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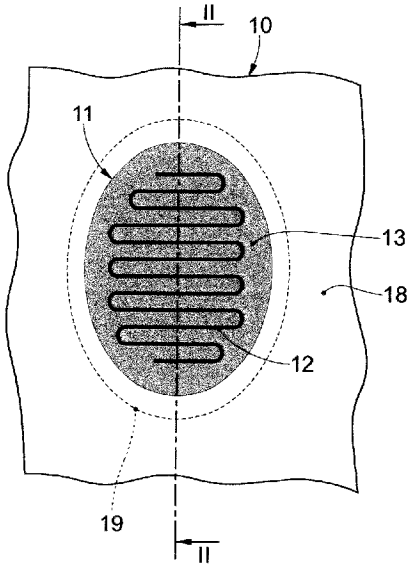

fig. 1

(57) Abstract: Capacitive sensor, comprising: a pad (1 1) made of an elastomeric insulating material, in which a least one central part (15) and at least one peripheral part (16) are provided; an antenna (12) made of an electrically conductive material housed at least inside the internal part (15) of the pad (1 1); and at least a resistor (21) connected to the antenna (12); at least the central part (15) is provided with an interaction area (13) above the antenna (12) and the peripheral part (16) is connectable, during use and by means of suitable joining elements (19), with a part (18) of an object or article (17) to which the capacitive sensor is applied.

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"CAPACITIVE SENSOR AND METHOD TO PRODUCE SAID CAPACITIVE SENSOR"

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FIELD OF THE INVENTION

The present invention concerns a capacitive sensor and a method to produce a capacitive sensor.

Possible applications of the present capacitive sensor can be, for example, articles or objects, in particular soft objects and/or made of fabric, such as toys, stuffed animals, chairs, beds, technological sofas, furniture, furnishing objects in general, sports objects, internal elements of motor vehicles, or others, therefore in general articles or objects used in fields where there is a need to detect the touch or movements of a user on or near a particular object.

The following description will focus in particular on the application of the present capacitive sensor to the world of toys, but it is obvious that the advantages obtainable from the invention can be found also in different fields of application.

BACKGROUND OF THE INVENTION

As is known, capacitive sensors are sensors sensitive to the touch and proximity of a conductive entity, for example a person or an animal, and are generally made by at least one dielectric insulating material and at least one conductive material. Examples of known capacitive sensors are described, for example, in document DE-A-102008050897 and in the publication "A Multifunctional Capacitive Sensor for Stretchable Electronic Skins", by Darryl PJ Cotton et al., IEEE Sensors Journal, IEEE Service Center, New York, NY, US, vol. 9, no. 12, 01-12-2009, pages 2008-2009.

When a person comes into contact with the insulating material, or arrives near it, a variation of the electromagnetic field is set, such as to allow the conductive material to detect this variation. The variation in the electromagnetic field can then be transmitted to a microcontroller, microprocessor or suchlike.

Known capacitive sensors, especially in the world of toys, have different functional limits, since they are point sensors, with a sensitive area reduced to the minimum due to requirements of cost and production, which have difficulty in providing a uniform detection on a surface or wider area, so they require

proximity or touch in a precise position.

Consequently, known capacitive sensors do not allow, particularly in the field of toys, to detect or monitor, in an effective way for the usability of the product, a movement or approach with respect to a particular area of an object to which the capacitive sensor is applied.

These disadvantages are further accentuated when one considers the use of traditional capacitive sensors, but also for other types of widely used sensors, in the world of toys.

For example, if we consider a soft object, such as a stuffed animal or suchlike, at present the user's interaction with this object is generally carried out by means of different components, such as, precisely, capacitive sensors, for example metal foils, but also buttons, mechanical switches or others.

All these components, however, need to be hidden under the surface of the object in which they are used, if we think for example of stuffed animals or similar soft toys, also for obvious limits of aesthetics, functionality and durability.

