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Description

- [0001] The invention relates to a diaphragm, wherein the diaphragm comprises at least two layers, wherein at least one of the at least two layers consists of an elastomer, and wherein an electric circuit is provided between the at least two layers. The invention also relates to a method for producing the diaphragm.
- [0002] From WO 2006/001971 A2, an approach is known for electrically connecting an antenna, which is arranged between the layers of a multilayer laminate structure, on the outside. The contact to the antenna is achieved by means of openings in the laminate structure.
- [0003] DE 19925 508 A1 relates to a device for detecting leaks on diaphragms. In this respect, it is proposed that the diaphragm consists of at least two diaphragm plates. At least one of the diaphragm plates has, on its inner surface, a coating with at least one conductor. In the case of a change in the diaphragm or in the conductor, the conductor brings about a change in a measured variable.
- [0004] US 2005/0115402 A1 discloses a multi-layer diaphragm for a hydraulic pump.
- [0005] GB 2 433 298 A discloses a diaphragm for detecting fractures. During the operation of a diaphragm pump, contact points are connected to a device which can determine the electrical current through a conductor loop. A resistance of the conductor loop can thus also be determined.
- [0006] It is the aim of the invention to improve the diaphragm of the type mentioned above with respect to the electrical contact.
- [0007] The invention achieves this aim by means of a diaphragm according to claim 1, as well as a method according to claim 9.
- [0008] In the diaphragm according to the invention, within at least one of the at least two layers, a conductive insert, with which an electrical connection of the electric circuit to or from the outside of the diaphragm can be achieved, is provided, wherein the electric circuit has a spiral structure for forming an antenna.
- [0009] By means of the invention, openings in the layers of the diaphragm are avoided. Instead, the contact to the electric circuit is integrated into the diaphragm - namely, into at least one of the two layers of the diaphragm.

In this way, it is possible to leave the properties of the diaphragm unchanged or to not change them by means of openings or the like. Furthermore, the production of the diaphragm is also simplified.

- [0010] In a development of the invention, the conductive insert contains conductive particles, which are introduced into the material of the relevant layer. For example, the relevant layer is enriched with carbonaceous material at the location or in the vicinity of the conductive insert. In this way, the production of the diaphragm is further simplified.
- [0011] It is furthermore possible that the conductive insert consists of at least one linear lead. With this lead, the electrical connection of the electric circuit to or from the outside of the diaphragm can then be realized.
- [0012] In a further development of the invention, the electric circuit is provided on a support, wherein the support is arranged on or between the layers. Preferably, the electric circuit consists of conductor paths and/or other electrical structures made of an electrically conductive material, which are arranged on the support.
- [0013] Additional features, possible applications, and advantages of the invention can be taken from the description below of exemplary embodiments of the invention, which are illustrated in the respective figure.
- [0014] The sole figure 1 shows a schematic perspectival view of an exemplary embodiment of a diaphragm according to the invention.
- [0015] Figure 1 shows a diaphragm 10, which can, in particular, be used in a valve - for example, in a pneumatic or hydraulic or electrically operated diaphragm valve. In the top view, the diaphragm 10 has an approximately rectangular diaphragm surface and an essentially constant diaphragm thickness transverse to the diaphragm surface.
- [0016] Of course, the diaphragm 10 may also have a differently designed geometric shape. For example, the diaphragm 10 may also have a round shape.
- [0017] It is noted that the diaphragm 10 in figure 1 is illustrated only for purposes of explanation in such a way that a yet to be explained top layer is partially opened upward; this is, however, not the case in the completed diaphragm 10.

- [0018] The approximately rectangular diaphragm surface constitutes the functional area of the diaphragm 10. In this functional area, approximately, the diaphragm 10 is installed in the associated valve. For example, the diaphragm 10 may be arranged in the functional area between two housing parts of the associated valve.
- [0019] On one of the longitudinal sides, the diaphragm 10 has a tab 12. In the present exemplary embodiment, the tab 12 is designed as an approximately rectangular projection, which protrudes beyond the approximately rectangular diaphragm surface. The dimensions of the tab 12 - in particular, the extension of the tab 12 approximately transverse to the respective longitudinal side of the diaphragm 10 - are selected such that the tab 12 preferably also protrudes beyond any housing parts of the associated valve.
- [0020] Of course, the tab 12 may also have a differently designed geometric shape. Where appropriate, the tab 12 may also be completely omitted.
- [0021] The diaphragm 10 with the tab 12 is constructed of a plurality of layers, wherein each of the individual layers may consist of an elastomer, a woven fabric, a stabilizing layer, or the like, and wherein the elastomers and the woven fabrics of the different layers may respectively consist of different materials, such as rubber, silicone, or the like.
- [0022] As can be seen in figure 1, the diaphragm 10 comprises at least two layers - namely, a base layer 14 and a top layer 15. The two layers 14, 15 are congruent, and both have the approximately rectangular surface of the diaphragm 10. Alternatively, it is also possible for the surfaces of the base layer 14 and the top layer 15 to deviate from one another and thus overlap only partially.
- [0023] In order to position the base layer 14 and the top layer 15 with respect to one another, both layers 14, 15 are respectively provided with at least one opening 17. In the present exemplary embodiment, four openings 17, respectively, are provided, which are arranged in the region of the corners of the diaphragm 10.

