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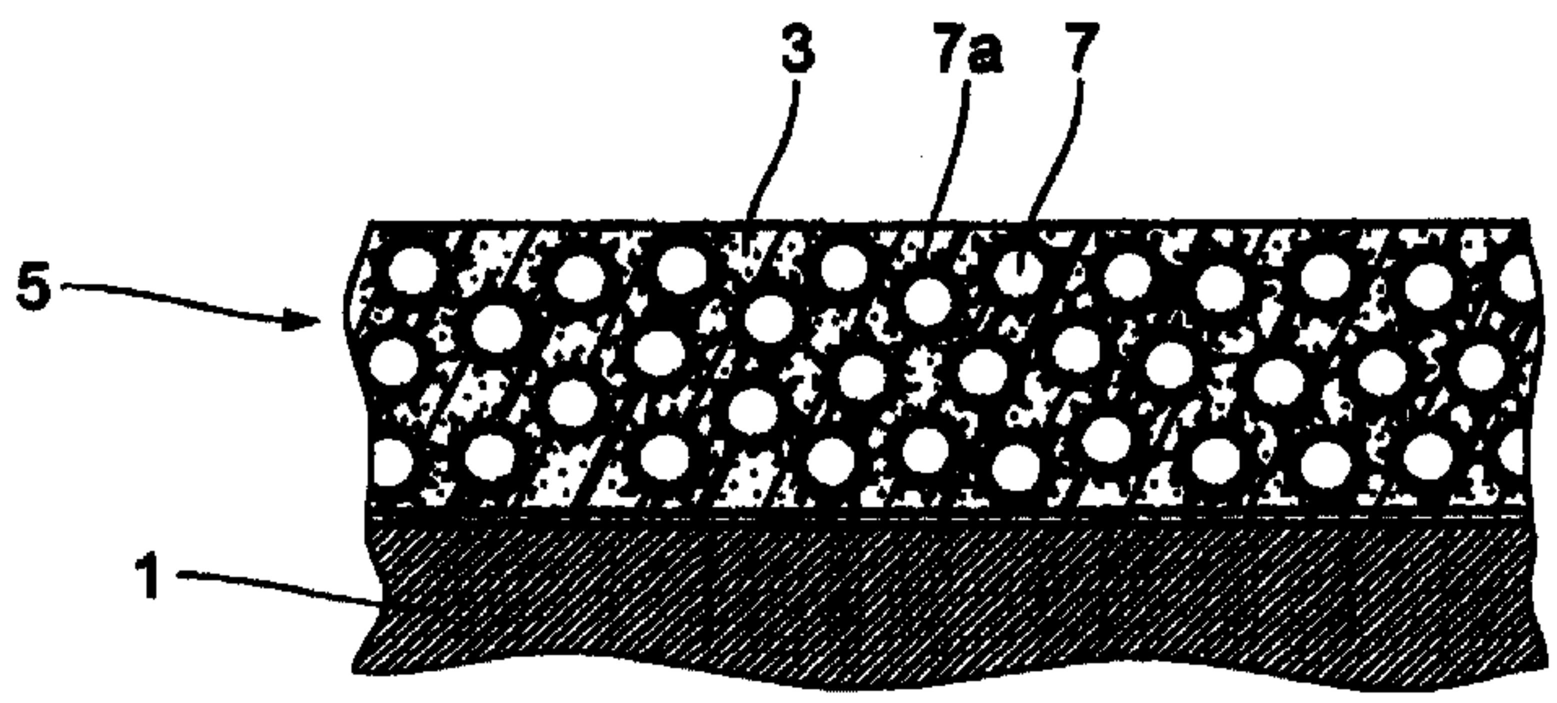
(54) **MATERIAU EN MATIERE PLASTIQUE ET ARTICLE EN MATIERE PLASTIQUE CONDUCTEUR**

(54) **PLASTIC MATERIAL AND CONDUCTIVE PLASTIC OBJECT**



(57) Matériau en matière plastique pour la fabrication d'un article en matière plastique conducteur, en particulier pour le formage d'un profil blindé (3) in situ sur un élément de boîtier blindé (1), comprenant une matrice en résine de matière plastique (5) liquide ou pâteuse, mouillable ou hautement visqueuse et des micro-corps creux (7) élastiques sous l'effet de la pression, en particulier compressibles, remplis de gaz dispersible dans ladite matrice en résine de matière plastique.