Buttons and switches, generally known as buttons, are very common in toys and allow a Boolean-type, that is, on-off, interaction, where a point pressure must be applied to a lever or slider. Since they are hidden, these interaction elements must be found and identified by the user in the object, to allow to use the product consistent with the expectations and requirements of the user. In most cases, embroidery is used on the fabric to indicate the zones where the functions can be activated, or, more economically, stickers or tags are affixed to the toy: these indications are temporary, and the usability of the product is linked to the personal memory of the user.

On the contrary, capacitive sensors with a metal foil are often inserted into the object, for example a toy, in contact with a rigid part, hidden from view and direct touch, which, in addition to influencing the functioning of the sensor, could also lead to premature oxidation and, in some cases, breakage of the metal foil, with all the problems that can derive from it.

The need for a rigid application surface limits their application to specific categories of objects, for example to rigid toys, as they are difficult to apply to soft structures or objects, such as stuffed toys for example.

Other types of technologies that would theoretically be applicable to detect the interaction of a user with similar types of interaction with an object could be touch-screen technologies, but these technologies are generally equipped with rather complex hardware components, they are expensive, generally fragile and not very resistant and therefore difficult to use, in the fields of application for which the invention has been conceived. Moreover, touch-screen technologies are generally negatively affected by temperature changes and by the action of external agents such as for example liquids, dust, food, residues of any kind, and also do not function in the presence of insulating objects between the system and the person, for example when using gloves.

Other limitations and disadvantages of conventional solutions and technologies will be clear to a person of skill after reading the remaining part of the present description with reference to the drawings and the description of the embodiments that follow, although it is clear that the description of the state of the art connected to the present description must not be considered an admission that what is described here is already known from the state of the prior art.

There is therefore a need to perfect an effective, resistant, economical and aesthetically pleasing capacitive sensor which can overcome at least one of the disadvantages of the state of the art.

One purpose of the present invention is to provide an effective capacitive sensor, provided with elasticity and suitable to be applied without limitation also on the external surface of an object, itself possibly becoming part of the visible surface of the object, thus presenting also considerable aesthetic as well as functional characteristics.

Another purpose of the present invention is to provide a capacitive sensor able to detect the interaction of a user on the whole of its surface, regardless of positioning, which is therefore able to monitor or detect even a single touch or approach in a certain area, which is therefore also able to guarantee an improved dynamism in the interaction with the user, since it does not advantageously present itself as a point sensor of the traditional type.

Another purpose of the present invention is to provide a capacitive sensor that is able to perceive in a univocal and precise way that the user has released his/her touch, generating a clean and net signal.

Another purpose of the present invention is to provide an effective and optimal method to produce a capacitive sensor which does not need to be hidden, which has considerable functional and aesthetic characteristics and which can guarantee a simple and effective interaction with the object on which it is applied.

The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

In accordance with the above purposes, one object of the present invention is a capacitive sensor, comprising: a pad made of an elastomeric insulating material, in which a least one central part and at least one peripheral part are provided; an antenna made of an electrically conductive material housed at least inside the internal part of the pad; and at least a resistor connected to the antenna; at least the central part is provided with an interaction area above the antenna and the peripheral part is connectable, during use and by means of suitable joining elements, with a part of an object or article to which the capacitive sensor is applied. The pad also comprises a series of holes so as to be able to be joined, during use and by means of at least a seam, to a flap of fabric of an object or article to which the capacitive sensor is applied.

The series of holes is preferably made on the peripheral part of the pad but it could also be made in another position, for example on the central part of the pad.

The elastomeric insulating material of the pad can be chosen from a group comprising polyurethane resins, polyurethane foams, natural latex, silicones, such as silicones for polyaddition or silicones for condensation or suchlike.

The elastomeric insulating material with which the pad is made can also be transparent.

Advantageously, the transparent elastomeric insulating material with which the pad is made can be silicone rubber.

The interaction area can have a rounded shape.

Moreover, behind the capacitive sensor a light source can be positioned, in

particular in a zone under the pad and the antenna.

The antenna can be connected in series to the resistor, which can be connected electrically to at least a microcontroller.

