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(54) Title: DIGITAL PRESSURE SENSOR FOR AN ELECTRICAL APPLIANCE, CALIBRATION METHOD, AND ELECTRICAL APPLIANCE PROVIDED WITH SAID DIGITAL PRESSURE SENSOR

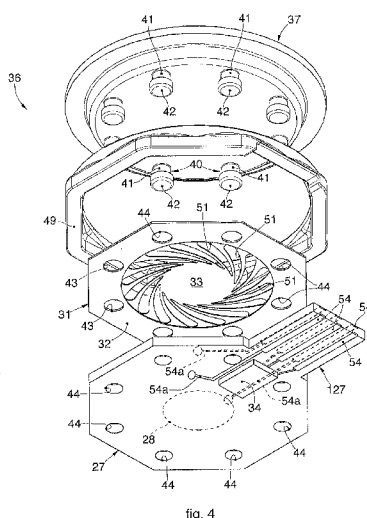


fig. 4

(57) Abstract: A digital pressure sensor of the capacitive type comprises at least a pressure detector unit (36) to detect at least a pressure in an electrical appliance (1). The pressure detector unit (36) comprises at least a conductive plate (28) of a printed circuit (27) and a conductive membrane (31) disposed parallel and distanced with respect to each other to define a capacitor with variable capacity due to the effect of said pressure, and pressure measuring means (34) configured to detect variations in capacity and to generate a signal relating to the variations detected. The printed circuit (27) comprises at least a connection portion (127) provided with at least six connection terminals (54) each defining an end of a conductive track (54a), which is connected, at the opposite end, to one and/or the other of the conductive plate (28), a part of the printed circuit (27) other than the connection portion (127), the conductive membrane (31), the pressure measuring means (34).



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“DIGITAL PRESSURE SENSOR FOR AN ELECTRICAL APPLIANCE,
CALIBRATION METHOD, AND ELECTRICAL APPLIANCE PROVIDED
WITH SAID DIGITAL PRESSURE SENSOR”

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FIELD OF THE INVENTION

The present invention concerns a digital pressure sensor of the capacitive type, suitable for application in electrical appliances, such as for example, but not only, washing machines or dish washers, to detect the pressure values in order to condition the activation of functions and pre-determined functioning cycles of the electrical appliance.

The invention also concerns a method for calibrating the digital pressure sensor and an electrical appliance provided with the sensor.

BACKGROUND OF THE INVENTION

Capacitive sensors are known, which are normally provided with a flexible conductive membrane kept by a spacer at a determinate distance from a conductive plate connected to a printed circuit, or PCB (Printed Circuit Board).

The conductive membrane and the conductive plate make up the two plates of a capacitor, which is loaded with a predefined tension.

External perturbations cause flections of the conductive membrane and consequent reductions in the distance between the membrane and the conductive plate. These reductions in distance give rise to increases in the capacity of the capacitor, which are recorded by a micro-controller integrated in the PCB and converted into an output signal coherent with the quantity to be measured.

Capacitive sensors can be used in various fields in the state of the art, to measure different quantities, such as for example pressure, displacements, chemical composition, electric or magnetic field, acceleration, level or composition of a fluid.

The sensors can also be of micrometric sizes and have very high sensitivity and resolution, and operate with variations in capacity even in the order of 5 aF.

Currently, such sensors are generally used as components of miniaturized electro-mechanical systems, also known as MEMS (Micro Electro-mechanical Systems), normally provided with electrical, electronic and mechanical devices integrated into the same silicon substrate.

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Other applications of these capacitive sensors provide them to be used as high-resolution proximity sensors.

It is known that in some electrical appliances, such as for example a washer machine, such as a washing machine or dishwasher, or in a drier or washer-drier, or in a refrigerator, a freezer, a boiler or other electrical appliances used for treating and/or cooking foods or drinks, one or more pressure sensors are used in order to detect particular and defined values of a pressure and to determine the activation or de-activation of a particular function or functioning cycle of the appliance, based on the commands of an electronic or electro-mechanical programmer.

Various types of pressure sensors are known for this purpose, and comprise for example pressure switches of the electro-mechanical type, which can be activated when the pressure reaches a predetermined level.

One disadvantage of known pressure sensors used in electrical appliances is that they are bulky, often due to the large number of components and accessories needed for functioning, and they are not very reliable or accurate, due to the limited duration over time of the mechanical components with successive operating cycles.

Furthermore, known pressure switches have the further disadvantage that they are not very versatile, since they are generally calibrated only to detect a predetermined pressure and do not perform any measuring of the quantity.

Another disadvantage of known pressure sensors is that they are not very flexible in use.

The need is therefore known, to obtain a digital pressure sensor which is not bulky, is reliable, inexpensive and able to measure with great accuracy at least a pressure in an electrical appliance, to allow the automatic management of a plurality of functioning programs.