(57) A plastic material to produce a conductive plastic object, especially to form a shielding profile (3) in situ on part (1) of a shielding housing, comprising a liquid or paste-like, cross-linkable or highly viscous plastic resin matrix (5) and gas-filled, compression-elastic, especially compressible micro hollow bodies (7) dispersed in said plastic resin matrix.

Abstract

A plastic material for the production of a conductive plastic article, in particular for forming a screening profile member (3) in situ on a screening housing portion (1), with a fluid or pasty, cross-linkable or highly viscous synthetic resin matrix (5) and gas-filled compression-elastic, in particular compressible, micro-hollow bodies (7) dispersed in the synthetic resin matrix.

Figure 1

Plastic material and conductive plastic article

Description

The invention concerns a plastic material as set forth in the classifying portion of claim 1 and a conductive plastic article produced from that material, in particular a sealing and screening profile member.

Silicone-based electrically conductive sealing materials with conductive filling for the production of housing seals or gaskets with an electromagnetic screening action on the spot ("mold-in-place gaskets" = MIPG or "form-in-place gaskets" = FIPG) are known.

Up to the beginning of the Nineties they were used in particular for adhesively sealing off the individual parts of screening housings or for gluing on prefabricated screening seals or gaskets during housing assembly, and they were correspondingly adjusted in terms of their properties. In regard to corresponding products attention is directed to data sheet CS-723 "Conductive Caulking Systems" (1972) from Tecknit, USA, Technical Bulletin 46 "CHO-BOND 1038" (1987) from Comerics, USA, and DE-A-39 36 534.

DE-A-39 34 845 discloses a multi-part screening seal or gasket which comprises an elastic carrier and a highly conductive cover layer, and permits both prefabrication of housing parts with a seal or gasket prior to assembly and also repeated opening of the housing after it has been closed for the first time. This structure is intended specifically to counter the problems of non-homogeneity, which occur by virtue of the high density of the metal particles which afford the conductivity of the material. Production of the multi-component seal or gasket however is expensive.

Therefore, the process described in EP-B-0 629 114 has gained general acceptance in mass production, wherein the conductive material in an initial pasty condition is applied by means of pressure from a needle or nozzle directly onto a housing portion and elastically sets thereon, adhering to the surface thereof, in such a way that a screening profile member which is at the same time conductive and elastic is formed (free from shaping structure). The configuration of the screening profile member is predetermined by way of a suitable selection of the cross-sectional shape and size and the sweep speed of the needle or nozzle, and also by adjustment of the material properties such as viscosity, thixotropy and hardening or cross-linking rate.

In the case of known, highly conductive sealing materials, the filler materials used are in particular massive noble metal particles, for example of silver, noble metal-coated particles with a base core such as for example Ag- or Pt-coated Cu- or Ni-particles, composites of base metals such as for example Ni-coated Cu-particles, or noble metal-coated glass or ceramic particles. The carbon-based fillers which are also known cannot meet present-day requirements in terms of their conductivity.

In the course of the progressive large-scale use and falling prices of electronic equipment which only operate reliably with highly effective screening, the production of screening housings is subject to a high level of cost pressure which inter alia forces a search for inexpensive sealing materials which are nonetheless easy to process and which are variably adjustable in terms of their properties and which give screening profile members which are reliably effective.

Therefore the object of the present invention is to provide such an improved plastic material and electrically conductive plastic article.

That object is attained by a plastic material having the features recited in claim 1 and an electrically conductive plastic article having the features of claim 15.

