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[73]	Assignee	USM Corporation Boston, Mass.

[54] CHEMICAL MANUFACTURE
8 Claims, 17 Drawing Figs.

[52] U.S. Cl..... 12/146,
36/44

[51] Int. Cl. A43d 00/00,

[50] **Field of Search**..... 36/43, 44;
12/146

[56]

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ABSTRACT: A flexible polyvinyl chloride foam member is provided with a permanent profile or shape by use of compressive pressure and radio frequency heating.

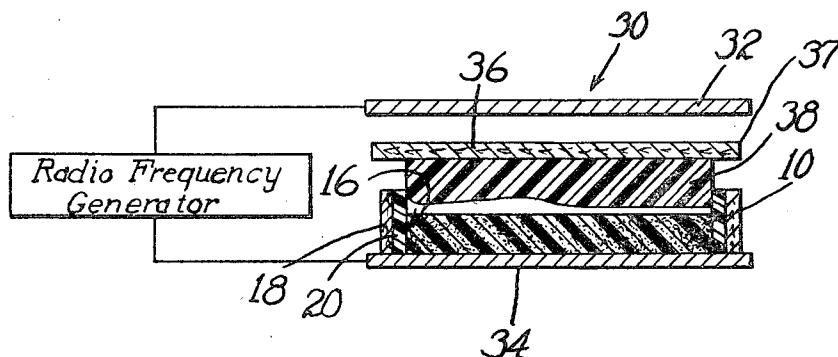


Fig. 1

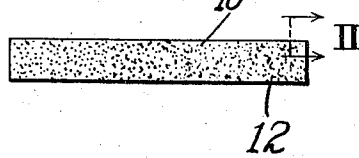


Fig. 2

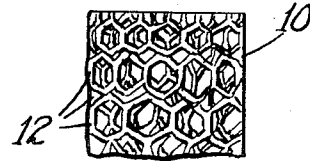


Fig. 3

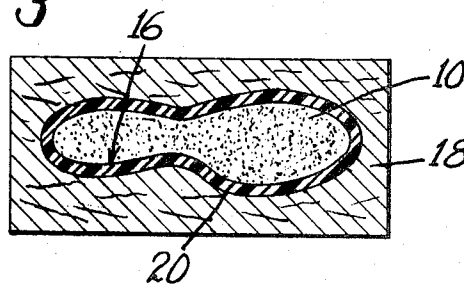


Fig. 4

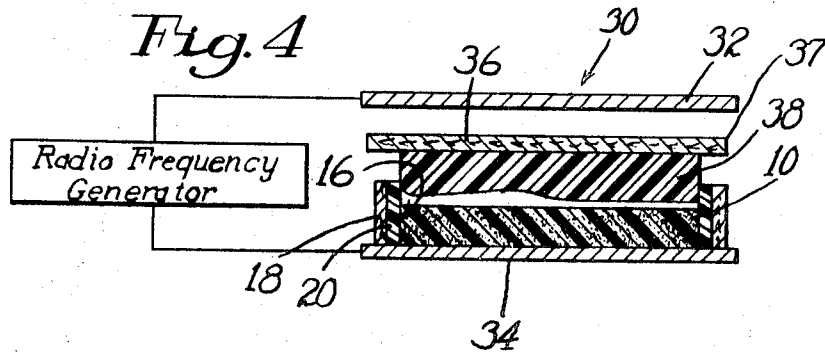


Fig. 5

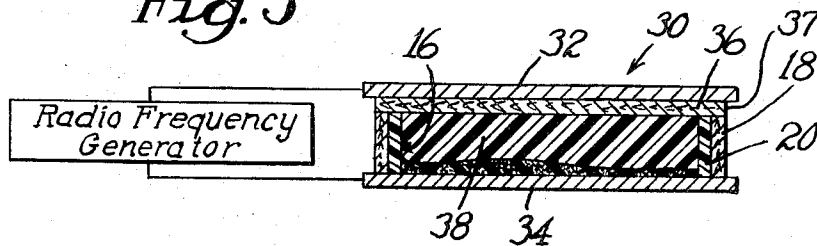


Fig. 6

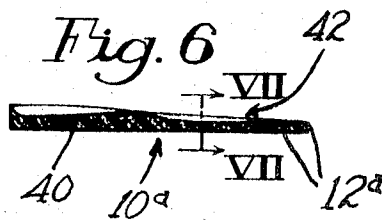
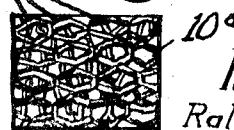


