



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.07.2020 Bulletin 2020/30

(51) Int Cl.:
H01H 50/02 (2006.01)

(21) Application number: **19398002.6**

(22) Date of filing: **18.01.2019**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **ANTI-ICING HOUSING**

(57) The invention relates to an anti-icing housing for an electrical device, such as an electromagnetic relay. In order to improve anti-icing housings, an anti-icing housing according to the invention comprises a flat base adapted to an anti-icing housing (300, 400, 500, 600) for an electrical component, especially a relay comprising a flat base, adapted to accommodate relay components, a cover (310, 410, 510, 610, 710) placed on the flat base, the cover comprising side walls (330, 430, 530, 630) and

a top surface (320, 420, 520, 620) wherein either one of the side walls (330, 430, 530, 630) or the top surface (320, 420, 520, 620) of the cover comprises at least one opening (340, 440, 540) and a porous membrane (350, 450, 550, 650) covering the opening (340, 440, 540) and wherein the porous membrane (350, 450, 550, 650) is fixed to the side walls (330, 430, 530, 630) or top surface (320, 420, 520, 620) of the cover by ultrasonic welding, laser welding or gluing.

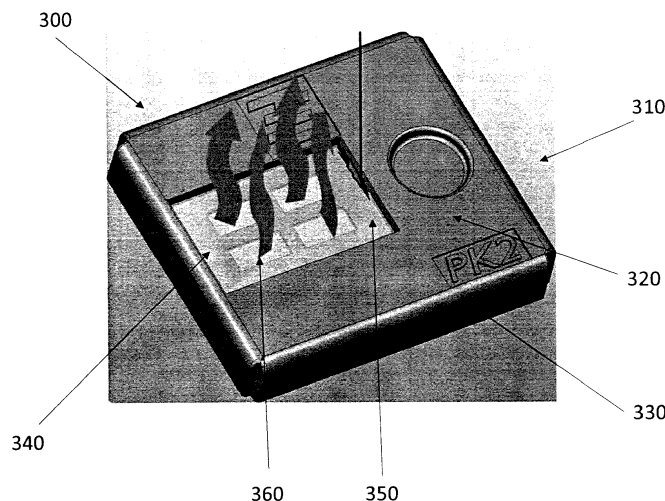


FIG 3

Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to an anti-icing housing for an electrical device, such as an electromagnetic relay.

BACKGROUND OF THE INVENTION

[0002] Sealed housings for protecting the electrical devices components against the penetration of fluids, moisture and/or dew condensate, are used in applications where water condensate and icing is likely to occur. For example, icing inside relays is a problem that may prevents the relay from switching. This can happen when in the electromagnetic relay, some parts, such as the bobbin or other plastic parts, when being heated up release humidity, which condensates on the contacts, as they are having a cold surface. Freezing of the condensate may occur and prevent switching.

[0003] Several components inside a relay tend to absorb some of the surrounding humidity which, when inside the relay, can evaporate and condensate. The coil is one of the biggest contributors for this humidity harvesting and when the core is energized and heated up, most of the coil's water content evaporates within the relay housing and condensates on colder surfaces like the contacts surfaces.

[0004] A common configuration of a conventional relay with a sealed housing is shown in Fig 1. The relay assembly components are accommodated inside the housing 110 from which the electrical terminals 120 of the relay 100 protrude through a flat base 130. The flat base 130 is sealed by mean of a sealing glue 140 that is applied on the components' interfaces of the relay base 130. This configuration of the sealed relay effectively avoids passage of external fluids or moisture to the inside of the relay housing.

[0005] However, this configuration has the disadvantage of not allowing escaping of fluids from inside the relay, so that in case humidity is generated inside the system, for example released from the bobbin, it will also remain trapped in the system, which can lead to defective operation of the relay.

[0006] Fig 2 shows a relay configuration 200, where a vent hole 250 with a minimum diameter of 0.3 mm is incorporated in the housing on the top surface. In this case fluids evaporate, but over a longtime range.

[0007] CN203312222 discloses a vehicle integrated fuse relay integration box comprising a plurality of sealing rings arranged between an upper cover and a bottom cover between which a water proofed main casing is arranged, the bottom cover provided with a structural hole which is covered with a waterproofed gas permeable membrane. The plurality of sealing rings ensures high sealing performances with optimized pressure. However, this solution is quite complex and requires a number of

seals. This housing system requires also many manufacturing steps.

[0008] CN201117572 is directed to a waterproof and breathable structure for electromagnetic relays. The relay housing comprises three holes on the different surfaces, the holes having a specific orientation and communicating with each other. One of the holes is covered by a tape, which prevents water from entering into the housing, except for a special angle. The tape, however is not semipermeable, and the gas generated inside the relay get discharged through one left open hole. Disadvantages of this housing are the complex construction and the fact that the system works efficiently only if certain sizes and specific designs are maintained.

[0009] The first of the above configurations do improve the protection of the components inside the components' box but does not guarantee the protection of the single components within the housing and from conditions developed within the housing. The second of the above configurations does not use membranes therefore it is limited to the dimensions of the structure's channels.