The present invention also concerns a method to produce a capacitive sensor comprising: at least a step of preparing a mold; at least a step of positioning in the mold at least one antenna of the capacitive sensor, the heads of which are left protruding from the mold; a step of casting in the mold an elastomeric insulating material so as to produce the pad, a step of hardening the elastomeric material and extracting the pad from the mold and a step of applying a resistor to the heads of the antenna.

The present invention also concerns an article able to detect the nearness and/or the touch of an electrically conductive entity, such as a person, an animal, an object or other, comprising at least one part made of soft material to which, by means of suitable joining elements, at least a capacitive sensor is connected. The article is advantageously able to detect the pressure on the capacitive sensor, different from a normal touch on the article.

These and other aspects, characteristics and advantages of the present disclosure will be better understood with reference to the following description, drawings and attached claims. The drawings, which are integrated and form part of the present description, show some forms of embodiment of the present invention, and together with the description, are intended to describe the principles of the disclosure.

The various aspects and characteristics described in the present description can be applied individually where possible. These individual aspects, for example aspects and characteristics described in the attached dependent claims, can be the object of divisional applications.

It is understood that any aspect or characteristic that is discovered, during the patenting process, to be already known, shall not be claimed and shall be the object of a disclaimer.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other characteristics of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a schematic plan view of a capacitive sensor according to the present invention;
- fig. 2 is a view of the present capacitive sensor along the section line II-II in fig. 1;
- fig. 3 is a diagram of a possible functioning electric circuit of the present capacitive sensor;
- fig. 4 is a front view of an object to which several capacitive sensors are applied according to the present invention;
- fig. 5 is a lateral view of the object in fig. 4.

To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can conveniently be incorporated into other embodiments without further clarifications.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

We will now refer in detail to the various embodiments of the present invention, of which one or more examples are shown in the attached drawings. Each example is supplied by way of illustration of the invention and shall not be understood as a limitation thereof. For example, the characteristics shown or described insomuch as they are part of one embodiment can be adopted on, or in association with, other embodiments to produce another embodiment. It is understood that the present invention shall include all such modifications and variants.

Before describing these embodiments, we must also clarify that the present description is not limited in its application to details of the construction and disposition of the components as described in the following description using the attached drawings. The present description can provide other embodiments and can be obtained or executed in various other ways. We must also clarify that the phraseology and terminology used here is for the purposes of description only, and cannot be considered as limitative.

Fig. 1 shows a plan view of a capacitive sensor 10 according to the present invention, comprising a pad 11 made of an elastomeric insulating material.

The elastomeric material can be selected, for example, from the group of polyurethane resins, polyurethane foams, natural latex, silicones, such as

silicones for polyaddition or silicones for condensation, or suchlike.

Silicone rubber has proved particularly effective as a material with which to make the pad 11. Silicone rubber, in fact, is a neutral material, guarantees mechanical resistance and is difficult to break, cut and generally deteriorate. In the world of toys, in particular, the use of silicone rubber for making the pad 11 is particularly advantageous, for example from the point of view of safety, resistance and practicality.

Inside the pad 11 made of an elastomeric insulating material an antenna 12 is housed, made of an electrically conductive material.

The antenna 12 can be, for example, a wire of suitably shaped conductive material, for example with a sinuous shape as shown in fig. 1, or suchlike.

Alternatively, the antenna 12 could be made in the form of a net, grid or suchlike.

The antenna 12, therefore, can comprise at least one metallic component, which can be made of copper, tinned copper or suchlike.

The pad 11 substantially defines an interaction surface or area 13, unlike normal capacitive sensors which are substantially point sensors.

The antenna 12 is disposed in the pad 11 so as to guarantee an effective interaction by the user over the whole interaction area 13.

The interaction area 13 can have a rounded shape, so as to guarantee better usability and use of the capacitive sensor 10.

The pad 11 could be made of transparent material, for example silicone rubber as above of the translucent type, therefore, in this case, it would be possible to put a light source behind the pad 11, such as a screen 14, lights 26, such as LED lights or suchlike, or other.

