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54 **Frangible housing for an electrical component.**

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Description

This invention relates to a frangible housing having improved resistance to explosive shattering, and to its method of manufacture. In particular, the invention is concerned with improving the resistance to explosive shattering of a hollow housing that is made of a frangible material, particularly, though not exclusively, for use in electrical applications, that is to say, where the housing is arranged to contain or forms part of, an electrical component, especially a high voltage electrical component.

Frangible housings, for example made of a ceramic or other refractory material, and particularly made of porcelain, find extensive application in the electrical power industry in for example components such as surge arrestors, bushings (on voltage and current transformers or switchgear for example), cable terminations and insulators. Such housings may be hollow in the sense that they contain other components or form a part of components, such as resistor blocks of a surge arrestor or an electrical conductor of a bushing or cable termination, or may otherwise be subject to internal pressure such as in a gas- or oil-filled insulator. Housings of this kind can be subject to high mechanical and thermal stresses and in extreme cases are liable to explode so that flying fragments of porcelain can cause damage to property or people in their vicinity. Hollow housings for example can be subject to an electrical overload of the components they contain, leading to explosion. UK Patent Application Publication No 2050719 A for example discloses a surge arrestor housing that is provided with a rupturable diaphragm at one end, that is arranged to be pierced on occurrence of an internal overpressure. There are instances, however, when such an arrangement is not convenient, such as when two or more surge arrestors are mounted in proximity, for example side-by-side, such that an explosion of or from one may adversely affect another. Furthermore, and in particular for housings in a high voltage application, that is to say greater than about 1kV, the housing, instead of being of regular tubular configuration, may have a convoluted or a shedded outer surface so as to increase the path length along the outer surface and thus minimise the effects of creepage current. An outer surface of such configuration usually gives rise to a variation in the wall thickness of the housing along its length with a consequent longitudinal variation in the mechanical strength of the housing. In other instances, however, mechanically weaker regions of a housing may arise from use of different materials at different regions.

GB-A-376984 discloses the use of spaced-apart metal wire bindings or clips wrapped as reinforcing means around a porcelain electrical insulator so as to hold together fragments that can arise on breakage.

CH-A-616265 discloses a feedthrough having

elastomeric material that forms a liner that extends over the entire inner surface of the porcelain housing of the feedthrough so as to restrain the movement of broken fragments thereof.

It is an object of the present invention to provide a hollow housing of frangible material that has improved resistance to explosive shattering. This is achieved by selectively applying insulating restraining means externally to relatively weaker regions of the housing, or by applying restraining means so as to strengthen one or more regions of the housing, thereby making it less susceptible to explosive shattering.

In accordance with one aspect of the present invention, there is provided a hollow frangible housing that is arranged to contain or to form part of an electrical component, the housing having at least one relatively weak region and at least one relatively strong region, characterised in that cured electrically insulating restraining material is mounted on only an outer surface of the housing and only at said at least one weak region thereby to restrain any explosive shattering of the housing at said region arising from adverse operation of the electrical component.

The at least one relatively weak region is more subject to fracture than the at least one relatively strong region.

The one embodiment, the housing comprises a substantially uniform configuration, such as a circular cylindrical configuration, and the restraining means is applied at only one region thereof or at a plurality of spaced apart regions to provide local reinforcement for retention in the event of an explosion.

It will be appreciated that part of the housing is not covered, for example enclosed, by the restraining means. This positively allows the frangible housing to break and to release the excess pressure, whilst the adjacent restraining means tends to hold the pieces together.

The housing will, in general, be elongate.

In accordance with another aspect of the present invention, there is provided a method of reinforcing a hollow frangible housing that is arranged to contain or to form part of an electrical component, the housing having at least one relatively weak region and at least one relatively strong region, characterised in that cured or curable electrically insulating restraining material is applied only to an outer surface of the housing and only at said at least one weak region, thereby to restrain any explosive shattering of the housing at said region arising from adverse operation of the electrical component, and in that, if the material is curable, effecting or allowing cure thereof.

The method may include where applicable the further step of curing the material of the restraining means. This step may be carried out before, or after the curable material has been applied to the housing. For example, a certain amount of curing may be effec-

ted before the material is applied to the housing. If desired, further curing may then be effected after the material has been applied to the housing.

The electrically insulating restraining material advantageously, especially for outdoor use or use in contaminated environments, is electrically non-tracking and resistant to a hostile environment, for example resistant to salt, water and acid such as found in heavily contaminated industrial environments.