The invention includes the fundamental notion of forming a starting material for a conductive plastic article in the form of a synthetic resin matrix with incorporated micro-hollow bodies which afford elasticity in respect of shape, consequently being of low density with a high degree of elasticity. The material contains in particular a conductive filler; in an alternative embodiment the conductivity of the finished thermoplastic or thermosetting plastic article however can be produced or increased by an at least partial conductive coating.

The wall of the micro-hollow bodies preferably has a plastic material and is substantially gas-tight, which together affords the desired high degree of elasticity, in particular elastic compressibility, of the filler bodies. As an alternative the hollow bodies are formed substantially exclusively from metal, in which case in conjunction with the gas filling and the nature of the metal wall a certain degree of elasticity is also achieved.

In a preferred embodiment at least a part of the metal filler is in the form of a metal casing or coating on the micro-hollow bodies so that the conductivity of the overall material (matrix with filling) is achieved at least in a considerable part by way of the contact of the conductive walls of the hollow bodies.

If the metal filler is present substantially solely in the form of a casing on the micro-hollow bodies, that mechanism requires a relatively high degree of filling with the hollow bodies so that a sufficiently great density of current paths can be formed by way of the wall contacts, over a seal or gasket cross-section to be produced. In that respect the degree of filling is to be set to a correspondingly higher level, the smoother the surface of the conductive coating is.

If however the metal coating has a rough surface, in particular with a substantially radially oriented crystallite structure, it is however advantageously possible to manage with moderately high degrees of filling and in addition a particularly stable bond between the matrix and the filling bodies is achieved.

If however in another development of the notion of the invention the metal filler is substantially dispersed in the usual manner in the form of metal powder into the matrix, the degree of filling with the micro-hollow bodies (which are then not conductive and which consequently form insulating regions) should not be too high.

The micro-hollow bodies are desirably of a diameter in the range of between 5μm and 100 μm, in particular between 15 μm and 50 μm.

In a variant which is technologically simple to implement and which affords an electrically and mechanically isotropic plastic material, at least a part of the micro-hollow bodies is in hollow sphere form. Specific properties - for example thixotropy and electrical and mechanical anisotropy - can be achieved if at least a part of the micro-hollow bodies is of an approximately ellipsoidal, cylindrical or prismatic configuration (that also includes a briquette-like configuration or flake form), wherein the length of the longest major axis of an ellipsoid is at least 1.5 times the next larger major axis or the height of the cylinder is at least 1.5 times the radius or the height of the prism is at least 1.5 times the length of its largest base surface side. Specifically when such a material is discharged from a needle or nozzle or when the material is applied by means of a doctor or squeegee, more specifically, due to the dynamic interface orientation effects, orientational alignment of the elongate micro-hollow bodies can occur, and subsequent hardening on the substrate preserves that orientation.

The micro-hollow bodies can also be subdivided in the interior by intermediate walls or can be made up from a plurality of separate hollow spaces or cavities.

The metal casing preferably embraces the entire surface area of the micro-hollow bodies and thus ensures in particular gas-tight integrity thereof and elastic compressibility with a high return force which is practically constant over a long time. It is of a mean thickness in the range of between 0.1 µm and 5 µm, which is so matched to the dimensions of the micro-hollow bodies that the effective density of the coated micro-hollow bodies is not substantially greater than that of the plastic matrix.

In the described manner, two main disadvantages of plastic materials filled with solid metal powder - the high degree of tendency to sedimentation and the limited "compression set" - are highly effectively remedied and excellent storability and easy mechanical processability are achieved.

A corresponding plastic article - more especially a screening profile member which is formed in self-supporting relationship by applying a sealing material of this kind to a surface of a screening housing portion - accordingly has an almost ideally homogenous distribution of the micro-hollow bodies in the synthetic resin matrix and a uniformly high level of elasticity and stability in respect of shape.

The surface of the metal casing of the micro-hollow bodies is preferably rough or porous, down to heavily structured coatings with crystallite-like, substantially radially oriented extensions which ensure an intimate connection to the matrix and - by way of methodical interlocking of the hollow bodies which are adjacent to each other in the matrix - a high level of volume conductivity, even with a relatively low degree of filling.