[0010] Accordingly, there is still the need for housings for electrical devices, such as electromagnetic relays, which are secured against the presence of fluids that can condensate and induce icing formation e.g. on the relay terminals components, prevent water droplets into the relay inside while allowing the flow of water vapor and air to flow through, which are cost effective and of easy construction.

SUMMARY OF THE INVENTION

[0011] The object of the present invention is to provide a cost effective vented housing for an electrical device, such as a relay, that effectively protects the electrical device components from fluids inside and outside the housing and that consequently minimizes the risk of defective operation functions, due to electrical isolation caused by condensation of moisture and humidity on the electrical device contacts causing icing. A further object of the present invention is to provide a vented relay using the vented housing. A further object of the invention is to provide a housing incorporating a porous membrane, which will avoid the transfer of liquids and particles while allowing the exchange of water vapor and air.

[0012] These objects are solved by the subject matter of the appended independent claims. Advantageous embodiments of the present invention are the subject matter of the appended dependent claims.

[0013] According to the present invention, it is provided an anti-icing housing for an electrical component, especially a relay comprising a flat base adapted to accommodate relay components and a cover placed on the flat base, the cover comprising side walls and a top surface wherein either at least one of the side walls or the top surface of the cover comprise at least one opening and a porous membrane covering the opening and wherein the porous membrane is fixed to the side walls or top

surface of the cover by ultrasonic welding, laser welding or gluing.

[0014] The housing protects components of the electrical device against the effect of fluids which may condensate on the contacts when humidity is released from inside the relay. The housing of the present invention allows water vapor and air to flow through, while avoiding transfer of liquids and particles.

[0015] When the relay is used and the coil is activated heat is produced, this will generate humidity from relay parts e.g. the bobbin and the pressure and relative humidity inside the relay will change driving the water vapor out through the porous membrane.

[0016] The porous membrane avoids the transfer of liquids and particles from the outside environments into the relay housing, while allowing the water vapor and air to flow through. This has the advantage of avoiding condensation on the contacts and consequent icing.

[0017] According to a further development, the cover comprises more openings in the form of slits. The presence of more slits allows reaching a high venting area which can be easily modified by changing the shape of the slits.

[0018] According to a further development, the porous membrane comprises pores which have a diameter such as to avoid passage of liquids and particles while allowing passage of gases.

[0019] According to a further development, the pores of the porous membrane have a diameter of 16 μm typically. The pores diameter makes the membrane resistant against the passage of particles.

[0020] According to a further development, the porous membrane is made of a material which is chemically inert, UV-resistant, hydrophobic, oleophobic, semipermeable and has low friction.

[0021] According to a further development, the porous membrane is made of a polytetrafluoroethylene.

[0022] According to a further development, the porous membrane has a thickness comprised between 130 μm and 250 μm , preferably 195 μm and the side walls and top surface have a thickness comprised between 450 μm and 650 μm , preferably 550 μm .

[0023] According to a further development, the porous membrane is resistant at temperatures comprised between -40°C and $+160^{\circ}\text{C}$, preferably between -40°C and $+125^{\circ}\text{C}$. This working temperature range allows usage of different methods for joining the membrane to the cover, so that it will be possible to choose also simple manufacturing methods.

[0024] According to a further development, the edges of the at least one opening define a step on which the borders of the porous membrane will be fixed. This will allow obtaining a flat top surface in which the membrane will be integrated.

[0025] According to a further development, the porous membrane is first molded within a frame and then fixed with the frame within the step. Using a frame has the advantage of increasing mechanical stiffness while hav-

ing a system that is easy to assemble as two rigid bodies are going to be joined together. The mechanical stability is assured by reinforcing the membrane with a frame there where the membrane could potentially be weakened because of the treatment for fixing it at the edges of the opening. In an alternative embodiment, the frame is placed on the porous membrane.

[0026] According to a further development, the porous membrane is covered by a sealing plate having a slot. Use of a sealing plate assure very high mechanical stiffness. The cover is also easy to be assembled as two rigid parts, i.e. the plate and the cover are joined together. The plate will protect the membrane and prevent potential damages.

[0027] According to a further development, the opening hosting the membrane is a circular opening and the porous membrane a circular membrane.

[0028] According to a further development, the porous membrane is coated at least on one side, with a hydrophobic coating. The hydrophobic coating will render the membrane resistant to the passage and adherence of liquids. Additionally, the hydrophobic coating will keep the membrane stable also at higher relay working temperatures.

[0029] According to the present invention, it is provided an electromagnetic relay comprising a relay assembly; one or more electrical terminals coupled to the relay assembly and an anti-icing housing according to any of the preceding claims for accommodating the relay assembly.

[0030] The accompanying drawings are incorporated into and form a part of the specification for the purpose of explaining the principles of the invention. The drawings are not to be construed as limiting the invention to only the illustrated and described examples of how the invention can be made and used.