When the housing has more than one relatively weak region, restraining means may be applied to each of them, or to one or only some of them as desired.

It will be appreciated that the restraining means is not intended to prevent breakage of the frangible housing, but that should the housing shatter due to an internal or external impulse, the tendency for it to fly apart causing further damage or injury to people or property by impact of fragments will be reduced due to the restraining action of the cured material.

The restraining material may be cured by being subjected to moisture, or by comprising a single- or multi-part, for example two part, curing system such as epoxy resin or silicone material. Preferably however, the material is curable by being subjected to ultra-violet radiation. The material may be cured all the way through, or may be cured in an outer portion only, thus leaving an inner portion with some conformability. In any event, it is desirable that the restraining material retain some elasticity, thus giving it the ability to absorb energy. In this way, should the housing fracture due to an excessive internal pressure, the restraining material is able to expand to allow the excess pressure to be released to the atmosphere, but still retain the fractured pieces of the housing together. The extent of the curing would depend, for example, on the thickness of the material, its composition, and, in a particular example, on the amount of photo-initiator present and on the amount of exposure to ultra violet radiation.

A positive step of curing the material may take place soon or immediately after it has been applied to the housing, and in the case of UV curable material for example this can be achieved by subjecting it to radiation from a UV lamp. Alternatively, and in the case of appropriately curable material, the curing may be allowed to occur naturally, by exposure to the local atmosphere, for example sunlight over an unspecified period of time. It is desirable that the material is curable without the application of any significant amount of heat, since too much heat could put too much thermal stress on the housing.

Advantageously, the curable material is provided and applied to the housing in tape or sheet form. This may be of about 3 mm thickness and may be wrapped two or more times around the housing. The thickness and number of layers used will depend on the particular application, in general more curable material being

applied the greater the likelihood of fracture of the housing.

The restraining action may be enhanced by embedding fibrous material, for example polyester or glass fibres, into the curable material, for example by including fibres within the body of the curable material during manufacture, or by applying the fibres, for example as a discrete layer, during application of the curable material to the housing. The fibrous material advantageously is in the form of a braid, such as a polyester braid, but may be a weave or a knit. The fibrous material should be electrically insulating and non-tracking, and have good mechanical strength, and in particular should have high strength and low elongation.

Preferably the curable material comprises a compound of a polymeric material, an acrylate or methacrylate monomer, oligomer or prepolymer or a mixture thereof, and a photoinitiator that is responsive to ultra-violet radiation. Advantageously, the polymeric material is selected from polyacrylate homo or co-polymer, polymethacrylate homo or co-polymer, for example Plexigum P-24 (from Roehm) or Elvacite 2044 (from Du Pont), ethylene-vinylacetate co-polymer, preferably with a vinyl acetate content above about 45% by weight of the total weight of the composition, for example Escorene MP02020, chlorinated polyethylene, for example Bayer CM 3614, chlorosulphonated polyethylene, for example Hypalon 20 (from Du Pont), and ethylene-methylacrylate-organic acid terpolymer, for example Vamac N 123 (from Du Pont).

The acrylate or methacrylate monomer, oligomer or prepolymer is preferably bi-functional, with a chain length of at least 6 carbon or carbon and oxygen atoms, for example Chemlink 2000 (from ARCO chemical). Combinations of bifunctional and monofunctional acrylates may be used if the cured material is required to have enhanced flexibility. The material is chosen to counteract the inherent inflexibility of the chosen polymeric material, so that the required degree of flexibility and lack of brittleness is achieved in the curable state of the material.

The polymeric material is required to dissolve in the acrylate or methylacrylate material, and for this the polymer preferably is in powdered form. Polymeric material that is conventionally available only in pellet form may be ground, for example using a cryogenic grinder, to a powder of suitable particle size, for example between 100 microns and 800 microns.

The preferred curable material also comprises a photoinitiator that is responsive to ultra-violet radiation, preferably a hydroxy-alkylbenzophenone material, for example Darocur 953 (from E Merck). Other suitable photoinitiators are benzoin ethers, alkylphenones, benzophenones, xanthenes, thioxanthenes, and their derivatives.

The curable material may also comprise a plasticiser for enhancing processing of the material and

providing desired characteristics. Preferably, the plasticiser is a reactive material that can be built into the matrix of the polymeric material. A suitable material is an acrylated epoxidised soybean oil such as Photomer 3005 (available from Diamond Shamrock).