Fig. 7



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Fig. 8



Fig. 9

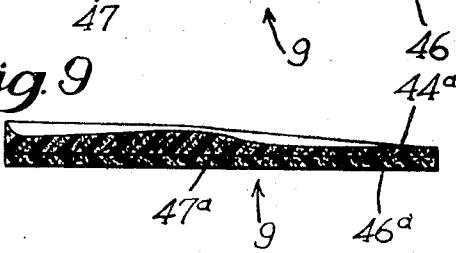


Fig. 10

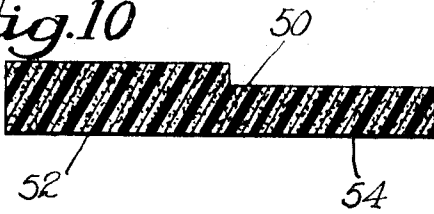


Fig. 11

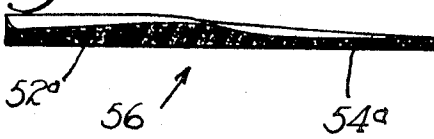


Fig. 12

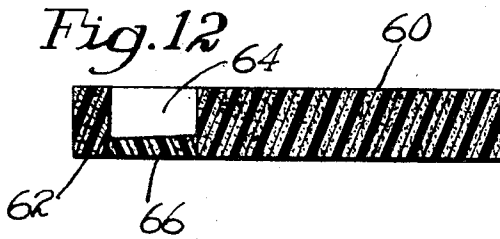


Fig. 13



Fig. 14

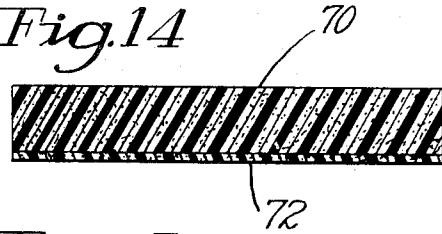


Fig. 15

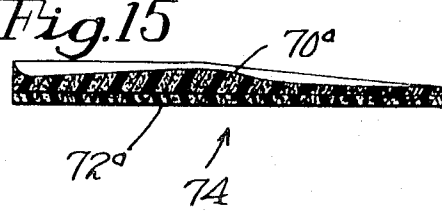


Fig. 16

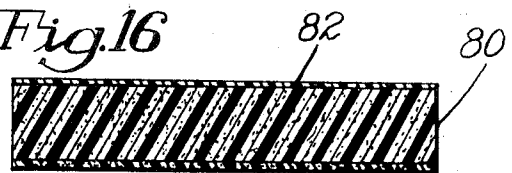
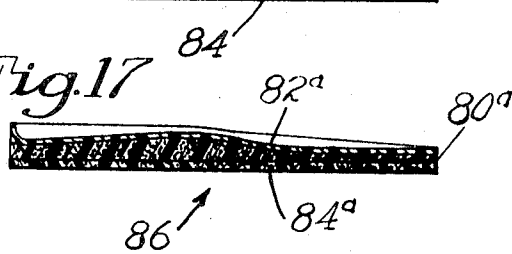


Fig. 17



CHEMICAL MANUFACTURE

The present invention relates to flexible synthetic polymer cellular or foam materials and particularly to a method for profiling or shaping the same.

Introducing a defined or predetermined profile of a permanent nature into a block or member of flexible, thermoplastic synthetic polymeric cellular or foam material in such a way that the member retains a foam or cellular nature, is a desired expedient. Care must be taken in choosing the proper heating conditions to avoid the cellular structure from becoming completely collapsed. Various products such as cushions, cushion insoles and other foot supports as well as pads and cushion padding for garment, automotive and many other end uses may be produced in this manner. Not only does this provide the member with the desired profile or shape, but, additionally it may be practiced to produce a cellular member with predetermined or cushioning capacities or properties, which, incidentally may be provided in different magnitudes within a single member. This latter is particularly desirable in members, such as cushioning members, where it may be anticipated that a portion or portions of the same will be subjected to a greater impact or compression force than the remainder. A comparable increase in cushioning capacity, or foam density in that portion or portions of the member will then more effectively absorb or cushion the impact, and serve to distribute the force of the same, that much better or more evenly throughout the member.