[0031] Further features and advantages will become apparent from the following and more detailed description of the invention as illustrated in the accompanying drawings, in which:

- Fig. 1 illustrates a vented relay housing according to a prior art configuration
- Fig. 2 illustrates a vented relay housing with a vent hole according to a prior art configuration
- Fig. 3 shows one of the configurations of the present relay housing where the membrane is on top of four slits
- Fig. 4 is a perspective view of the vented relay housing section showing the membrane and a frame around the membrane incorporated in the top surface of the cover
- Fig. 5 is a perspective view of the vented relay housing section showing the membrane

and a frame around the membrane incorporated in the top surface of the cover

Fig. 6 is a perspective view of the vented relay housing section showing the membrane covered by a sealing plate

Figs. 7 to 9 show three different perspectives of the relay housing, wherein the opening and the membrane are located on the cover's sidewall

Fig. 10 is a view of the vented relay according to a further embodiment

DETAILED DESCRIPTION OF THE INVENTION

[0032] The present invention will now be more fully described hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The present invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that the disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In particular, although certain features of the exemplary embodiments below will be described using terms such as "top", "bottom", "upper", "outward" and "inward", these terms are used for the sole purpose of facilitating the description of the respective features and their relative orientation and should not be construed as limiting the claimed invention or any of its components to a use in a particular spatial orientation. Like numbers refer to like elements throughout the description.

[0033] Fig. 3 represents a section of the top surface 320 of the cover 310 of the anti-icing housing 300 according to one of the embodiments of the invention. In Fig. 3 the top surface 320 comprises an opening 340 forming a recess further comprising four slits 360. The area is covered by a porous membrane 350. The membrane on top of the slit is fixed by laser welding. It could be also fixed by ultrasonic welding, gluing or with other material joining technologies. The system is easy to assemble and allows reaching a high venting area. Fig. 3 represents only one possible example. A similar design can be obtained placing the slits and porous membrane on the side walls instead than on the top surface of the cover. The membrane can be made of expandable polytetrafluoroethylene (ePTFE) which is a chemically inert material, UV-resistant, hydrophobic, oleophobic and with low friction coefficient. The ePTFE confers the membrane a microporous structure, which makes it suitable for this kind of applications. The porous membrane is a breathable membrane which will indeed allow the flow, as indicated from the arrows, from inside the housing to the outside and vice versa, of the water vapor and air generated inside the housing from the hot relay compo-

nents, such as the bobbin or other plastic parts. Due to the pores dimensions and hydrophobic coating the membrane avoids the passage of particles and liquids and ensures a pressure balance from the outside to the inside of the relay and vice versa. The ePTFE can be used at temperatures between -40°C and +160°C, preferably between -40°C and +125°C.

[0034] In Fig 4 an example according to the invention is shown. In the top surface an opening 440 is given in the form of a recess. The opening could also be in the side walls. The edges of the of the opening 440 or recess define a step 470. The opening can be one bigger opening or consists of smaller openings or slits 460. Before being placed on the opening, the membrane is inserted into a frame 480 which is then placed on the opening and fixed by laser welding, ultrasonic or gluing. When a frame is used, the membrane needs to be over-molded or treated by a similar alternative process to be fixed within the frame.

[0035] The membrane, for example can have a thickness comprised between 130 μm and 250 μm , preferably of about 195 μm and the frame has a U form profile to incorporate the membrane. Those values and geometries are provided as an example and should not be considered as limiting.

[0036] In Fig. 5 another example according to the invention is shown. In the top surface an opening 540 is given in the form of a recess. The opening could also be in the side walls. The edges of the of the opening 540 or recess define a step 570 on which the membrane 550 is placed and vented. The opening can be one bigger opening or consists of smaller openings or slits 560. The membrane, for example can have a thickness comprised between 130 μm and 250 μm , preferably of about 195 μm . The thickness of the top surface and the side walls of the cover is comprised between 450 μm and 650 μm , preferably of about 550 μm , so that when the membrane is inserted in the opening, it will be below the top surface 520 of the cover 510 or side walls 530. The membrane is placed directly on the step and then covered by a frame 580 which, after correct alignment, can be joined together with the membrane to the cover by a gluing component like epoxy resin or by ultrasonic or laser welding treatment. Processes like ultrasonic or laser welding are to be preferred over gluing because processes involving use of glue require extra care due to the flow of glue.

[0037] Fig. 6 shows a further option, in which the membrane 650 placed on the top surface 620 on the one or more openings 660 of the cover 610, is covered by a sealing plate 680 which has a single slit 690. The sealing plate has a U form and is joined at the edges on the step 670 by ultrasonic welding treatment or laser welding or gluing. The sealing plate will assure high mechanical resistance, while decreasing the area of the membrane which is exposed.

[0038] Fig. 7 is a perspective view of the relay anti-icing cover 710 having a circular opening 710 for accommodating the membrane on a cover side wall. In this spe-

cific example the side walls have a thickness of typically 1.6 mm and comprise a step 770 and it is specifically designed for ultrasonic welding processing. The step has a height of typically 350 μm . Fig 8 shows the relay anti-icing cover 810 and opening 840 from the inside.

[0039] Fig. 9 shows the cover 910 with the membrane 920. The housing cover has a circular opening 940 covered by the circular porous membrane 950 incorporated on a side wall.

[0040] Fig. 10 is a perspective view of a vented relay 10 with the anti icing cover viewed from a top side. The housing cover has a circular opening covered by the circular porous membrane 20 incorporated on a side wall.