The curable material may also contain other additives in minor amounts, usually less than 10% by weight of the total weight of the composition, of antioxidants, stabilizers and fillers for example.

Preferably, the polymeric material comprises between 30% and 70%, the acrylate or methacrylate between 10% and 40%, the photoinitiator between 1% and 5%, and the plasticiser between 0% and 20%, by weight of the total weight of the curable composition.

The components are advantageously mixed together under vacuum, thus avoiding the inclusion of air bubbles that would otherwise be detrimental to use of the material to encapsulate high voltage electrical components. The resulting liquid material may then be poured into a mould, such as a horizontal tray, protected by release paper, to a depth dependent on the required sheet thickness. If desired, fibrous material may be added at this stage. The material is then left, protected from ultra-violet radiation to undergo a large viscosity change to a gel-like consistency, having a viscosity at 80°C greater than about 1.5×10^3 Pa-sec, the viscosity at room temperature being too high to be conveniently measured. The gelling time depends, for example, on the compatibility between the polymeric material and acrylate or methacrylate monomer, oligomer or prepolymer, and on the particle size (that is to say surface area) of the polymeric material, and can vary from a few minutes to several hours. The resulting material is a flexible sheet that in its uncured state has form-stability, that is to say, will retain its configuration over a substantially indefinite length of time. The material is chosen such that the time it needs to gel is sufficient for the initially flowable liquid to adopt a smooth upper surface, the lower surface of the sheet being smoothed by conformity with the bottom of the tray-mould. For those polymeric material that gel in the shorter times, say two or three minutes, another manufacturing process, for example employing a twin screw extruder, is preferable. Such a process is simpler, provides better mixing of the constituents, and results in a faster gelling time.

The uncured, gel-like material advantageously is stretchable, and preferably elastic, for ensuring proper conformity with the substrate. On curing, the material should adhere and preferably seal to the substrate material, especially porcelain.

On curing, within a time period of a few minutes, the material becomes a thermoset, but advantageously retains some flexibility.

In one preferred configuration, the housing, for example of refractory material, such as porcelain, has a shedded outer surface, that is to say a surface that longitudinally comprises one or more projections that

extend laterally, for example radially, away from a central core of the housing, for the purpose of shedding, or directing, any water or other liquid contaminant away from the housing when operated in contaminated environmental conditions. Alternatively, the outer surface may be convoluted for example of a sine-wave configuration, whilst the inner surface is cylindrical, or otherwise smooth. Typically, the housing will be of generally cylindrical configuration and the sheds or convolutions extending generally circularly therearound. It will be appreciated that in such configurations the relatively thinner wall portions between the sheds or in the troughs of the convolutions comprise relatively weaker regions of the housing.

In another preferred configuration, the refractory housing is of hollow tubular configuration, having substantially homogeneous strength.

The restraining material when cured, preferably is electrically insulating and advantageously is substantially non-tracking. By non-tracking is meant that the material passes the ASTM D2303 inclined plane test, such that it has good resistance to the formation of carbonaceous paths along its surface.

The present invention also provides an electrical component, such as a surge arrestor, bushing, insulator or cable termination, comprising a housing as herein described.

Housings in accordance with the present invention will now be described, by way of example, with reference to Figures 1 and 2 of the accompanying drawing, which show a section through two embodiments of surge arrestor.

Referring to Figure 1, the surge arrestor comprises a generally cylindrical hollow porcelain housing 2 that has integral circular sheds 4 extending radially therefrom. The housing 2 contains a plurality of blocks 6 of non-linear resistive material that act as voltage dividers to affect arresting of electrical surges between the ends (not shown) of the surge arrestor.

A tape 8 of material that is curable by ultra violet radiation is tightly wound around the housing 2 between each pair of sheds 4, that is to say, in regions where the housing wall is relatively thin. It may, however, in some instances not be desirable or necessary to apply the tape 8 to each of the weaker regions.

The tape 8 comprises 64 parts by weight of Plexigum P.24, a polybutylmethacrylate - methylmethacrylate powdered copolymer, 24 parts by weight of Chemlink 2000, a bifunctional long chain acrylate oligomer, 11 parts by weight of Photomer 3005, an acrylated epoxidised soybean oil plasticiser, and 1 part by weight of the photoinitiator Darocur 953, and was mixed under vacuum to dissolve the copolymer in the oligomer. The mixed composition was then poured into a metal tray, to a depth of 3 mm, a braid 10 of polyester fibre embedded therein, covered with a release paper to protect it from sunlight,

and left for 12 hours. During this time, the material became converted from a liquid to a form-stable sheet of elastically stretchable gel having a slightly tacky surface, and being optically transparent.

