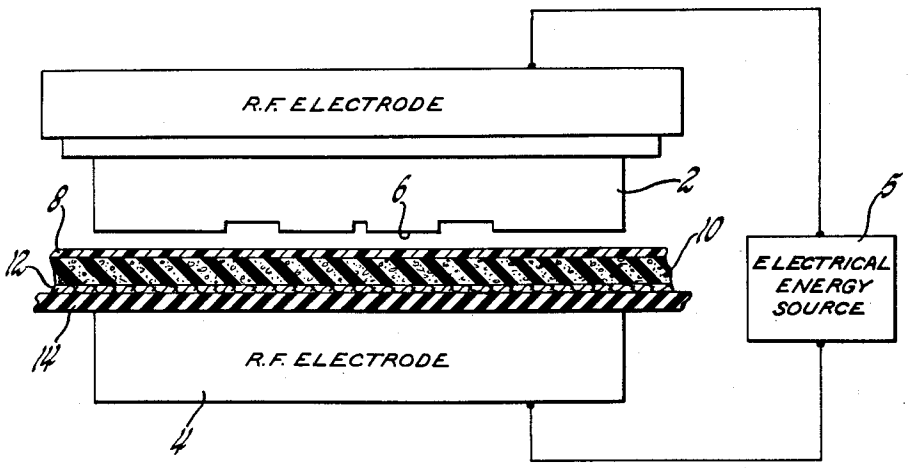
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PROCESS AND APPARATUS FOR DIELECTRIC HEATING

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INVENTORS
Wilburn A. Schattler &
Ralph M. Stallard
BY
G. M. Shampo
ATTORNEY

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PROCESS AND APPARATUS FOR DIELECTRIC HEATING

Wilburn A. Schattler, Warren, and Ralph M. Stallard, Utica, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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This invention relates to an improved process and apparatus for dielectric heating and embossing.

In the process of dielectric heating, the material to be processed is pressed between two electrodes, generally in the form of metal plates, while high frequency alternating voltage is applied to generate heat within the material. For dielectric embossing, the surface of one of the electrodes is contoured with the design desired to be imparted to the material during the dielectric heating and pressing step. The process may be used, for example, to manufacture decoratively embossed automobile upholstery comprising a trim material positioned on a fibrous or foam pad which is made of or impregnated with a heat-fusible plastic and is supported on a fiberboard backing. Upon operation of the dielectric press an embossed pattern is produced wherein the trim material is bonded to the backing through the pad, the plastic in the pad along the embossed lines having been melted and cured, thus serving as the bonding adhesive. In practice, the frequency used for the dielectric heating is in the range of 2 to 200 megacycles per second. Copending United States patent applications Serial No. 538,914, filed October 6, 1955, in the names of Peter P. Dusina, Jr., and Ralph M. Stallard; Serial No. 648,654, filed March 26, 1957, in the names of Ming C. Hsu and Ralph M. Stallard; Serial No. 702,653, filed December 13, 1957, in the name of Ralph M. Stallard; and Serial No. 651,356, filed April 8, 1957, in the names of Ming C. Hsu and Ralph M. Stallard; all of which are assigned to the assignee of the present invention, relate to such processes.

It is well known that the amount of heat generated in the material being dielectrically heated is dependent upon the high frequency voltage across the material. Therefore it is desirable to use a high voltage in order to obtain the maximum heating effect in the shortest time possible. The limiting factor on the voltage, however, is the dielectric strength of the materials between the electrodes, and one of the serious problems which has been encountered in dielectric heating and embossing operations is that of arcing with resultant damage to the material being processed, and sometimes also to the electrodes. Assurance against arcing may, of course, be accomplished by using a low voltage; however, this is unsatisfactory since it reduces the speed and over-all efficiency of the process.

It is an object of the present invention to provide an improved process and apparatus for fast efficient dielectric heating. More specifically, an object of the invention is to provide an improved dielectric heating and embossing process and apparatus which substantially eliminates the hazard of injury to the apparatus and to the material being processed due to arcing.

These and other objects of our invention are achieved by a layer of an insulating material of hereinafter-specified composition which is positioned between at least one of the electrodes and the material being processed. The composition of the insulating material is such as to substantially eliminate the hazard of arcing, and with this hazard eliminated higher electrical energies may be applied to thereby add speed and increased efficiency to the process.

Other objects and advantages of the invention will be obvious from the following detailed description made with reference to the accompanying drawing which shows a sectional view of a typical trim assembly positioned in a dielectric press preparatory to embossment in accordance with the invention, the view of the apparatus being generally schematic.