Particularly high material cost savings are possible in an embodiment in which the metal casing comprises at least two layers, wherein only the outer layer is a noble metal layer.

The conductive casing with the above-mentioned preferential features on the micro-hollow bodies is produced in a per se known electrode-less ("electroless") or galvanic process or in a vacuum process, specifically by vapor deposition or sputtering.

To form relatively soft screening profile members which have a certain degree of plasticity, the procedure advantageously uses a silicone matrix with a proportion of siloxane which does not involve cross-linking or which involves only slight cross-linking, of more than 3 % by mass.

The addition of a long-chain siloxane which is non-cross-linking as such affords for the matrix, after hardening of the cross-linkable silicone component (due to moisture in the air, heat or radiation), a wide-mesh cross-linked structure with a certain plasticity whose degree can be predetermined by the ratio of the components in the mixture. To form seals which are plastic to a high degree for specific uses but which nonetheless have sufficient elasticity by virtue of the incorporated hollow spheres which are elastic in respect of shape, the proportion of the non-cross-linking component can be increased to a multiple of the proportion of the cross-linkable component.

The optionally additional addition of an organic solvent serves on the one hand to optimize the processing properties of the material and on the other hand can positively influence the properties of use of the finished profile material. It causes so-to-speak "floating" of the matrix material and facilitates in particular mixing of the components and improves the wetting effect. Good results were achieved with proportions of between 5 and 20 % by mass of benzene and/or toluene.

A corresponding screening profile member can easily have a degree of deformation of over 30 %, in particular over 50 %, with respect to the magnitude of an unloaded U-shaped sealing profile member of solid material.

The matrix however can also be formed by a two-component epoxy resin or polyurethane mixture or other cross-linking or thermoplastic materials.

Gaps in housings of width which differ considerably over their lengthwise extent can also be reliably screeningly sealed off by virtue of the above-mentioned measures in terms of the material involved and possibly additional structural measures - in particular the imposition of a suitably flexurally elastic or compressible cross-sectional shape for the profile member. That permits for example inexpensively greater tolerances in terms of manufacture of the housings.

Advantageous developments of the invention are also characterized in the appendant claims and are set forth in greater detail hereinafter in the context of the description of preferred embodiments of the invention with reference to the drawings in which:

Figure 1 is a diagrammatic view in cross-section through a screening profile member in accordance with a first embodiment,

Figure 2 is a diagrammatic view in cross-section through a screening profile member in accordance with a further embodiment, and

Figure 3 is a diagrammatic view in cross-section through a screening profile member in accordance with a further embodiment.

For a first embodiment of the invention, the following Table sets forth as mixture 1 an electrically conductive material for a matrix which represents a thermosetting single-component system. This material which after hardening is elastic but relatively soft is suitable for the production of screening profile members on edges of re-closable EMI-housings with moderate production tolerances.

As can be seen from Figure 1, this material for the matrix 5 of a screening seal or gasket 3 which is formed on a housing portion 1 is filled with PVDC (polyvinylidene chloride) hollow spheres 7 of a mean diameter of about 20 μm with a heavily crystal-like structured Ag-coating 7a of a mean thickness of about 1 μm in a ratio by volume of 1:1.

<u>Mixture 1</u>

			Proportion (% by mass)
Component	I:	Silicone "TSE 3220" from GE	32.4
	II:	Polydimethylsiloxane with terminal methyl or hydroxyl groups (dyn. visc. 20 ... 500 mPa.s)	10.7
	III:	Silicone resin solution GE "PSA 529"	19.5

IV:	Toluene	16.3
V:	Benzene	21.1

For a second embodiment mixture 2 is an electrically conductive plastic material whose matrix material represents a two-component system which hardens at room temperature. The screening profile member formed from this material has a high degree of deformation, exhibits marked plasticity, and is suitable in particular for sealing gaps in EMI-screening housings with considerably production tolerances.