Profiling or shaping of members of the type described has generally involved a process in which the members are compressed into the desired profile and then heated to temperatures sufficiently high to melt or orient the polymeric materials, followed by cooling to set the profile or shape introduced; both the heating and cooling being carried out while the member is maintained in the compressed condition. As indicated previously care must be taken in heating to avoid the members from becoming completely collapsed or collapsed to the extent that they lose their foam or cellular nature.

One of the heating methods prescribed has been the radio frequency type. In many respects that technique seems particularly well adapted because of its ability to penetrate quickly to the interior portions of a polymer foam body, which latter because of its strong nonconductive quality so far as heat transfer is concerned, makes it resistant to being heated to a uniform temperature throughout using other types of heating, particularly those which rely for heat transfer on heat conductivity.

Despite the advantages obtained from using radio frequency type of heating certain shortcomings persist. This has reference to the difficulties met in providing the introduced profile or shape in a permanent set condition while at the same time avoiding overheating which would result in collapse and loss of the cellular structure. Various expedients have been practiced in attempts to overcome this situation. One has been to include a thermoplastic resinous material coated or deposited on the cell walls. This added material is chosen to have a lower melting point than does the material constituting the foam, and acts either as an adhesive material which serves to adhere the then constricted cell walls together, or as a restraining material which effects the same end by setting or stiffening, etc. the cell walls in the constricted or deformed position introduced as a result of shaping pressure or compression applied to the foam or cellular body. Other materials included in the foam or cellular materials for the purpose of facilitating permanent profiling on using radio frequency heating, have been the so-called conditioning materials such as water, alcohol, etc. which are more resistant to radio frequency emissions than the polymer material constituting the foam or cellular structure, and as a result cause an increase in the heat generated by radio frequency electrical field introduced into the foam or cellular body at their particular location within the same. The necessity for including any of the indicated materials into the foam is a definite disadvantage.

It is an object of this invention to provide an improved method or process for profiling or shaping cellular or foam members of thermoplastic synthetic polymeric material.

It is another object of the invention to provide a process or method as above which does not require added materials in order to obtain profiling or shaping which may be permanently set in the cellular or foam member.

It is another object of the invention to produce a profiled foam member as indicated which retain a foam or cellular structure.

These and other objects of the invention are attained in a process or method for producing a profiled cellular article. The process involves a number of steps. The first is that of compressing a flexible, open cell, coherent body or member comprises of polyvinyl chloride material to a predetermined profile or cross-sectional dimension. Then while the body is maintained compressed it is first subjected to a field of radio frequency electrical energy and following is cooled or allowed to cool sufficiently for the introduced profile or shape to become set in the body or member.

The following drawings are included for the purpose of illustrating the invention in which:

FIG. 1 is an end elevation of an open-cell flexible polyvinyl chloride insole blank;

FIG. 2 is a partial section taken along the lines II-II of FIG. 1;

FIG. 3 is a plan view, in section, of a bottom half of a profiling mold;

FIG. 4 is a side elevation, generally schematic and partly in section showing a radio frequency heating press, preparatory to carrying out a profiling operation;

FIG. 5 is a view corresponding to that of FIG. 3, showing the heating press during the profiling operation;

FIG. 6 is a longitudinal vertical section of a cushion insole produced by profiling in the press shown in FIGS. 3 and 5;

FIG. 7 is a partial section taken along the lines VII-VII of FIG. 6;

FIG. 8 is a vertical section through an insole blank constituted of two unattached pieces of flexible open-cell polyvinyl chloride;

FIG. 9 is a vertical section through an insole produced from the blank shown in FIG. 8;

FIG. 10 is a vertical section through an insole blank of flexible, open-cell polyvinyl chloride;

FIG. 11 is a vertical section through an insole produced from the blank shown in FIG. 10;