- [0024] Between the base layer 14 and the top layer 15, a support 19 is provided, which is equipped with an electric circuit 20. The support 19 can also be arranged on one of the layers.
- [0025] The support 19 is designed to be planar and has merely a slight thickness. The support 19 may, for example, be a film - in particular, a flexible film. The support 19 consists of an electrically non-conductive material. The support 19 may have the shape of the diaphragm 10. It is, however, also possible for the surface of the support 19 to be smaller than the surface of the diaphragm 10. It is, in particular, possible for the support 19 to have only the surface area that is required to accommodate the electric circuit 20 on the support 19.
- [0026] The electric circuit 20 may, for example, consist of conductor paths and/or other electrical structures made of an electrically conductive material, which are arranged on the support 19. The electric circuit 20 may also include resistances and/or capacitances and/or inductances. This may be achieved by an appropriate design of the structure and/or an appropriate selection of the material for the conductor paths. The electric circuit 20 may thus, for example, constitute a part of an antenna and/or a part of a measuring circuit and/or the like.
- [0027] The electric circuit 20 is arranged on the support 19 and firmly connected to it. For example, the electric circuit 20 may be vapor-deposited onto the support 19 or firmly mounted onto the support 19 in another manner.
- [0028] Additionally, with respect to the support 19 and the electric circuit 20, reference is made to so-called flexible printed circuit boards, which are thin, flexible electric circuits that are constructed on, for example, polyimide films.
- [0029] In the present exemplary embodiment, the electric circuit 20 has a spiral structure 21 of an antenna, which is provided with three exemplary connecting lines 22a, 22b, 22c. In the present case, the support 19 furthermore has a surface that is only slightly larger than the surface constituted by the spiral structure 21 and the connecting lines 22a, 22b, 22c.

- [0030] Of course, other numbers of connecting lines, as well as other laminar shapes of the structure 21, are also conceivable.
- [0031] In the present exemplary embodiment, it is assumed that at least the region facing the electric circuit 20 of the base layer 14 and/or top layer 15 of the diaphragm 10 is electrically non-conductive. Where applicable, this can be achieved by means of an additional non-conductive layer or the like, which is arranged in the region of the electric circuit.
- [0032] In order to position the support 19 on the base layer 14, the support 19 and the base layer 14 are respectively provided with at least one opening 24. In the present exemplary embodiment, two openings 24 are respectively provided, which are arranged in the region between the three connecting lines 22a, 22b, 22c. Of course, the support 19 – instead of the base layer 14 – may also be positioned with respect to the top layer 15.
- [0033] The support 19 together with the electric circuit 20 may be firmly connected to the base layer 14 and/or the top layer 15. This may, for example, be achieved by means of an adhesive or another material, which is inserted between the support 19 and the base and/or top layer 14, 15. The fixing of the support 19 within the diaphragm 10 may alternatively, however, also be carried out by connecting the base layer 14 and the top layer 15 firmly to each other, and in this way also connecting the support 19 firmly with the base and/or top layer 14, 15.
- [0034] In the base layer 14, a conductive insert 26 is provided, which consists of three linear leads 27a, 27b, 27c in the present exemplary embodiment.
- [0035] The conductive insert 26 or each linear lead 27a, 27b, 27c may be obtained in that, at the desired locations or in the desired regions of the base layer 14, additional conductive particles are introduced into the material of the base layer 14. A doping of the material of the base layer 14 with conductive particles thus occurs precisely where the conductive insert 26 or the linear leads 27a, 27b, 27c are to be arranged. It is, for example, possible to enrich the material of the base layer 14 at the desired locations or in the desired regions with a carbonaceous material.