[0041] The effectiveness and efficiency of anti-icing covers with porous membrane were tested comparing the performances of a relay with anti-icing covers with porous membrane with those of relays having covers with an open vent hole and water tight cover (closed cover, vented vent hole). For this purpose, a very small relay was selected as those are very sensible to the icing matter. The samples were all filled with approximately 5 ml of water and put in an oven at 90°C during 72 h.

[0042] The relays having the anti-icing cover with a porous membrane with a circular venting area of 2 mm in diameter took in average 6.5 h to release the entire water content. Relays with an open vent hole with minimum diameter equal to 0.3 mm took in average 60 hours to release all the water content, while relays with a closed cover did not lose any water even after months of test completion.

[0043] The implementation of a porous membrane clearly improves the vapor transfer across the cover, even though the effective area of the membrane is small. With a membrane circular diameter of ca 2 mm and pores of ca 16 μm , water evaporated about 10 times as fast as when a vent hole with a 0.3 mm diameter was used. The membrane material chosen is ePTFE since it is very stable and chemically inert.

[0044] This test shows the significant difference in performance within the relays with the different covers.

[0045] Additional tests were done with the cover of Fig. 6. The 'icing test' consists on a stepwise change of temperature where, at each temperature step, the switching behavior of the relay was checked.

[0046] The relays were pre-conditioned in a humidity oven with 85% relative humidity and at a temperature of 85°C during a time of minimum of 24 h. In each run the test channels from the measuring system and the position inside the oven were modified to break relation with test channel and position and ensure randomness. After the pre-conditioning step the relays were stored at 23°C $\pm$ 5 for about 4 h. Finally the relays were put at a pre-cooling temperature of 5°C with temperature gradient of approximately 10 K/h. Starting with 5°C the temperature has been decreased stepwise, with steps of 5 °C, down to a final temperature of -40°C. At each step the relay behavior was tested, with a coil voltage of 16 V and a load current of 1 A. The relay needs to switch in less than

1 sec. The coil's voltage, the contacts' voltage drop and the chamber temperature were constantly monitored.

[0047] The samples were put in the humidity oven for 48 h, after this they were soldered to the PCBs and put back in the humidity oven for an additional period of 48 h to ensure saturation.

[0048] Results show that relay with anti-icing covers with porous membrane show a good switching behavior on each step within the whole range of temperature. Good switching behavior means that the relay switched in less than 1 sec.

[0049] Relays having covers with an open vent hole switched in less than 1 sec until a temperature of -20°C. Between -20°C and -30°C some relays failed to switch, some switched within 1 sec. Below a temperature of -20°C, no switching was observed.

[0050] All relays with a water tight cover (closed cover glued to a glass blade) failed to switch at temperatures below -20°C.

[0051] Randomly, some relays had a switching time of over 1 sec.

[0052] All relays without membrane show evidence of failure around -20°C. The formations and distribution of ice in the contacts is random as is, to a certain level, the contact point. The thickness of the icing layers is also not fixed so the observed differences in performance are most likely related to this.

[0053] The membranes are very effective in preventing the isolation due to icing and this is related to their characteristic that allows the gases to easily flow out. Counterpart is that membranes also allows gases to flow in more easily, because of the gradient in pressure between the relays inner and outer atmosphere.

[0054] The membranes used in this study have an operating temperature range of -40°C to +125°C. Some membranes are available to go up to 160°C. Those are in particular the membranes which are coated with PTFE.

[0055] The principles of the present invention can also be advantageously applied to other types of electrical and/or electronic devices which require an efficient protection of the respective electrical terminals against dew condensate, moisture accumulated at the outside surfaces of the electrical devices and/or icing.

Claims

1. An anti-icing housing (300, 400, 500, 600) for an electrical component, especially a relay comprising:

a flat base, adapted to accommodate relay components,
a cover (310, 410, 510, 610, 710) placed on the flat base, the cover comprising side walls (330, 430, 530, 630) and a top surface (320, 420, 520, 620)
wherein
either one of the side walls (330, 430, 530, 630)