FIG. 12 is a vertical section through an insole blank of flexible, open-cell polyvinyl chloride including an insert of material effectively resistant to change of state when subjected to radio frequency electrical heating;

FIG. 13 is a vertical section through an insole produced from the blank shown in FIG. 12;

FIG. 14 is a vertical section through an insole blank of flexible open-cell polyvinyl chloride assembled on an insole bottom sheet;

FIG. 15 is a vertical section through an insole produced from the assembly shown in FIG. 14;

FIG. 16 is a vertical section through an insole blank of flexible open-cell polyvinyl chloride assembled in interposed relationship with an insole bottom sheet and an insole top sheet; and

FIG. 17 is a vertical section through an insole produced from the assembly shown in FIG. 16.

The present invention utilizes as blanks, blocks or other starting members, those which are produced from flexible, open-cell polyvinyl chloride. The polyvinyl chloride material used may be either a homopolymer or a copolymer such as those produced by copolymerizing vinyl chloride and vinyl acetate. In the case of the homopolymer, and copolymers, the latter in possibly lesser extent quantitatively, flexibility results from the introduction into the resin of a plasticizer such as dioctyl phthalate, tricresyl phosphate, butylbenzylphthalate, dioctyl adipate, and the like. Flexibility in the copolymer

material may be obtained as a result of internal plasticization, the choice in type and amount of comonomer determining this, and by external plasticizers such as the dioctyl phthalate used in conjunction with the same. In this regard, polyvinyl chloride materials including 20 to 60 parts by weight of plasticizer, such as dioctyl phthalate based on 100 parts by weight of polyvinyl chloride polymer have sufficient flexibility for conveniently practicing the present invention.

The blanks may be produced from the polyvinyl chloride resin in the open cell form by chemical, mechanical or a combination of those techniques. Chemical techniques involve the use of blowing agents. The resin including the latter is heated to a temperature above the gasification or boiling point of the blowing agent, depending on which type is chosen and after being allowed to expand in fluid form or while gelling in the case of plastisols the mass is then allowed to cool. Generally, a free blow is practiced and the blank or block which is to serve as the starting member is cut out of the then cooled, solidified, foam mass. The blank may be blown directly in a mold, but is the less convenient technique of the two. Either way the conditions and constituents, the latter having particular reference to molecular weight of the polyvinyl chloride polymer used, choice of plasticizer, and blowing or foaming agent may be varied to produce a foam or cellular material of the desired cell structure. Mechanical techniques involve punching or leaching to remove a certain amount of the mass at selected intervals and thereby introduce an open cell structure into an otherwise solid body or a closed cell body, or an open cell body in which more open porosity is desired. In the latter two instances needling may also be used to increase open porosity. The most convenient procedure is to produce the starting blank using the chemical blowing technique. It is also preferred to use starting blanks which have at least a high incidence of open porosity. This allows for the production of final products in a wide range of foam densities, cushioning qualities, and porosities, the latter being important where vapor or liquid transmission by the final product, such as insoles, is a desirable attribute. Starting blanks having foam densities of 2 to 10 pounds per cubic foot operate well in this respect, with a further preference directed to blanks having foam densities ranging 4 to 6 pounds per cubic foot.

The present invention uses radio frequency heating to facilitate profiling of a permanent nature in or on flexible polyvinyl chloride foam blanks or members. Frequencies which operate for this purpose may range from about 10 mHz. to 200 mHz. with a preferred range being about 25 mHz. to 120 mHz. Power factors include wattages ranging 1 kw. to 100 kw. with a preferred range being about 1 to 25 kw. Specific choices within the above ranges of frequency and wattage relate to the size electrodes used, and that of the workpiece, blank or member to be profiled. In this latter regard the material and construction of the mold used, are considerations. The voltage used, between electrodes, is maintained as high as is possible without causing breakdown of material taking place. This has reference to the dielectric strength of the material, which is the amount of voltage a material can withstand before breaking down, indicated by burn out of the same. Generally, the narrower the gap between electrodes, the less the time required for heating.

The time required for exposure to radio frequency is dependent upon the frequency, wattage, and voltage used. Generally periods may range about 2 to 60 seconds. Based on the preferred ranges indicated above, heating periods of 5 to 10 seconds suffice. The cooling period which may also be referred to as dwell, sufficient for the latter may range 0—10 seconds. Both times which are of extremely short duration are indications of the efficiency obtained from using the radio frequency heating.