The pad 11 can therefore be made of translucent material to obtain this backlighting characteristic, but it could also be opaque or contain colors with reversible or irreversible color variation, such as for example thermochromic, photochromic, hydrochromic or other materials.

Therefore, below the interaction area 13, the pad 11 is equipped with a central part 15 with a certain thickness, since the antenna 12 is housed in the central part 15.

The pad 11 of the capacitive sensor 10 comprises a peripheral part 16 suitable

to be attached to an article or object 17 to which the capacitive sensor 10 is to be applied.

The article or object 17 is able to detect the proximity and/or the touch of a conductive entity, such as an object, a person, an animal or other.

The object 17 can be for example a soft toy, for example a stuffed animal or suchlike, as shown in figs. 4 and 5, and the peripheral part 16 can be attached to a part 18 of the object by at least one seam 19, made for example using a thread.

The part 18 can be a strip of fabric, or other soft material, for example rubber or other, depending, for example, on the material of which the object 17 is made.

The peripheral part 16 of the pad 11 is preferably annular and the seam is preferably made along the entire extension of the peripheral part 16.

To this end, in the peripheral part 16, holes 25 can be made which facilitate the insertion of at least one thread, without needing to perforate the peripheral part 16.

The holes 25 can be made equidistant on the peripheral part 16 of the pad 11.

The holes 25 could however be made in another suitable position of the pad 11, for example in the central part 15, or both in the central part 15 and in the peripheral part 16, or elsewhere.

It is evident that the thread represents one of the multiple joining means or elements with which it is possible to connect the peripheral part 16 of the present capacitive sensor 10, 10', 10" with the part 18, or other part of an object to which the capacitive sensor 10, 10', 10" can be applied.

The peripheral part 16 is positioned below the part 18 to which it is attached, and therefore only the interaction area 13 of the object 17 is substantially visible.

The elastomeric sensor 10, 10', 10" as seen in figs. 4 and 5 advantageously lends itself to having various shapes, sizes and positions in the object to which it is applied, for example the object 17 shown.

The sizes of the central part 15 of the pad 11 can be made according to the most suitable shapes and sizes, see for example the elastomeric sensors 10' positioned on the head of the object 17.

As can be seen, the elastomeric sensors 10, 10', 10" are left outside the object 17, so they do not need to be hidden under the surface 24 of the object 17, but on the contrary can form an integral part thereof.

In the electric circuit 20 of fig. 3 the antenna 12 is shown, in series to which a resistor 21 is put.

The antenna 12, through the resistor 21, is connected to a microcontroller 22, so as to make it possible to process the signals received through a relative firmware, belonging to the object to which the capacitive sensor 10, 10', 10" is applied.

The microcontroller 22 can order light sources to be switched on, such as the screen 14, the lights 26, or other, and/or can order a sound source 23 to be switched on, to emit sounds, words, music or suchlike, or still other.

The capacitive sensor 10, 10', 10" is also able to provide an electric signal usable by the microcontroller 22 which can interpret and indicate, according to the rules imposed by the firmware, when and how the user interacts with the interaction area 13, for example by proximity, or by a gesture of contact with the hand or a gesture withdrawing the hand.

This mode of interaction with an interaction area 13, and therefore not with a point or an area that is too localized, allows great dynamism and variability of input, such as for example for the object 17, without the constraint of mechanical buttons, keys or other.

Inside the pad 11, the antenna 12 generates an electromagnetic field in its immediate vicinity: the electromagnetic field preferably has a limited amplitude, since both the voltage and the current applied are low, for example about 5V and about 20mA.

The pad 11 substantially acts as an amplifier of the electromagnetic field, allowing a better detection thereof.

From a functional point of view, when a user, or other conductive entity, for example an animal, an object or other, interacts with the electromagnetic field emitted by the antenna 12, a variation in the magnetic field is produced which entails an inversion of current inside the antenna 12, for example with a specific time frame, which is a function of parameters such as the type of resistor 21 applied, the diameter of the conductive wire, the interaction area, the voltage, the current or others. With these parameters it is therefore possible to interpret the user's gestures by analyzing the signal received by the microcontroller 22.