Referring now to the drawing, there is shown a dielectric embossing press having upper and lower electrodes 2 and 4, respectively, in series with a high frequency generator 5. Between the electrodes is a laminated trim assembly comprising a sheet of plastic or similar trim material 8 positioned on a layer 10 of sponge rubber and having a paper or cloth backing sheet 12 secured thereto. The upper electrode 2 is formed to serve as an embossing die by way of a plurality of embossing blades 6 thereon which are arranged to impart the desired depressed pattern or design to the trim assembly by application of pressure and heat upon the closing of the press and actuation of the high frequency generator. It will be understood that the precise composition, form and structure of the material being embossed forms no part of the present invention, the above example being given merely for purposes of illustration.

In accordance with the present invention there is interposed between one of the two electrodes and the material being embossed, a layer 14 of insulating material consisting essentially of from about 60% to 90% barium titanate and the remainder a binder of heat-resistant organic polymer. The thickness of the insulating layer will, of course, depend on the amount of insulation desired and on the exact composition selected; generally, for optimum advantage, the thickness will be in the range of 1/32 inch to ½ inch. Where, as in the embodiment illustrated, only one of the electrodes is formed with embossing blades and the other electrode is flat, it is preferable that the insulating layer be positioned directly over the surface of the flat electrode as shown. It may either be attached to the electrode by suitable clamps or the like, or may be merely placed over the electrode prior to or simultaneously with insertion of the material to be embossed.

The barium titanate used may be commercial grade and may show on analysis minor amounts of inert or non-deleterious ceramic ingredients or impurities such as zirconia, silica, iron oxide and the like. Likewise, the barium titanate may contain either baria or titania in slight excess of that required on a stoichiometric basis. The following analyses of two different commercially available barium titanates will serve to illustrate:

	Percent by weight
BaO	64.58
TiO_2	28.99
ZrO	6.20
Fe_2O_3	.06
MgO	.08
BaO	68.50
TiO_2	32.08
Fe_2O_3	.07

Spectographic analyses of each of these commercial barium titanates showed, in addition to the above, trace amounts of SiO_2, Al_2O_3 and Na_2O.

Because of its particularly suitable electrical and physical properties, silicone rubber is by far the preferred binder for the barium titanate. Silicone rubber is a polysiloxane, generally represented by the formula $-(SiR_2O)_n-$ where R is an alkyl, aryl or alkaryl radical and n is some large number. Two of the common silicone rubbers are, for example, polydimethylsiloxane and

dimethylsiloxane-divinylsiloxane copolymer, cured by a peroxide such as ditertiary butyl peroxide or benzoyl peroxide. As will be clear from the examples which follow, the silicone rubber binder should be in its cured non-tacky solid state; however, it is not essential that any one particular polysiloxane be used. Also, if desired, binders other than silicone rubber, such, for example, as butyl rubber, polytetrafluoroethylene or epoxy resin may be used though not to the same advantage. It is generally desirable that the binder have rubber-like resiliency as well as good wearing characteristics and high heat resistance.

The preferred composition for the insulating layer **14** consists of from about 70% to 75% barium titanate and the remainder binder, preferably cured silicone rubber. The following examples will serve to more fully illustrate:

(1) One hundred parts (by weight) polydimethyl siloxanedivinylsiloxane gum, about sixteen parts ditertiary butyl peroxide catalyst and 270 parts barium titanate are thoroughly milled together, pressed or calendered to a sheet of 1/16 inch thickness and cured for about 15 minutes at 340° F. in a press and then for an additional 24 hours at 480° F. in an oven. The resulting rubber-like sheet, white in appearance, is then cut to the desired size to fit over the electrode of the dielectric press. This material has a dielectric constant of about 11 and a power factor of about .0029 at 14 mc. s.

(2) Same as Example 1 except that 340 parts by weight barium titanate are used instead of 270 parts. With this increase in barium titanate content, the resulting material has a dielectric constant of 14 and a power factor of .0027 at 14 mc. s.

The most important advantageous characteristics of the preferred compositions are a high dielectric constant and a low power factor, the former in all instances exceeding about 6 and the latter not being in excess of about .01. The high dielectric constant minimizes the stray field adjacent to the embossing electrodes and thereby provides highly increased assurance against arcing even at relatively high voltages on the order of 2000 volts RF and higher. The low power factor results in a minimum heat loss in the layer **14**. Thus, a relatively short heat cycle may be used.