Mixture 2

Component	I/A:	Silicone GE "SLE 5300 A"	53.3
	I/B:	Silicone GE "SLE 5300 B"	5.3
	II:	Polydimethylsiloxane with terminal methyl groups (visc. ca. 50 mPa.s)	20.7
	III:	Toluene	20.7

As Figure 2 shows this matrix material 15 for a screening seal 13 on a housing portion 11 is filled with approximately cuboidal ACN (acrylonitrile) hollow bodies 17 with a coating comprising a Ni-layer 17a and thereover a porous Ag-layer 17b with a total thickness of about 2 μm in a ratio of about 1 part by volume of matrix and 2 parts by volume of filling bodies, and the overall mixture has anisotropic mechanical and electrical properties by virtue of the anisotropic nature of the filler bodies.

As a third embodiment a mixture 3 is a thermosetting single-component system corresponding to the first example, in which the conductive component is contained in the matrix in the form of powder comprising crystallitic, stellate or flake-like particles of relatively large surface area or in the form of a mixture of particles of such forms.

Mixture 3

			Proportion (% by mass)
Component	I:	Silicone "TSE 3220" from GE	13.6
	II:	Polydimethylsiloxane with terminal methyl or hydroxyl groups	

	(dyn. visc. 20 ... 500 mPa.s)	4.5
III:	Silicone resin solution GE "PSA 529"	8.2
IV:	Toluene	6.8
V:	Benzene	8.9
VI:	Ag-powder	58.0

Figure 3 shows filling of this matrix material 25 with the Ag-particles 25a for a screening seal 23 on a housing portion 21 with spherical and ellipsoidal thermoplastic hollow bodies 27 in a ratio of about 2 parts by volume of matrix and 1 part by volume of filler bodies in order to reduce the mean density of the profile member and to improve the elasticity properties, in particular so-called "compression set". With this degree of filling, a sufficiently dense distribution of the silver particles 25a in the overall volume and thereby (in conjunction with the extensive configuration of the particles) the provision of continuous current paths is also ensured. The specific shape of the metal particles as is shown also firmly binds into the matrix both the metal particles and also the hollow bodies 27 which are so-to-speak anchored by the metal particles.

In a fourth embodiment the hollow bodies exclusively consist of an Ni- or Ni/Ag-metal casing with a wall thickness of between 4 and 5 μm and are formed by applying a metal layer to plastic particles of suitable diameter and substantially removing the plastic core by pyrolysis.

The formation of a screening profile member from the plastic material is preferably effected in the per se known manner which is basically illustrated for example in EP-B-0 629 114, but depending on the setting of the physico-chemical properties it is also possible for it to be applied to the housing portions to be screened by gun application or spraying, or application by means of a stamp or punch.

The invention is not limited in regard to its implementation to the preferred embodiments set forth hereinbefore. On the contrary it is possible to envisage a large number of alternative configurations which make use of the principles set forth in accordance with the accompanying claims even in configurations of different kinds.

In particular, depending on the requirements of the specific purpose of use, it is possible to implement differentiated mixed or hybrid forms between introduction of the metal into the material exclusively as a coating on the micro-hollow bodies and the introduction thereof exclusively in the form of a powder - besides non-conductive micro-hollow bodies. As a result of the reduced amount used, besides silver, it is also possible to use gold, platinum or platinum alloys, to an increased extent, as the metal filling.

Additional optimization opportunities are afforded by the combination with a conductive, in particular purely metallic, surface coating on the plastic article produced.

Besides silicone mixtures, it is also possible to use as the matrix material polyurethanes, epoxy resins, MDK or other tried-and-tested plastic materials which are to be prepared and processed in the respectively specific fashion in the form of single-component or multi-component mixtures.

The conductive plastic article formed from the material according to the invention can be used not only as "form-in-place" or "mold-in-place" screening seals or gaskets, but also as a prefabricated seal or gasket or for other uses in the area of electrical engineering and electronics.