The present capacitive sensor 10, 10', 10" is therefore advantageously able to

detect the interaction of the user, or other conductive entity, on an interaction area or surface 13, which, as can be seen, can be of any size, shape and location, regardless of the position.

The capacitive sensor 10, 10', 10" does not need to be hidden in the object 17 to which it is applied, on the contrary, since it is pleasing to look at and absolutely safe, it can be left on the surface 24 of the object 17 or form an integral part thereof.

From the tests and trials carried out, it has emerged that the present capacitive sensor 10, 10', 10" is advantageously able to perceive in a univocal and precise manner the release of the touch, generating a clean and clear signal.

This characteristic, that is, the clear perception of the signal that touch has been released, is further optimized if the pad 11 is made of silicone rubber, in particular silicone rubber for polyaddition.

The present capacitive sensor 10, 10', 10", for example with a pad 11 made of silicone rubber and antenna 12 incorporated in the pad 11, can be made as follows.

In a first production step a mold is developed, using, for example, a CAD digital model through a 3D printing process.

The mold can be made of polymer, for example polylactic acid PLA, with 3D printing of the FDM (Fused deposition modeling) type, according to a pre-determined design of a template.

On the peripheral part 16 of the pad 11, the holes 25 will then be made which facilitate the insertion of the thread and therefore the joining with the part 18, in this case a strip of fabric.

The mold allows to cast the silicone rubber precisely and always in the same way; however, for the insertion of the antenna 12 into the central part 15 of the pad 11, it may be necessary to have recourse to a template provided with very thin pins which has been made so as to position the antenna 12, immersed in the silicone rubber, according to a design that allows the most uniform distribution possible of the antenna 12, as shown for example in fig. 1, fig. 4 or fig. 5.

The template can also be made of polymer PLA, with FDM 3D printing technology, and can be removed once the production of the pad 11 with the antenna 12 has been completed.

Therefore, in the event of production of a capacitive sensor with antenna 12 incorporated in the pad 11, a step to prepare the elastomeric material is first carried out, for example silicone rubber for polyaddition and a suitable catalyst, thickener or suchlike for silicone rubbers.

The elastomeric material is cast inside the mold where the antenna 12 of conductive material has already been disposed, for example a suitably shaped copper wire, as for example in fig. 1.

The ends of the copper wire are left protruding from the mold. As we said above, if necessary, it will be possible to use a suitable template with pins to be introduced into the mold to facilitate the disposition of the metal wire in the mold.

The copper wire is then disposed inside the mold at a certain height inside the cavity of the mold, so that, in the end, it is located in the central part 15 of the pad 11, as for example in fig. 2.

We then wait until catalysis is complete and therefore the elastomeric material hardens inside the mold. If the template with pins is used, the template is extracted from the mold.

When hardening and catalysis is complete, the pad 11 is extracted from the mold and has incorporated the antenna 12 formed for example by the copper wire with ends protruding from the pad 11.

The pad 11 will also comprise the peripheral part 16, by means of which it can be connected, for example, to the part 18, by means of, for example, the thread, if the part 18 is a strip of fabric.

The resistor 21 is applied to one of the ends or heads of the copper wire. Subsequently, small insulated copper cables are applied, or other conductive elements, at the end of the resistor and of the copper wire without resistor. These small copper cables, or other conductive elements, serve to use the pad with the microcontroller 22.

As stated in the description, the result obtained is a capacitive sensor 10, 10', 10" with obvious functional advantages, also aesthetically pleasing as is usual, in particular, in the world of toys.

The antenna 12 is visible, since it is not hidden but preferably central to the pad 11, so as to define a large interaction area 13.

The pad 11 can also be advantageously transparent so as to possess excellent qualities of translucency for possible backlighting, see for example the light sources 14, 26.

The capacitive sensor 10, 10', 10" can also be equipped with different types of resistors 21, having different firmware configurations.

The present capacitive sensor 10, 10' and 10" therefore allows interaction in central zones of the pad 11, in particular on an interaction area 13, on which it is possible to monitor the touch and/or proximity of the user.