- [0036] Analogously, a conductive insert 28, which, for example, consists of three linear leads 29a, 29b, 29c, is also provided in the top layer 15 in the present exemplary embodiment.
- [0037] Of course, alternatively, only one of the two inserts 26, 28 may be present, and/or, alternatively, only one or two linear leads may be present in the inserts 26, 28, or appropriate mixed forms may be provided.
- [0038] By means of the conductive inserts 26, 28 or the linear leads 27a, 27b, 27c, 29a, 29b, 29c, an electrical connection of the electric circuit 20 to or from the outside of the diaphragm 10 is achieved.
- [0039] The linear leads 27a, 27b, 27c, 29a, 29b, 29c of the two conductive inserts 26, 28 are arranged within the base layer 14 and the top layer 15 such that a contact of the previously mentioned leads with the connecting leads 22a, 22b, 22c is possible from a spatial perspective. This can, in particular, be achieved by the linear leads 27a, 27b, 27c, 29a, 29b, 29c at least partially forming an overlap region with the associated connecting leads 22a, 22b, 22c.
- [0040] The contact between the linear leads 27a, 27b, 27c, 29a, 29b, 29c and the connecting leads 22a, 22b, 22c may be carried out by pressing the layers 14, 15 onto or together with the support 19 arranged between them. Alternatively or in addition, it may be provided that a firm connection is established in the mentioned overlap regions by means of a conductive adhesive and a contact is thus achieved.
- [0041] Furthermore, the linear leads 27a, 27b, 27c, 29a, 29b, 29c of the two conductive inserts 26, 28 are arranged within the base layer 14 and the top layer 15 such that an electrical contact of the same to or from the outside of the diaphragm 10 is possible. In the present exemplary embodiment, this is achieved in that contact with the linear leads 27a, 27b, 27c, 29a, 29b, 29c may be made on the top side of the diaphragm 10, on the face side of the diaphragm 10, as well as on the bottom side of the diaphragm 10. Of course, in doing so, only a single possible contact may also be sufficient.
- [0042] Additionally, the diaphragm 10 may be provided with upper and/or protective layers not shown. These protective layers may then have appropriate

openings at those locations where an electrical contact of the linear leads 27a, 27b, 27c, 29a, 29b, 29c is to take place.

[0043] In the following, a possible method for producing the diaphragm 10 is explained.

[0044] As has been explained, the diaphragm 10 is constructed of several layers - out of at least the base layer 14 and the top layer 15. The desired shape or outer contour of the diaphragm 10 is initially cut out of the respective materials of the individual layers. This outer contour is, for example, punched out of the provided elastomer(s), as well as out of the woven fabric material(s) provided.

[0045] Subsequently, the individual cut-out layers of the diaphragm 10 are arranged in the desired sequence on top of one another and inserted into a tool - in particular, into a mold cavity. Within the scope of these measures - namely, prior to mounting the top layer 15 onto the subjacent base layer 14 of the diaphragm 10 - the support 19 is inserted together with the electric circuit 20.

[0046] In doing so, the support 19 with the electric circuit 20 is produced in advance independently of the diaphragm 10.

[0047] For positioning the layers 14, 15 and the support 19, the openings 17, 24 are used.

[0048] Subsequently, the arrangement of the layers of the diaphragm 10 present in the tool, together with the support 19 contained therein, is vulcanized.

[0049] Of course, other methods for production of the diaphragm 10 are also conceivable.

P a t e n t k r a v

- 5 **1.** Membran (10) til en membranventil, hvor membranen (10) har mindst to lag (14, 15), hvor mindst et af de mindst to lag (14, 15) består af en elastomer, og hvor der mellem de mindst to lag (14, 15) forefindes et elektrisk kredsløb (20), hvor der inde i mindst et af de mindst to lag (14, 15) forefindes et ledende indlæg (26, 28), med hvilken en elektrisk forbindelse af det elektriske kredsløb (20) til eller uden for membranen (10) kan opnås, **kendetegnet ved, at** det elektriske kredsløb (20) har en spiralformet struktur (21) til dannelse af en antenne.
- 10 **2.** Membran (10) ifølge krav 1, hvor det ledende indlæg (26, 28) indeholder ledende partikler, som er indført i materialet af det pågældende lag (14, 16).
- 15 **3.** Membran (10) ifølge krav 2, hvor det pågældende lag (14, 16) på stedet eller i området af det ledende indlæg (26, 28) er beriget med kulstofholdigt materiale.
- 20 **4.** Membran (10) ifølge et af de foregående krav, hvor det ledende indlæg (26, 28) består af mindst en linjeformet ledning (27a, 27b, 27c, 29a, 29b, 29c).
- 5.** Membran (10) ifølge et af de foregående krav, hvor kontakt med det ledende indlæg (26, 28) kan skabes uden for membranen (10).
- 25 **6.** Membran (10) ifølge et af de foregående krav, hvor det elektriske kredsløb (20) forefindes på en bærer (19), og hvor bæreren (19) er anbragt på eller mellem lagene (14, 15).
- 30 **7.** Membran ifølge krav 6, hvor det elektriske kredsløb (20) består af lederbaner og/eller øvrige elektriske strukturer af et elektrisk ledende materiale, hvilke er anbragt på bæreren (19).
- 8.** Membran (10) ifølge et af de foregående krav, hvor membranen (10) er forsynet med øvre og/eller nedre beskyttelseslag.

- 5 **9.** Fremgangsmåde til fremstilling af membranen (10) ifølge et af de foregående krav med de følgende trin: den udvendige kontur af membranen (10) udskæres fra de pågældende materialer af de enkelte lag, de enkelte udskårne lag anbringes oven på hinanden, hvor det elektriske kredsløb (20), inden laget (15) påføres, placeres på membranens (10) lag (14), som ligger derunder, anbringelsen af lagene (14, 15) med det elektriske kredsløb (20), som er anbragt derimellem, vulkaniseres.

Fig. 1