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New claims

1. A plastic material for producing a conductive plastic article, in particular for forming a screening profile member (3, 13, 23) in situ on a screening housing portion (1, 11, 21), with a fluid or pasty, cross-linkable or highly viscous synthetic resin matrix (5, 15, 25) and gas-filled, micro-hollow bodies dispersed in the synthetic resin matrix and having a metallically conductive casing, characterized in that the micro-hollow bodies are elastically compressible.

2. A plastic material as set forth in claim 1 characterized in that the wall of the micro-hollow bodies (7, 17, 27) has a plastic material and is substantially gas-tight.

3. A plastic material as set forth in claim 1 or claim 2 characterized in that the mean density of the micro-hollow bodies (7, 17, 27) is not substantially greater than the density of the synthetic resin matrix (5, 15, 25).

4. A plastic material as set forth in one of the preceding claims characterized in that the micro-hollow bodies (7, 17, 27) are of a diameter in the range of between 5 μm and 100 μm, in particular between 15 μm and 50 μm.

5. A plastic material as set forth in one of the preceding claims characterized in that at least a partial quantity of the micro-hollow bodies (7, 27) is of an approximately hollow spherical shape.

6. A plastic material as set forth in one of the preceding claims characterized in that at least a partial quantity of the micro-hollow bodies (17, 27) is anisotropic in form and in particular is of an approximately ellipsoidal, cylindrical or prismatic configuration, wherein the length of the longest major axis of an ellipsoid is at least 1.5 times the next larger major axis or the height of the cylinder is at least 1.5 times the radius or the height of the prism is at least 1.5 times the length of the greatest base surface side thereof, in such a way that the plastic material has anisotropic mechanical and/or electrical or thixotropic properties.

7. A plastic material as set forth in one of claims 4 through 6 characterized in that the metal casing (7a, 17a, 17b) covers substantially the entire surface of the micro-hollow bodies (7, 17).

8. A plastic material as set forth in one of claims 4 through 7 characterized in that the metal casing of the micro-hollow body comprises at least two layers (17a, 17b).

9. A plastic material as set forth in one of claims 4 through 8 characterized in that the metal casing (7a, 17b) of the micro-hollow bodies (7, 17, 27) has a rough surface, in particular with a substantially radially oriented crystallite structure.

10. A plastic material as set forth in one of claims 4 through 9 characterized in that the metal casing (7a, 17a, 17b) is of a mean thickness in the range of between 0.1 μm and 5 μm, wherein the mean thickness is so matched to the dimensions of the micro-hollow bodies that

the effective density of the micro-hollow bodies is not substantially greater than that of the plastic matrix.

11. A plastic material as set forth in one of the preceding claims characterized by a silicone-based synthetic resin matrix (5, 15, 15) with a proportion of siloxane which is non-cross-linking or slightly cross-linking of more than 3% by mass.

12. A plastic material as set forth in one of the preceding claims characterized by a proportion of more than 3% by mass of an organic solvent in the starting material of the synthetic resin matrix.

13. A conductive plastic article comprising a plastic material as set forth in one of claims 1 through 12, in particular a screening profile member (3, 13, 23) formed in self-supporting relationship by application of such a plastic material to a surface (1, 11, 21) of a screening housing portion, characterized by homogenous distribution of the micro-hollow bodies (7, 17, 27) in the synthetic resin matrix (5, 15, 25).

14. A plastic article as set forth in claim 13 characterized by a degree of deformation which can be achieved reversibly of over 30% and in particular over 50% with respect to the height of an unloaded U-shaped sealing profile member of solid material.

15. A plastic article as set forth in claim 13 or claim 14 characterized by an at least partial conductive coating, in particular in conjunction with a non-conductive filling.

16. A plastic article as set forth in one of claims 13 through 15 characterized by anisotropic mechanical and/or electrical properties by

virtue of a filling with micro-hollow bodies which are anisotropic in form and which are oriented in a preferential direction.