The present capacitive sensor also allows to perceive in a univocal and precise manner when the touch is released, with a peak of values that can be clearly highlighted with the firmware. Normal capacitive sensors are able to monitor the proximity or approach, while the pad generated here is able to monitor the touch and/or proximity on an interaction area and in particular the gesture of release.

It is clear that modifications and/or additions of parts can be made to the capacitive sensor and corresponding production method as described heretofore, without departing from the field and scope of the present invention.

It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve many other equivalent forms of capacitive sensor, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

In the following claims, the sole purpose of the references in brackets is to facilitate reading: they must not be considered as restrictive factors with regard to the field of protection claimed in the specific claims.

CLAIMS

1. Capacitive sensor, comprising: a pad (11) made of an elastomeric insulating material, in which a least one central part (15) and at least one peripheral part (16) are provided; an antenna (12) made of an electrically conductive material housed at least inside said internal part (15) of the pad (11); and at least a resistor (21) connected to said antenna (12); at least said central part (15) being provided with an interaction area (13) above the antenna (12) and said peripheral part (16) being connectable, during use and by means of suitable joining elements (19), with a part (18) of an object or article (17) to which the capacitive sensor is applied, **characterized in that** said pad (11) comprises a series of holes (25) so as to be able to be joined, during use and by means of at least a seam (19), to a flap (18) of fabric of an object or article (17) to which the capacitive sensor is applied

2. Capacitive sensor as in claim 1, **characterized in that** said series of holes (25) is made on said peripheral part (16) of the pad (11).

3. Capacitive sensor as in claim 1 or 2, **characterized in that** said elastomeric insulating material of the pad (11) is chosen from a group comprising polyurethane resins, polyurethane foams, natural latex, silicones, such as silicones for polyaddition or silicones for condensation or suchlike.

4. Capacitive sensor as in claim 3, **characterized in that** said elastomeric insulating material with which the pad (11) is made is transparent.

5. Capacitive sensor as in claim 4, **characterized in that** said transparent elastomeric insulating material with which the pad (11) is made is silicone rubber.

6. Capacitive sensor as in any claim hereinbefore, **characterized in that** said interaction area (13) has a rounded shape.

7. Capacitive sensor as in any claim hereinbefore, **characterized in that** it comprises at least a light source (14, 26) positioned in a zone under said pad (11) and said antenna (12).

8. Capacitive sensor as in any claim hereinbefore, **characterized in that** said antenna (12) is connected in series to said resistor (21), which is connected electrically to at least a microcontroller (22), microprocessor or suchlike.

9. Method to produce a capacitive sensor as in any of the claims from 1 to 8,

characterized in that it comprises: at least a step of preparing a mold; at least a step of positioning in the mold at least one antenna (12) of the capacitive sensor, the heads of which are left protruding from the mold; a step of casting in the mold an elastomeric insulating material so as to produce the pad (11), a step of hardening the elastomeric material and extracting the pad (11) from the mold and a step of applying a resistor (21) to the heads of the antenna (12).

10. Article able to detect the nearness and/or the touch of an electrically conductive entity, such as a person, an animal, an object or other, **characterized in that** it comprises at least one part (18) made of soft material to which, by means of suitable joining elements (19), at least a capacitive sensor (10, 10', 10'') as in any of the claims from 1 to 8 is connected.