- or the top surface (320, 420, 520, 620) of the cover comprises at least one opening (340, 440, 540) and a porous membrane (350, 450, 550, 650) covering the opening (340, 440, 540) and wherein the porous membrane (350, 450, 550, 650) is fixed to the side walls (330, 430, 530, 630) or top surface (320, 420, 520, 620) of the cover by ultrasonic welding, laser welding or gluing.
2. An anti-icing housing according to claim 1, wherein the cover comprises multiple openings and the openings are in the form of slits (360, 460, 560).
 3. An anti-icing housing according to claims 1 or 2, wherein the porous membrane (350, 450, 550, 650) comprises pores which have a diameter such as to avoid passage of liquids and particles while allowing passage of gases.
 4. An anti-icing housing according to claim 3, wherein the pores of the porous membrane (350, 450, 550, 650) have a diameter of 16 μm .
 5. An anti-icing housing according to claims 1 to 4, wherein the porous membrane (350, 450, 550, 650) is made of a material which is chemically inert, UV-resistant, hydrophobic, oleophobic or has low friction.
 6. An anti-icing housing according to claims 1 to 5, wherein the porous membrane (350, 450, 550, 650) is made of a polytetrafluoroethylene.
 7. An anti-icing housing according to claims 1 to 6, wherein the porous membrane (350, 450, 550, 650) has a thickness comprised between 130 μm and 250 μm and the side walls (330, 430, 530, 630) and top surface (320, 420, 520, 620) have a thickness comprised between 450 μm and 650 μm .
 8. An anti-icing housing according to claim 7, wherein the porous membrane (350, 450, 550, 650) has a thickness of 195 μm and the side walls (330, 430, 530, 630) and top surface (320, 420, 520, 620) have a thickness of 550 μm .
 9. An anti-icing housing according to claims 1 to 8, wherein the porous membrane (350, 450, 550, 650) is resistant at temperatures comprised between -40°C and $+160^{\circ}\text{C}$, preferably between -40°C and $+125^{\circ}\text{C}$.
 10. An anti-icing housing according to claims 1 to 9 wherein the edges of the at least one opening define a step (470, 570, 670) on which the borders of the porous membrane (350, 450, 550, 650) will be fixed.
 11. An anti-icing housing according to claim 10, wherein the porous membrane (350, 450, 550, 650) is first molded within a frame (480) and then fixed within the step (470).
 12. An anti-icing housing according to claim 10, wherein a frame (580) is placed on the porous membrane (350, 450, 550, 650).
 13. An anti-icing housing according to claims 1 to 10, wherein the porous membrane (350, 450, 550, 650) is covered by a sealing plate (680) comprising a slot.
 14. An anti-icing housing according to claims 1 to 13, wherein the opening is a circular opening (740, 810) and the porous membrane a circular membrane (920).
 15. An anti-icing housing according to claims 1 to 14, wherein the porous membrane (350, 450, 550, 650) is coated on at least one side with a hydrophobic coating.
 16. An electromagnetic relay comprising a relay assembly; one or more electrical terminals coupled to the relay assembly and an anti-icing housing (300, 400, 500, 600) according to any of the preceding claims for accommodating the relay assembly.