After strips of the tape 8 were wrapped discretely around the weaker regions of the housing 2 to a thickness of about 3 mm, the output from an ultra-violet lamp, having its peak intensity within the range 320 nanometers to 400 nanometers is then directed substantially evenly on to the tapes 8 for a period of 4 minutes to cure the material. This causes the tape to become a tough thermoset, hardening whilst still being slightly flexible. On curing a slight shrinkage of the material takes place, thus enhancing its securement on to the housing 2.

Thus, should there be an electrical overload of the surge arrestor leading to an increase of pressure therewithin, the tendency for the housing 2 to shatter and explode in the weaker regions between the sheds 4 will be resisted by the fibre reinforced cured tapes 8, which will, in the event of the housing 2 bursting, tend to prevent pieces of the housing being projected through the air.

Referring to Figure 2, the surge arrestor comprises a generally cylindrical hollow porcelain housing 20 having smooth inner and outer surfaces, and contains surge arresting elements (not shown) and suitable metal end fittings (not shown).

Three portions of the tape 8 of material described above are wound circumferentially around the housing 20 at longitudinally spaced-apart regions to provide local reinforcement, and to retain the integrity of the housing 20 should excess pressure in operation cause it to crack.

Claims

1. A hollow frangible housing (2 ; 20) that is arranged to contain or to form part of an electrical component, the housing (2 ; 20) having at least one relatively weak region and at least one relatively strong region (4), characterised in that cured electrically insulating restraining material (8) is mounted on only an outer surface of the housing (2 ; 20) and only at said at least one weak region thereby to restrain any explosive shattering of the housing (2 ; 20) at said region arising from adverse operation of the electrical component.

2. A housing according to claim 1, wherein said material comprises a material (8) that is curable by exposure to ultra-violet radiation or to moisture, or by comprising a two-component curable system.

3. A housing according to claim 1 and 2, wherein said material comprises a tape or sheet (8) that is wrapped around the housing.

4. A housing according to any preceding claim, wherein the restraining means has fibrous material

(10) embedded therein.

5. A housing according to any preceding claim, wherein the material (8) comprises a compound of a polymeric material, an acrylate or methacrylate monomer or oligomer or prepolymer or a mixture thereof, and a photoinitiator responsive to ultra-violet radiation.

6. A housing according to any preceding claim, comprising refractory material (2 ; 20), preferably porcelain.

7. A housing according to any preceding claim, wherein the cured material (8) is substantially electrically track resistant.

8. A housing according to any preceding claim, having a plurality of spaced-apart relatively weak regions, each of which has the cured material (8) mounted thereon.

9. A housing according to any preceding claim, having an outer surface that is of shedded (4) or of convoluted configuration.

10. An electrical component such as a surge arrestor, bushing, insulator or cable termination comprising a housing in accordance with any preceding claim.

11. A method of reinforcing a hollow frangible housing (2 ; 20) that is arranged to contain or to form part of an electrical component, the housing (2 ; 20) having at least one relatively weak region and at least one relatively strong region (4), characterised in that cured or curable electrically insulating restraining material (8) is applied only to an outer surface of the housing (2 ; 20) and only at said at least one weak region, thereby to restrain any explosive shattering of the housing (2 ; 20) at said region arising from adverse operation of the electrical component, and in that, if the material is curable, effecting or allowing cure thereof.

12. A method according to claim 11, wherein the housing has a plurality of spaced-apart relatively weak regions, and wherein cured or material (8) is applied to each of said regions.

13. A method according to claim 11 or 12, comprising the step of applying ultra-violet radiation to the restraining means (8) to effect curing thereof.

Ansprüche

1. Hohles zerbrechliches Gehäuse (2 ; 20), das so angeordnet ist, daß es ein elektrisches Bauelement enthält oder einen Teil davon bildet, wobei das Gehäuse (2 ; 20) wenigstens einen relativ schwachen Bereich und wenigstens einen relativ starken Bereich (4) hat, dadurch gekennzeichnet, daß gehärtetes elektrisch isolierendes Begrenzungs material (8) nur auf einer Außenfläche des Gehäuses (2 ; 20) und nur an dem genannten wenigstens einen schwachen Bereich angeordnet ist, um dadurch explosives Ber-

sten des Gehäuses (2 ; 20) an diesem Bereich aufgrund eines ungünstigen Betriebs des elektrischen Bauelements zu begrenzen.