1/2

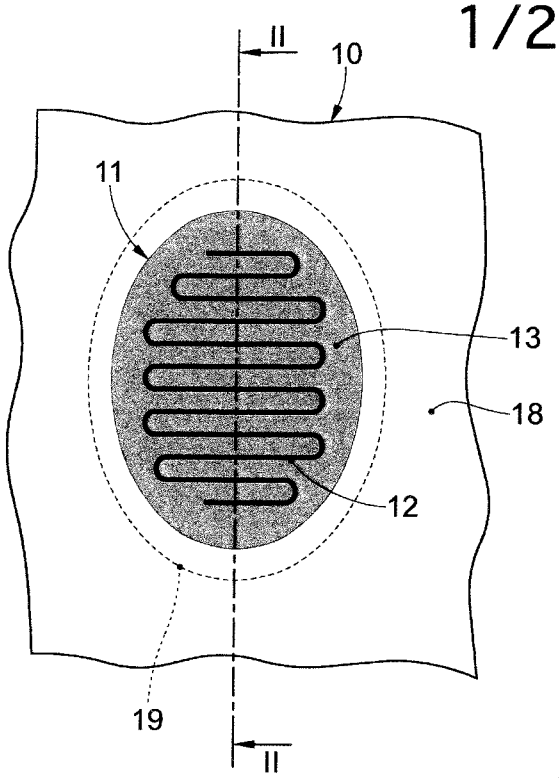

fig. 1

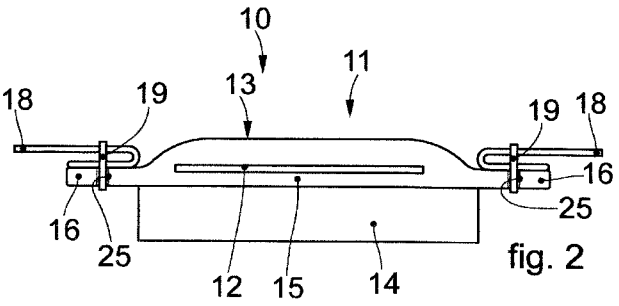

fig. 2

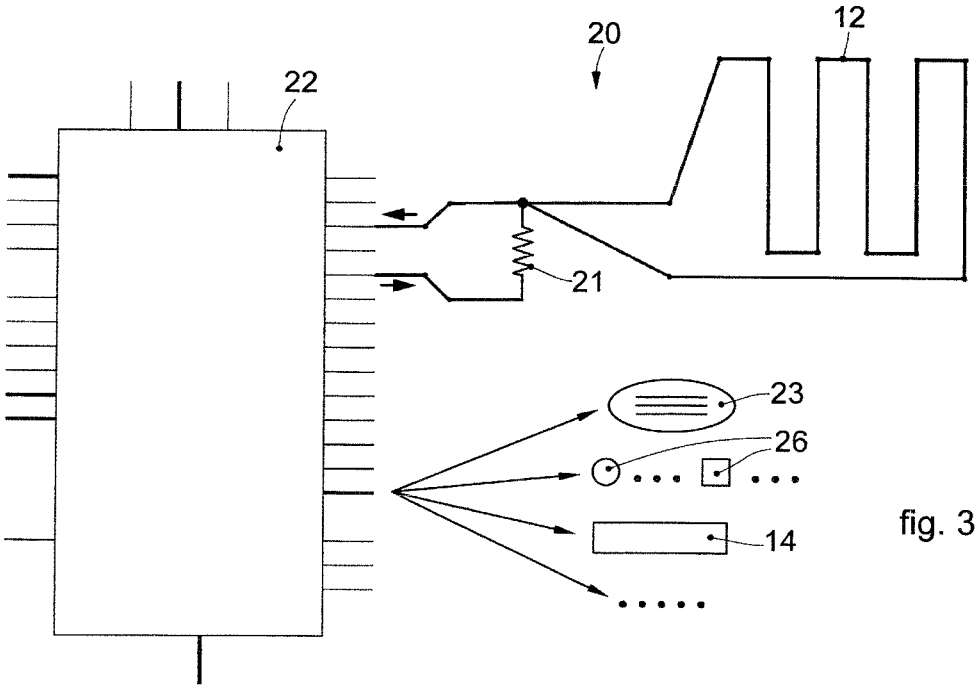