To this end, Applicant was the first to introduce also into the field of electrical appliances the use of capacitive sensors able to satisfy said need.

However, although extremely precise and reliable, and with much lower bulk and costs compared with those of the sensors used in the state of the art, known capacitive sensors have a disadvantage due to a calibration difficulty, and due to the fact that the calibration method can damage the sensor or negatively affect its

reliability.

The calibration process is necessary since the response of capacitive sensors is generally sensitive to some factors connected to the process of producing and assembling the sensor, and can vary even between sensors belonging to the same production batch or made using the same method.

Among the factors mentioned above the thickness of the conductive membrane, the planarity of the PCB, the spacing between the conductive membrane and the PCB and the type of spacer can be included, and other factors that can similarly be subject to even minimum tolerances or variations in the working or production process.

One disadvantage of known calibration methods is connected to the fact that they normally provide an invasive intervention on the sensitive element or the detector unit.

The invasive intervention can consist of dis-assembling the sensor in order to remove the PCB and hence allow access to the pins of the micro-controller so as to program it. In this way, however, the dis-assembly and re-assembly operations can introduce perturbations or modifications to the sensor which can alter its calibration constants.

Another invasive intervention can consist of using calibration needles to reach, from the outside, the pins of the micro-controller integrated in the PCB. This intervention can however deform the PCB during the calibration operations.

All the above is in contrast with the need to obtain pressure sensors with ever-greater accuracy, precision and reliability, to deal with the needs of the field of application of electrical appliances, where there is an increasing need for operative flexibility, together with an ever-greater variety of functioning programs. A greater optimization of consumption, for example of electricity or water, is also required, and the automation of the functioning programs plus a greater readiness in response to variations in pressure.

Another problem is to satisfy different requirements in terms of output signal with the same sensor, in order to be able to install the same sensor, possibly modifying only its programming, in applications that manage different output signals.

A purpose of the present invention is to obtain a digital pressure sensor that is

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able to measure at least a pressure in an electrical appliance with maximized precision, which is not bulky and not expensive, and which is configured to be calibrated using easy, simple and quick operations, and for which no invasive interventions are required on sensitive parts of the sensor.

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, a digital pressure sensor of the capacitive type according to the present invention is configured to measure at least a pressure in an electrical appliance and comprises at least a pressure detector unit which in its turn comprises a conductive plate of a printed circuit and a conductive membrane disposed parallel and distanced with respect to each other. Conductive plate and conductive membrane define in this manner a capacitor with variable capacity due to the effect of said pressure. The pressure detector unit also comprises pressure measuring means configured to detect variations in the capacity of the capacitor and to generate a signal corresponding to the variations detected.

According to the present invention, the printed circuit comprises at least a connection portion provided with at least six connection terminals each defining an end of a conductive track, with the opposite end connected to one and/or the other of the components mentioned above, that is, the conductive plate, the conductive membrane, a part of the printed circuit other than the connection portion, or the pressure measuring means.

In this way, the advantage is achieved of being able to feed and manage or control said components of the digital pressure sensor, electrically and electronically, only through the connection terminals already normally present in the connection portion of the printed circuit.

Managing and controlling electronically the components of the digital pressure sensor can also provide the calibration of the sensor through the detection of data

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and the programming of the pressure measuring means.

According to aspects of the present invention, the connection terminals are made on opposite surfaces of the connection portion cited above.

In some forms of embodiment, the connection terminals are integrated in the printed circuit, whilst in other forms of embodiment they can be distinct but connected thereto.

It is also an aspect of the invention to provide that the connection terminals are configured to connect to one or more connectors of the standard type, such as RAST 2.5 or RAST 5 connectors.

In some forms of embodiment, six connection terminals are provided configured to transmit and receive eight electric or electronic signals, for the electric power supply of the detector unit and for reading and writing data from and on the pressure measuring means.

The present invention also concerns an electrical appliance provided with a digital pressure sensor as described above.

The present invention also concerns a method for calibrating a digital pressure sensor comprising a detector unit provided with a printed circuit with a conductive plate, and a conductive membrane that, being distanced from and parallel to the conductive plate, defines with it a capacitor with a variable capacity due to the effect of the pressure to be measured. The detector unit is also provided with pressure measuring means.

The calibration method provides to assemble the digital pressure sensor inserting the detector unit inside a container so that a connection portion provided with at least six connection terminals is accessible from a connection cavity made in the container itself.

Then, a calibrating apparatus is prepared, comprising a connection interface and an electronic processor.

A calibration connector of the RAST 2.5 or RAST 5 type is then connected to the connection portion, connected in its turn to the connection interface. Subsequently, by means of one or more of the connection terminals mentioned above, electric power is transmitted to the detector unit and, at the same time as this electric power, the variations in pressure are detected by means of one or more of the connection terminals and by means of the electronic processor.