2. Gehäuse nach Anspruch 1, wobei das Material ein Material (8) umfaßt, das dadurch härter ist, daß es UV-Strahlung oder Feuchtigkeit ausgesetzt wird oder daß es ein härteres Zweikomponentensystem umfaßt.

3. Gehäuse nach Anspruch 1 und 2, wobei das Material ein Band oder einen Flächenkörper (8) umfaßt, der um das Gehäuse gewickelt ist.

4. Gehäuse nach einem der vorhergehenden Ansprüche, wobei in das Begrenzungsmittel Fasermaterial (10) eingebettet ist.

5. Gehäuse nach einem der vorhergehenden Ansprüche, wobei das Material (8) eine Verbindung aus einem Polymaterial, einem Acrylat- oder Methacrylatmonomer oder -oligomer oder -prepolymer oder ein Gemisch davon und einen auf UV-Strahlung ansprechenden Fotoinitiator umfaßt.

6. Gehäuse nach einem der vorhergehenden Ansprüche, umfassend Feuerfestmaterial (2 ; 20), bevorzugt Porzellan.

7. Gehäuse nach einem der vorhergehenden Ansprüche, wobei das gehärtete Material (8) im wesentlichen kriechstromfest ist.

8. Gehäuse nach einem der vorhergehenden Ansprüche mit einer Vielzahl von beabstandeten relativ schwachen Bereichen, auf denen jeweils das gehärtete Material (8) angeordnet ist.

9. Gehäuse nach einem der vorhergehenden Ansprüche mit einer Außenfläche mit Glocken- (4) oder Faltenkonfiguration ist.

10. Elektrisches Bauelement wie beispielsweise ein Überspannungsableiter, eine Buchse, ein Isolator oder ein Kabelendverschluß, umfassend ein Gehäuse nach einem der vorhergehenden Ansprüche.

11. Verfahren zum Verstärken eines hohlen zerbrechlichen Gehäuses (2 ; 20), das so angeordnet ist, daß es ein elektrisches Bauelement enthält oder einen Teil davon bildet, wobei das Gehäuse (2 ; 20) wenigstens einen relativ schwachen Bereich und wenigstens einen relativ starken Bereich (4) hat, dadurch gekennzeichnet, daß gehärtetes oder härteres elektisch isolierendes Begrenzungsmaterial (8) nur auf eine Außenfläche des Gehäuses (2 ; 20) und nur an dem genannten wenigstens einen schwachen Bereich aufgebracht wird, um dadurch explosives Bersten des Gehäuses (2 ; 20) an dem Bereich aufgrund eines ungünstigen Betriebs des elektrischen Bauelements zu begrenzen, und daß, wenn das Material härter ist, sein Härten durchgeführt oder zugelassen wird.

12. Verfahren nach Anspruch 11, wobei das Gehäuse eine Vielzahl von beabstandeten relativ schwachen Bereichen hat und wobei auf jeden dieser Bereiche gehärtetes oder härteres Material (8) aufgebracht wird.

13. Verfahren nach Anspruch 11 oder 12, umfassend folgenden Schritt : Aufbringen von UV-Strahlung auf das Begrenzungsmittel, um sein Härten zu bewirken.

Revendications

1. Boîtier creux cassant (2 ; 20) qui est conçu de manière à contenir un, ou à faire partie d'un, composant électrique, le boîtier (2 ; 20) comprenant au moins une zone relativement faible et au moins une zone relativement résistante (4), caractérisé en ce qu'une matière de contention réticulée électriquement isolante (8) est appliquée seulement à une surface extérieure du boîtier (2 ; 20) et seulement au niveau d'au moins une zone faible, ce qui permet de faire ainsi obstacle à tout éclatement explosif du boîtier (2 ; 20) au niveau de ladite zone, provenant d'un fonctionnement incorrect du composant électrique.

2. Boîtier suivant la revendication 1, dans lequel la matière consiste en une matière (8) qui est réticulable par exposition à une radiation ultraviolette ou à l'humidité, ou bien par la présence d'une composition réticulable à deux constituants.

3. Boîtier suivant les revendications 1 et 2, dans lequel la matière consiste en un ruban ou une feuille (8), qui est enroulé autour du boîtier.