fig. 3

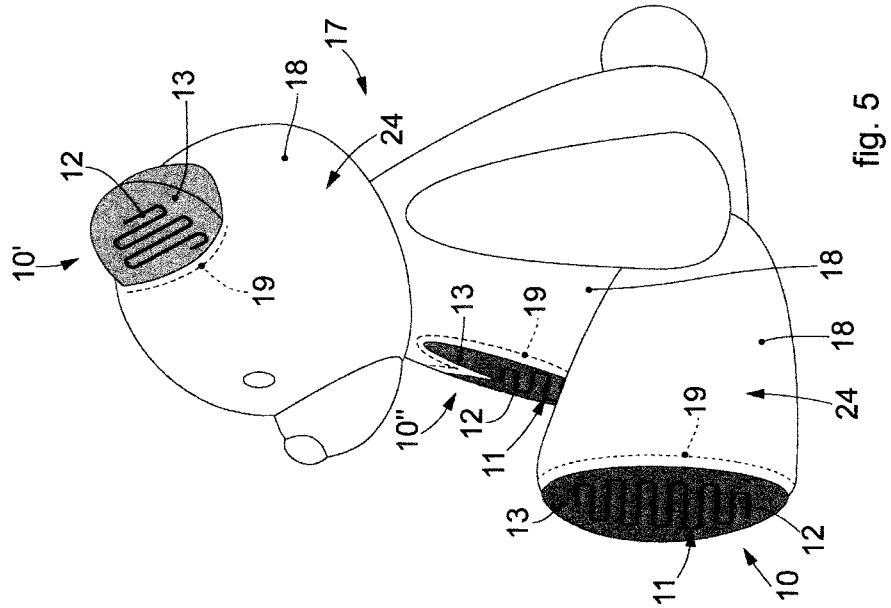

fig. 5

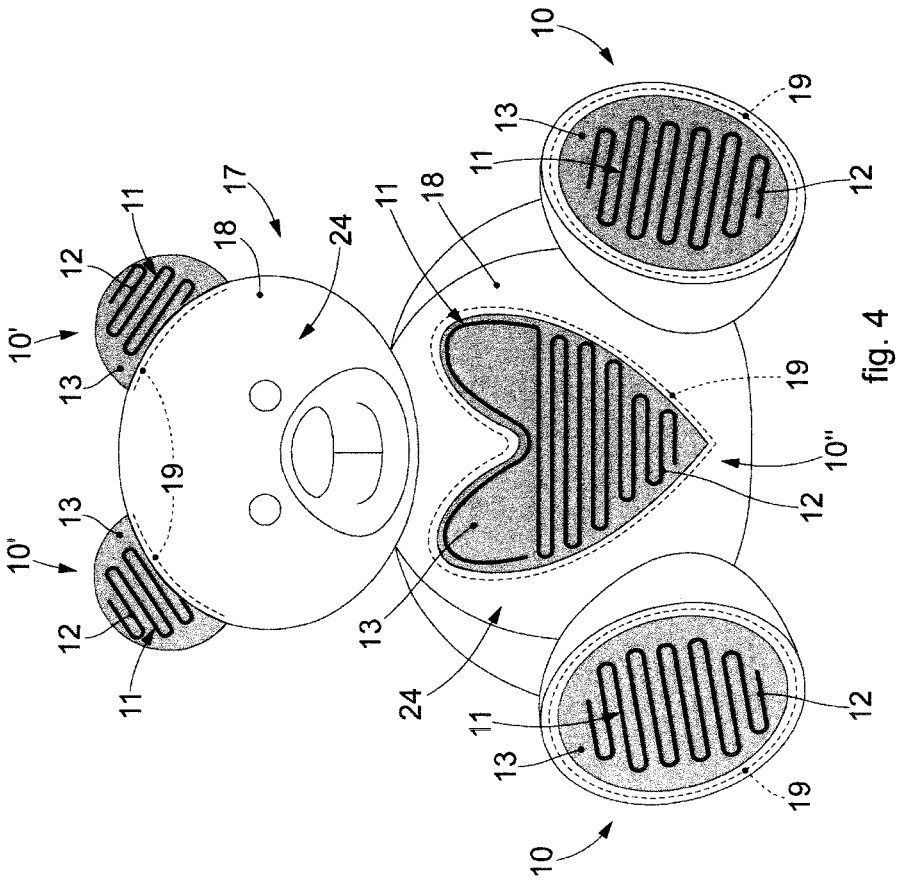

fig. 4