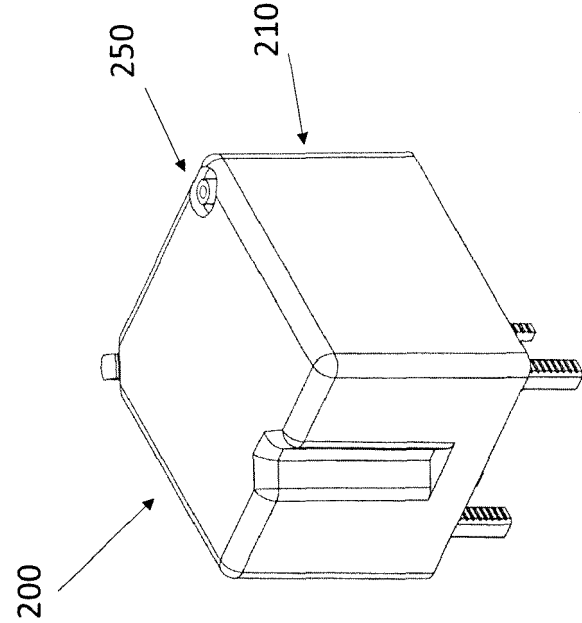


FIG 2

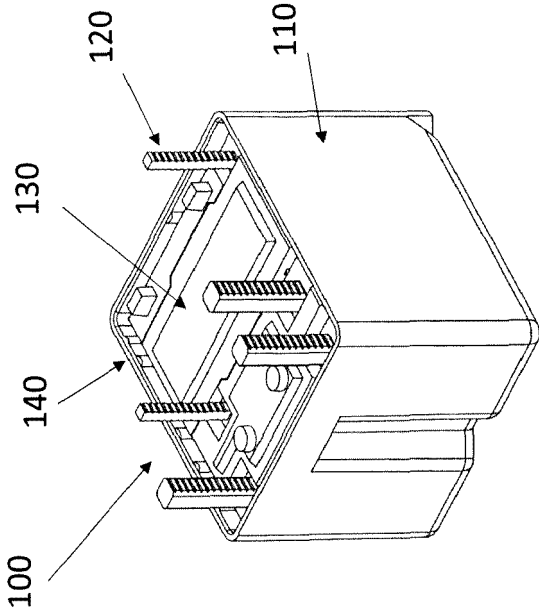


FIG 1

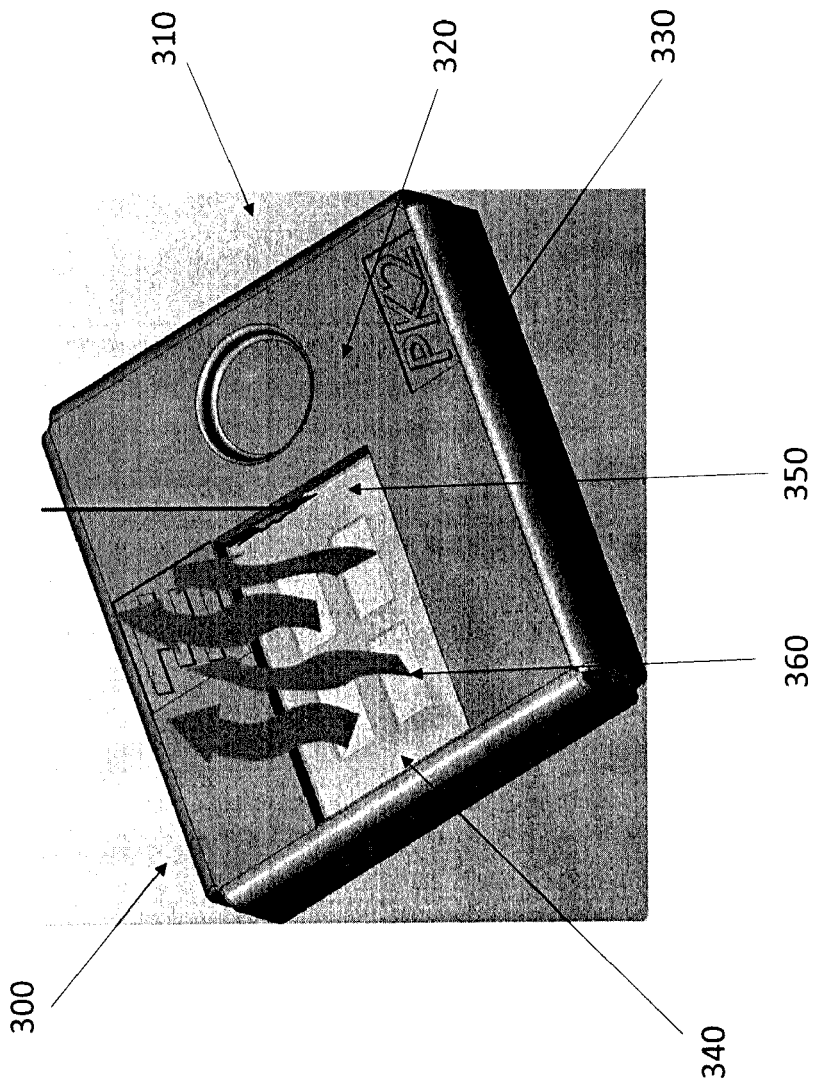


FIG 3

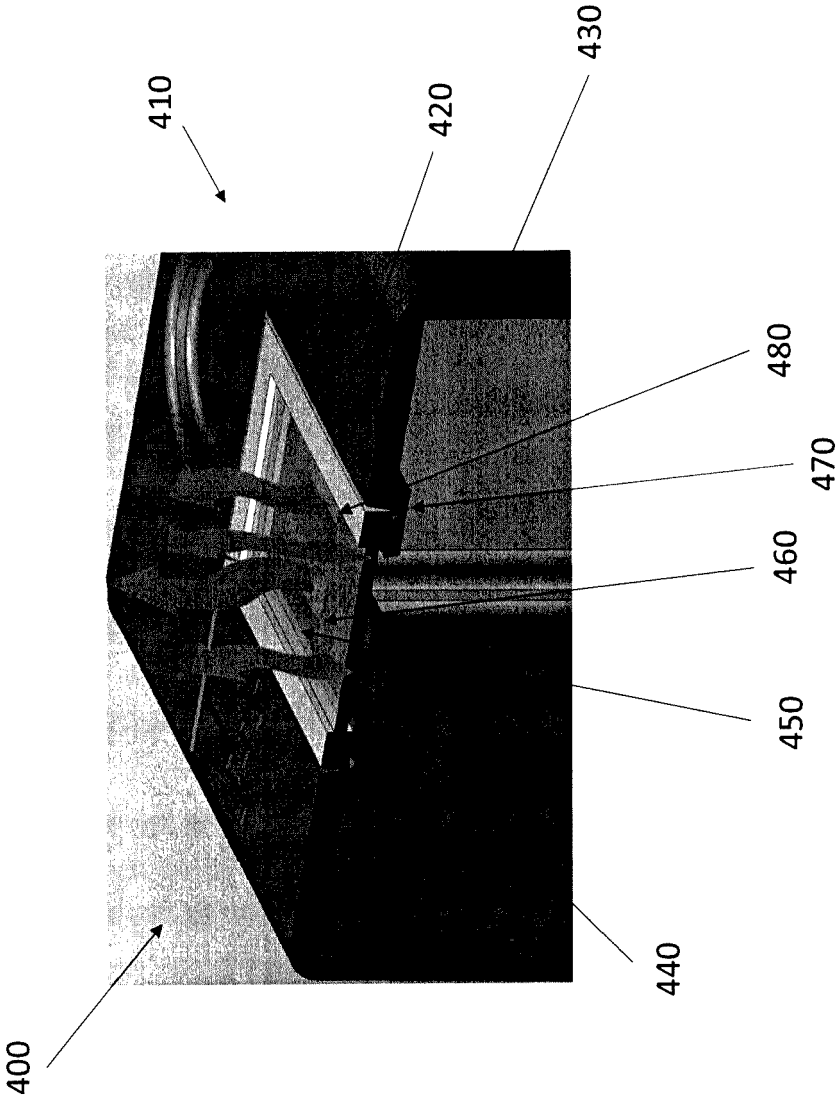


FIG 4

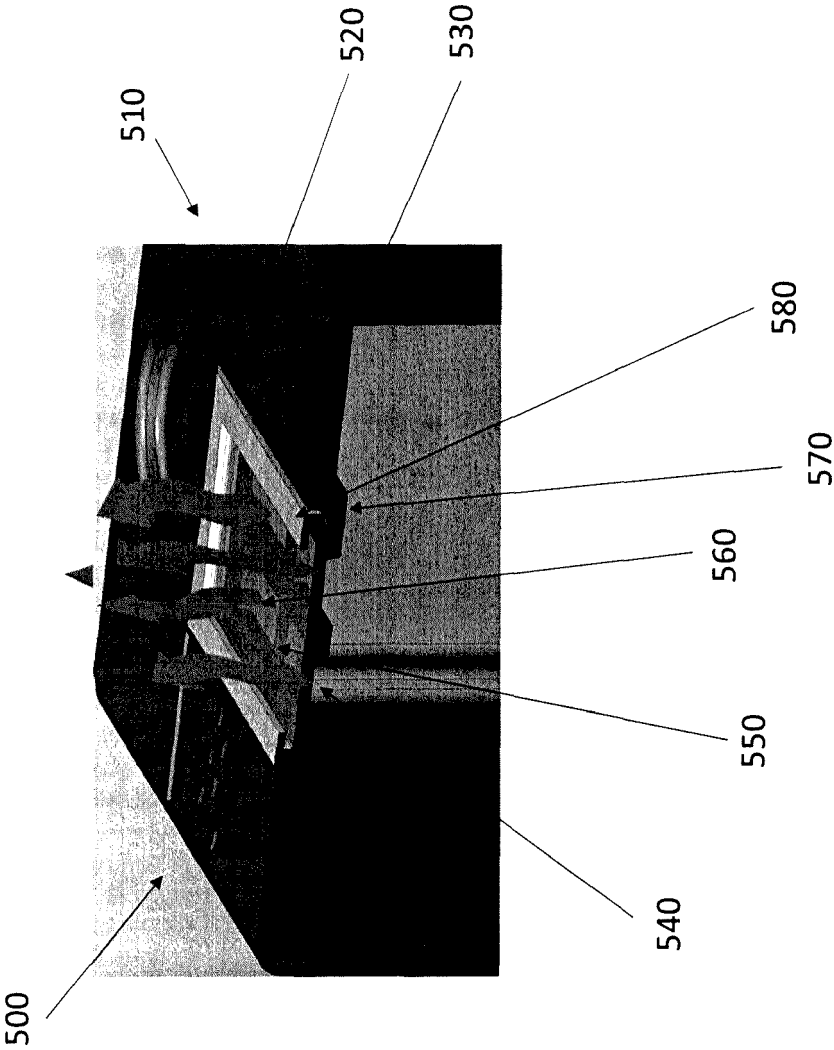


FIG 5

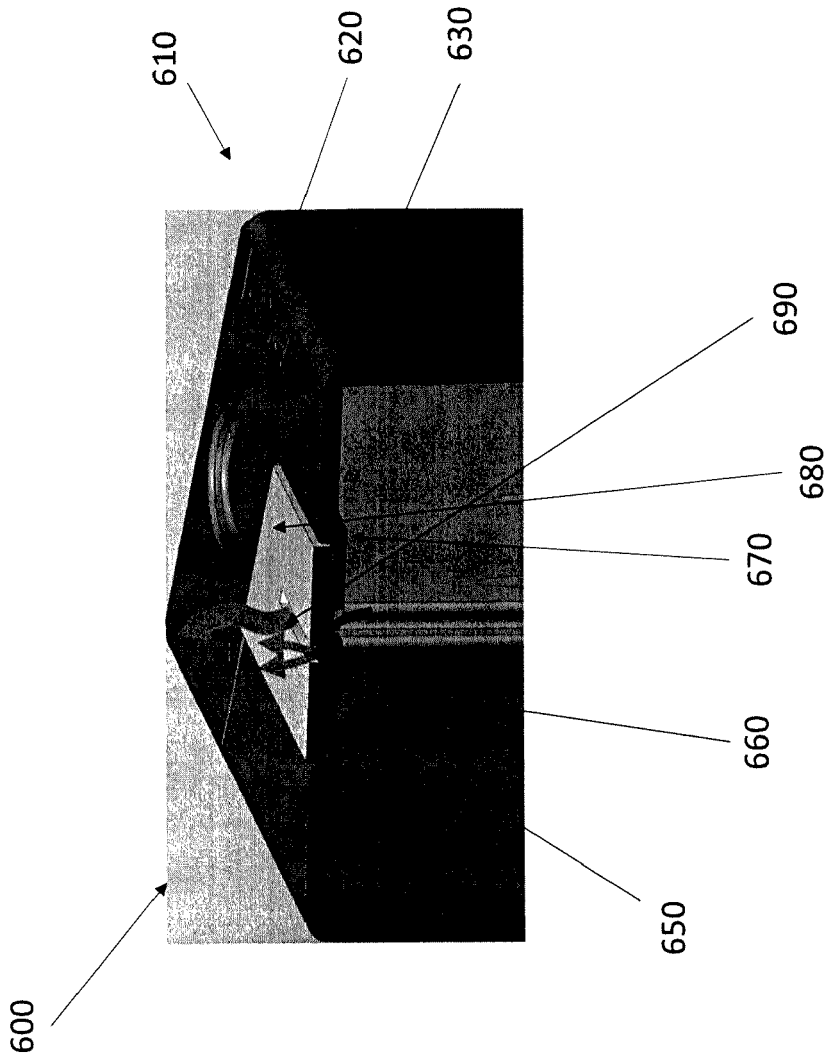