Reference is now made to the drawings, which are illustrative in nature.

FIGS. 1 and 2 illustrate a starting block or blank 10 of flexible, open-cell polyvinyl chloride material. As shown particularly at FIG. 2, a significant proportion of cells 12 are inter-

communicating or intercellular in nature, which pass completely, if randomly, through blank 10.

The block 10, which has previously been cut to or otherwise provided in planar dimensional or outline shape of an insole, is introduced into the correspondingly shaped cavity 16 of a mold bottom half 18. The mold is shown constituted of wood or similar material and also includes a cavity lining 20 of silicone rubber, see in this regard FIG. 3.

As shown in FIG. 4, the mold bottom half 18 carrying the block 10 is located within a radio frequency heated press 30, which includes a movable top plate or electrode 32 and a bottom plate or electrode 34. Both of plates 32 and 34 are connected to a high frequency generator. The mold bottom half 18 together with the mold top half 36, which includes a mold cover 37 and a dependent shaping or profiling portion 38, the latter fitted to the cavity 16, are positioned on the bottom plate 34. The mold cover 37 is shown constituted of wood, while the shaping portion 38 is constituted of silicone rubber or similar material.

With closing or lowering of the top plate 32, the mold top half 36 is similarly closed down into the mold bottom half 18, forcing the profiling or shaping mold portion 38 down on the block 10, introducing, or compressing the predetermined or desired profile shape into the block 10. See in this regard FIG. 5. The high frequency generator is then actuated to provide a radio frequency electrical field to which the block 10 is exposed. For illustrative purposes the radio frequency heated press 30 may be considered to be a 15 kw. unit having a 7.0 kw. output because of efficiency drop off. The frequency may be 60 mHz., and voltage KV attenuating R.F. voltage. Under those conditions the block 10, while compressed into the desired profile by force applied through the shaping portion 38, may be exposed to the field for a heat time of 5 seconds and a dwell time of zero seconds. At that point the power is cut off, the top plate 32 is lifted and the mold assembly unloaded. When the mold assembly is opened, a permanently profiled insole unit 10a, as shown in FIG. 6 is obtained. As shown specifically, at FIG. 7, the cells 12a are of smaller size than when previously shown as 12 in FIG. 2. Nevertheless an open cell structure is retained, giving an insole unit 10a having desirable vapor transmission properties, as well as increased foam density, and comparable increase in cushioning properties. This is increasingly so in concave shaped portions such as the heel portion 40 and the metatarsal arch portion 42 where this is particularly desirable.

The invention is also adapted to utilize more than a single starting block, in providing a profiled insole unit. The embodiment shown in FIGS. 8 and 9 illustrate this. In the first of those figures a pair of flexible open cell polyvinyl chloride blocks 44 and 46 are stacked together across an interface 47. After being exposed to a radio frequency electrical field in the manner previously described, the result obtained is the insole unit 48 shown in FIG. 9. The insole unit 48 constitutes the blocks 44a and 46a, profiled and partially welded together into a single unit across the interface 47a. Separation of the blocks 44a and 46a at interface 47a is accomplished only by tearing of the polyvinyl chloride material.

The embodiment illustrated at FIGS. 10 and 11 is intended to show a variation of the invention by which to obtain proportionately increased foam density in a predetermined area or portion of an insole unit. The starting block 50 shown in FIG. 10 is of greater thickness, and similarly includes more polyvinyl chloride material at the heel portion 52 than the forepart portion 54. When the block 50 is subjected to a radio frequency electrical field in the manner previously described, a permanently profiled insole unit 56 as shown in FIG. 11, is obtained, having proportionately greater foam density, and resultingly greater cushioning properties, in the heel portion 52a than at the forepart 54a. The increase in cushioning properties may be obtained at that portion while at the same time retaining vapor transmission capability. Variations may be practiced relative to this embodiment of the invention by locating increased foam thicknesses elsewhere on the starting

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block, singly or plurally and by varying thickness of same as desired. The increased thickness portions may be integral with the block as shown in FIG. 10 or it may be effected by a separate piece or pieces assembled for that purpose. Reference in this regard may be made to FIGS. 8 and 10 viewed together.