To practice the process of the invention, the insulating layer **14** is attached or placed over one of the electrodes of the dielectric press and the materials to be processed inserted between the electrodes, after which the electrodes are brought together with a pressure on the order of 200 to 800 p.s.i. The embossing cycle generally comprises two phases from the time standpoint, the time during which dielectric heating takes place (the heat cycle) and the time that pressure is maintained on the embossed assembly after the heating is accomplished (soak time). A heat cycle of from 6 to 60 seconds at about 13 megacycles per second, 2500 volts, and a hold time of up to 10 seconds are usually satisfactory. The precise times necessary for optimum results will depend on the exact frequency and voltage used, the materials being embossed, the nature of the pattern, etc. The peak temperature reached during the heat cycle may be from 250° F. to 350° F., a temperature of 325° F. being typical. After the soak time is completed, the embossed assembly is removed and a new assembly inserted. The insulating layer may, of course, be used over and over again, the excellent wear characteristics of silicone rubber providing an exceptionally long, useful life.

While the invention has been described most specifically with reference to dielectric embossing, it will be understood that it may also be used to great advantage in other dielectric heating processes. For example, it has proven itself highly successful for dielectric bonding of cloth to cloth with heat-fusible bonding material in the manufacture of automobile convertible tops. In this embodiment in particular, one of the advantages of the

invention is that it simplifies the manufacture of the electrodes, in the form of matched dies, used to press the cloth sections together. That is, by way of the dielectric layer of this invention, minor inaccuracies in the spacing between the matched die electrodes may be tolerated without the hazard of arcing which might otherwise occur. Thus, though the detailed description has been with reference to a particular embodiment thereof, it will be understood that other embodiments and modifications may be used all within the full and intended scope of the claims which follow.

We claim:

1. A dielectric heating apparatus comprising a pair of electrodes connected in series to a source of high frequency electrical energy, the surface of at least one of said electrodes being covered by a layer of dielectric material consisting essentially of from 60% to 90% by weight barium titanate and the remainder silicone rubber.

2. A dielectric heating apparatus comprising a pair of electrodes connected in series to a source of high frequency electrical energy, the surface of at least one of said electrodes being covered by a layer of dielectric material consisting essentially of from 70% to 75% by weight barium titanate and the remainder silicone rubber.

3. A dielectric heating apparatus comprising a pair of electrodes connected in series to a source of high frequency electrical energy and means for moving one of said electrodes toward the other so as to press the material to be heated therebetween, the surface of at least one of said electrodes being covered by a layer of dielectric material consisting essentially of from 60% to 90% by weight barium titanate and the remainder a resilient organic polymeric binder for said barium titanate.

4. A dielectric heating apparatus comprising a pair of electrodes connected in series to a source of high frequency electrical energy, and means for moving one of said electrodes toward the other so as to press the material to be heated therebetween, the surface of at least one of said electrodes being covered by a layer of dielectric material consisting essentially of from 70% to 75% by weight barium titanate and the remainder silicone rubber.

5. A dielectric embossing apparatus comprising a bottom flat electrode and a top embossing electrode connected in series to a source of high frequency electrical energy, means for moving said electrodes together so as to press the material to be embossed therebetween, the surface of said flat electrode being covered by a layer of 1/32 inch to 1/2 inch thickness of dielectric material consisting essentially of from 70% to 75% by weight barium titanate and the remainder silicone rubber.

6. In a dielectric heating process wherein the material to be heated is positioned between two electrodes connected in series to a source of high frequency electrical energy, the improvement which comprises positioning between at least one of said electrodes and the material to be heated a layer of dielectric material consisting essentially of from 60% to 90% by weight barium titanate and the remainder silicone rubber.

7. In a dielectric heating process wherein the material to be heated is positioned between two electrodes connected in series to a source of high frequency electrical energy, the improvement which comprises positioning between at least one of said electrodes and the material to be heated a layer of dielectric material consisting essentially of from 70% to 75% by weight barium titanate and the remainder silicone rubber.

8. In a dielectric embossing process the step of pressing the material to be embossed between a flat electrode and an embossing electrode connected in series to a source of high frequency electrical energy while having positioned between said flat electrode and the material being embossed a layer of dielectric material consisting essentially of from 70% to 75% by weight barium titanate and the remainder silicone rubber.

9. In a dielectric embossing process the step of pressing with from 200 to 800 p.s.i. the material to be embossed between a flat electrode and an embossing electrode connected in series to a source of high frequency electrical energy while having positioned between said flat electrode and the material being embossed a layer of 1/32 inch to ½ inch thickness of dielectric material consisting essentially of from 70% to 75% by weight barium titanate and the remainder silicone rubber.

10. In a dielectric heating process the step of pressing the material to be heated between two electrodes connected in series to a source of at least 2000 volts RF while having positioned between at least one of said electrodes

and the material being heated a layer of dielectric material having a dielectric constant of at least 6 and a power factor not exceeding .01 and consisting essentially of from 60 to 90% by weight barium titanate and the remainder a resilient heat resistant binder for said barium titanate.

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