the members, irradiating the layer of the members with infra-red irradiation to bring their temperature to at least 80° C. while being subjected to the vacuum, immersing the layer with a fluid composition in an amount to just cover the members, the fluid composition being relatively transparent to infra-red radiation, continuing irradiating while so immersed until the members reach a temperature above 80° C. and cease to give off gas bubbles and withdrawing the impregnated members from the vessel.

5. In the process of impregnating a porous member with a fluid composition, the steps comprising subjecting the member to a vacuum at an absolute pressure of less than 5 inches of Hg to withdraw air, moisture and other volatiles from the pores thereof, irradiating the member with infra-red radiation to cause its temperature to rise above 80° C. while still subjected to the vacuum, immersing the porous member with a fluid composition relatively transparent to the radiation in an amount barely covering the upper surface of the member while the member is maintained under vacuum, continuing heating the member with the infra-red radiation while it is so covered with the fluid composition until all gas bubbling from the member ceases, and withdrawing the impregnated member from the body of the fluid composition.

HERBERT M. KROFT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>577,671</td>
<td>Tesla</td>
<td>Feb. 23, 1897</td>
</tr>
<tr>
<td>1,163,342</td>
<td>Hurley</td>
<td>Dec. 7, 1915</td>
</tr>
<tr>
<td>1,760,583</td>
<td>Clark</td>
<td>May 27, 1930</td>
</tr>
<tr>
<td>2,282,317</td>
<td>Bennett</td>
<td>May 12, 1942</td>
</tr>
<tr>
<td>2,321,939</td>
<td>Quinn</td>
<td>June 15, 1943</td>
</tr>
<tr>
<td>2,557,286</td>
<td>Reavell</td>
<td>Sept. 5, 1944</td>
</tr>
</tbody>
</table>