4. Boîtier suivant l'une quelconque des revendications précédentes, dans lequel les moyens de contention comprennent une matière fibreuse (10) qui y est noyée.

5. Boîtier suivant l'une quelconque des revendications précédentes, dans lequel la matière (8) comprend une association d'une substance polymérique, d'un monomère, oligomère ou prépolymère acrylique ou méthacrylique ou d'un de leurs mélanges, et d'un photo-initiateur sensible à la radiation ultraviolette.

6. Boîtier suivant l'une quelconque des revendications précédentes, comprenant une matière réfractaire (2 ; 20), de préférence la porcelaine.

7. Boîtier suivant l'une quelconque des revendications précédentes, dans lequel la matière réticulée (8) est fortement résistante au cheminement électrique.

8. Boîtier suivant l'une quelconque des revendications précédentes, comprenant un grand nombre de zones relativement faibles espacées les unes des autres, la matière réticulée (8) étant appliquée à chacune de ces zones.

9. Boîtier suivant l'une quelconque des revendications précédentes, ayant une surface extérieure qui présente une configuration cloisonnée (4) ou une configuration convolutive.

10. Composant électrique tel qu'un parasurtenant, une traversée isolée, un isolateur ou une terminaison de câble, comprenant un boîtier suivant l'une

quelconque des revendications précédentes.

11. Procédé de renforcement d'un boîtier creux cassant (2 ; 20) qui est conçu de manière à contenir un, ou à faire partie d'un, composant électrique, le boîtier (2 ; 20) comprenant au moins une zone relativement faible et au moins une zone relativement résistante (4), caractérisé en ce qu'une matière de contention réticulée ou réticulable, électriquement isolante (8) est appliquée seulement à une surface extérieure du boîtier (2 ; 20) et seulement au niveau d'au moins une zone faible, ce qui permet de faire ainsi obstacle à tout éclatement explosif du boîtier (2 ; 20) au niveau de ladite zone, provenant d'un fonctionnement incorrect du composant électrique, et en ce qu'il consiste, si la matière est réticulable, à provoquer ou à laisser s'effectuer sa réticulation.

12. Procédé suivant la revendication 11, dans lequel le boîtier comprend un grand nombre de zones relativement faibles espacées les unes des autres, et dans lequel la matière réticulée (8) est appliquée à chacune desdites zones.

13. Procédé suivant la revendication 11 ou 12, comprenant l'étape consistant à appliquer une radiation ultraviolette aux moyens de contention (8) pour provoquer leur réticulation.

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Fig. 1.

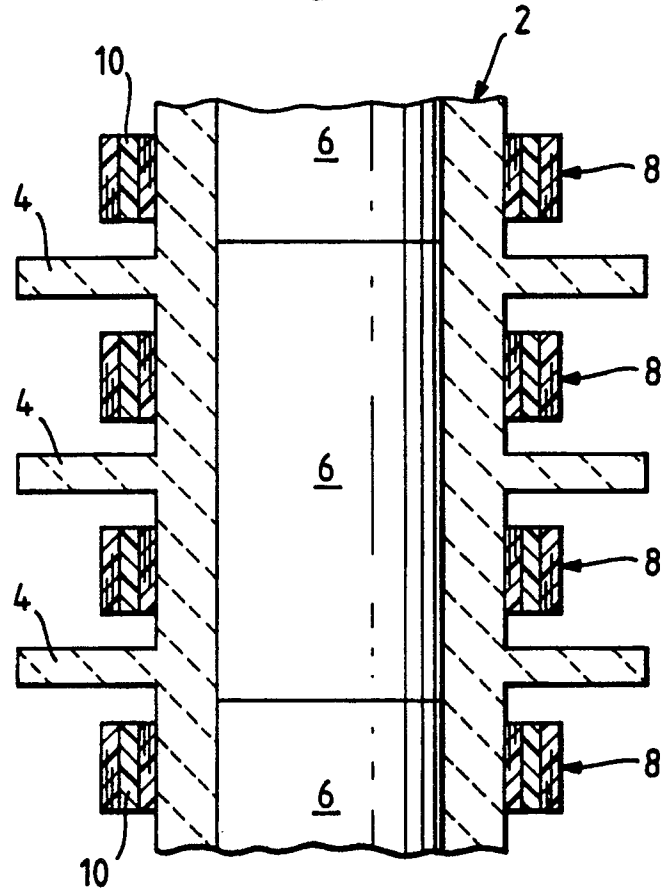


Fig. 2.