FIG 6

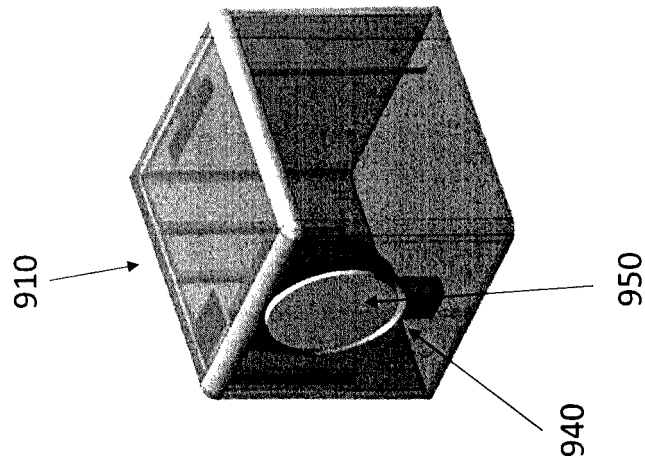


FIG 9

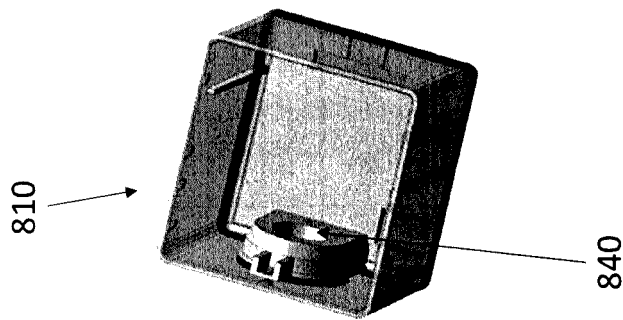


FIG 8

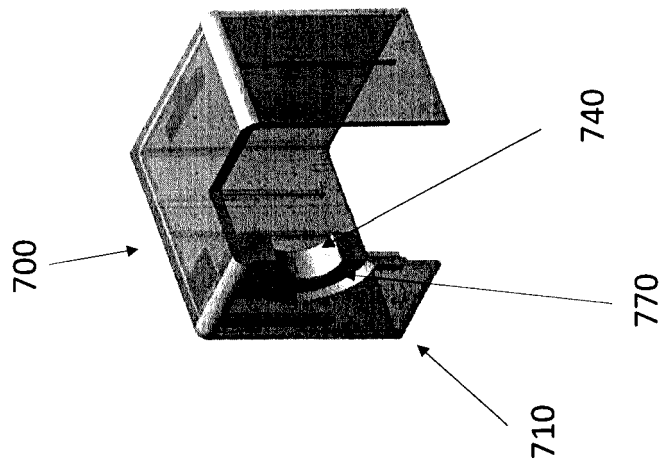


FIG 7

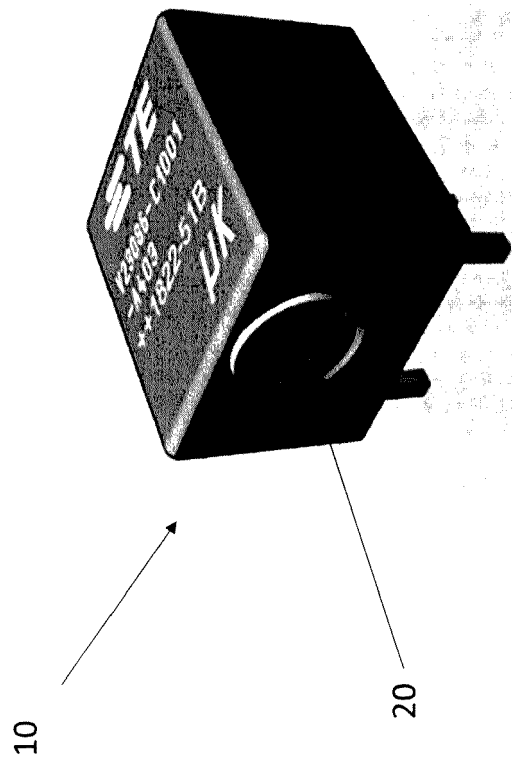


FIG 10



EUROPEAN SEARCH REPORT

Application Number
EP 19 39 8002

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 24 June 2019	Examiner Simonini, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 39 8002

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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