Another embodiment of the invention is illustrated at FIGS. 12 and 13. There starting block 60 of flexible open cell polyvinyl chloride is provided at the heel portion 62 with a slot 64 into which an insert member 66 is fitted. The insert member 66 is constituted of material which is effectively resistant to change of state when subjected to radio frequency electrical field. Materials such as polyurethane foam or foam rubber may be used for this purpose. The insert member 66 may serve as an effective thickness gauge operating to control the effective cavity depth of the mold used, and similarly the thickness of the insole unit 68 obtained as a result of the radio frequency heating, see FIG. 13. Note in this regard that the insert member 66a is of essentially the same thickness as 66 in the starting block 60. It is possible to include inserts of various sizes, shapes, thicknesses, numbers and at different locations with respect to a given starting block, and resulting insole unit, both for the purposes indicated above, and other purposes as well. Other materials may include those which are responsive to radio frequency electrical fields. In this regard inserts of responsive materials may be included to provide adhesive sites which would facilitate lamination with other materials and parts, size and style indicia, etc. based on their being inscribed while in a molten condition, etc.

Another embodiment of the invention is illustrated with respect to FIGS. 14 and 15. In this, an insole blank or starting member 70 of flexible open cell polyvinyl chloride is assembled superimposed on a bottom member 72 constituting a resin impregnated cellulosic member, such as Texon sheet, or the like. As a result of compressing and treating with radio frequency heating, as previously described, a permanently profiled insole unit 74, as shown in FIG. 15 obtained. The insole unit 74 includes the profiled top, lamina 70a which remains flexible, open-cell polyvinyl chloride, and is strongly attached to the lower sheet or lamina 72a.

Still another embodiment of the invention is shown with respect to FIGS. 16 and 17. In the first of those a blank of flexible open-cell, polyvinyl chloride 80 is assembled in interposed relationship with a top sheet 82 of thermoplastic synthetic polymeric material, and a bottom member 84 of resin impregnated sheet material. All three parts generally have a planar shape corresponding to that of an insole. Top sheet 82 is preferably one which has porosity to allow for vapor transmission. Examples of such materials, which are flexible in nature include crushed, blown polyvinyl chloride sheet, sprayed on open pore flexible, resin coatings, etc.

The profiled insole unit 86, which is obtained as a result of radio frequency heating under compression conditions as

previously described, is constituted of three laminae 80a, 82a and 84a, all of which are well attached one to the other. The unit 86 exhibits vapor transmission properties throughout. This is extremely desirable in insoles, for contributing greatly to wearer comfort.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in carrying out the above process and in the products set forth without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. A process for producing a modified profile in a cellular article which comprises the steps of compressing a flexible, open cell body consisting of polyvinyl chloride material to a predetermined profile, and while maintaining the body so compressed subjecting the same to a field of radio frequency electrical energy and then allowing it to set to the modified profile wherein the profile is provided intrinsically of the body so treated.

2. A process for producing a profiled cellular insole unit which comprises the steps of compressing a flexible, open cell, coherent insole unit blank consisting of plasticized polyvinyl chloride material to introduce a predetermined profile to the blank, and, while maintaining the blank so compressed subjecting the same to a field of radio frequency electrical energy and then setting the same whereby the profile is retained intrinsically of the blank.

3. A process according to claim 2 wherein the blank is compressed in a cross-sectional dimension while being maintained in a planar dimensional shape initially present in the insole blank.

4. A process according to claim 2 wherein the blank is compressed while superimposing an insole bottom member comprising a resin impregnated sheet having the planar shape of the insole blank.

5. A method according to claim 2 wherein the blank is compressed while interposed between an insole bottom member of resin impregnated sheet material, and a top sheet of thermoplastic synthetic polymeric material, the bottom member and top sheet having the planar shape of the insole blank.

6. A method according to claim 5 wherein the blank includes an insert member of predetermined thickness which is effectively resistant to change in state when subjected to a field of radio frequency electrical field.

7. A method according to claim 6 wherein the insert member is comprised of polyurethane foam.

8. A method according to claim 6 wherein the insert is a foam rubber.

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