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Moreover, during the detection of these variations, the signal generated by the measuring means is read by one or more of the connection terminals and by the electronic processor. After the reading, the signal generated is compared to a reference signal and, after the comparison, calibration parameters or constants are possibly written in the pressure measuring means, by means of one or more of the connection terminals and by means of the electronic processor.

In this way, the advantage is obtained of being able to configure and calibrate the digital pressure sensor when this has already been assembled, without having to dis-assemble it or perform other invasive interventions, such as the perforation of the container for example. In particular, the calibration is carried out by means of exchange of data and signals through the connection terminals, without having to use needles or other instruments which can damage conductive tracks of the printed circuit or sensitive components of the detector unit.

BRIEF DESCRIPTION OF THE DRAWINGS

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

- figs. 1 and 2 are schematic representations of a washing machine provided with a digital pressure sensor according to the present invention;
- fig. 3 is a schematic view in section of a form of embodiment of a digital pressure sensor according to the present invention;
- fig. 4 is a three-dimensional and exploded view of a part of the sensor in fig. 3;
- fig. 5 shows schematically a method for calibrating the digital sensor in figs. 3 and 4.

DETAILED DESCRIPTION OF SOME FORMS OF EMBODIMENT

With reference to fig. 1, a digital pressure sensor is indicated in its entirety by the reference number 10 and is shown schematically mounted in an electrical appliance, such as a washer machine, for example a washing machine 11.

The present description refers by way of example to a washing machine 11, but can easily be adapted to any electrical appliance in which it is necessary to measure one or more internal pressures.

Fig. 1 is used to describe by way of example a washing machine 11 of the known type and its corresponding functioning.

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The washing machine 11 is provided with at least a drum 12 in which the garments to be washed are contained and with an electric motor 13 configured to supply the desired rotatory motion to the drum 12.

During the washing cycles, clean water is introduced on each occasion into the drum 12 by means of an electrovalve 15 connected to the water supply and dirty water is removed by a discharge pump 16 connected to a discharge pipe 17. The operations to introduce and discharge the water can occur even several times within a washing cycle.

The digital pressure sensor 10 is connected to the drum 12 through a measuring pipe 18 that allows it to measure the pressure of the water contained in the drum 12 in an indirect way. The measuring pipe 18, initially full of air at atmospheric pressure when the washing machine 11 is idle and the drum 12 is empty, progressively fills with water as water is introduced into the drum 12 through the electrovalve 15. This introduction causes the compression of the air inside the measuring pipe 18, which air acts on the digital pressure sensor 10 determining the measurement of the pressure of the column of water contained in the drum 12, as will be clear hereafter in the description.

The measuring causes some steps of the washing cycle, which depend on the amount of water in the drum 12, to start and/or stop.

The washing cycles are managed by a command and control unit 19 to which the digital pressure sensor 10, the electric motor 13, the electrovalve 15 and the discharge pump 16 are connected, for example by means of electric feed and signal transmission cables.

The command and control unit 19 can include a memorization module 20, in which programs containing all the operations connected to the execution of each of the steps of the washing cycles can be memorized, and an electronic processor 21, configured to execute such programs. The memorization module 20 and the electronic processor 21 can both be integrated into a programmable card, or motherboard 22.

Moreover, the command and control unit 19 can also include a user interface 23, by means of which a user can select the desired washing cycle and the desired functions of the washing machine 11, or control the progress of the cycle.

The digital pressure sensor 10 measures the pressure of the water contained in

the drum 12, which causes some steps in the washing cycle to start and stop, for example the start of the filling of the drum 12 at the beginning of the cycle, the stop of said filling and the start of the washing step, the start of the partial discharge step and the subsequent further filling of the drum 12 during the washing cycle and the start of the spinning step.

In particular, for starting the steps of introducing the water into the drum 12, the digital pressure sensor 10 sends a signal relating to the pressure of the water in the drum 12 to the command and control unit 19. The electronic processor 21 processes the signal in order to obtain the value of the pressure and to compare it to a threshold value contained in the program to be executed and memorized in the memorization module 20. Based on this comparison, the command and control unit 19 selectively commands the electrovalve 15 to open or close. The digital pressure sensor 10 can be configured to send the signal corresponding to the pressure measurement to the command and control unit 19 continuously, in order to optimize and accelerate the response times of the command and control unit 19.

Similarly, by continuously controlling the measuring of the pressure of the water contained in the drum 12, it is possible to optimize the interventions of the command and control unit 19 and make them precise, in order to drive and stop the discharge pump 16.

It is therefore important that the digital pressure sensor 10 is provided with great precision and sensitivity, in order to make the washing conditions of each washing cycle repeatable and to optimize consumption, in particular of water.

This optimization of consumption, both of water and electricity, which can be obtained thanks to the accuracy and the reliability of the digital pressure sensor 10, allows to obtain better performances and higher energy certification of the electrical appliance, in this case the washing machine 11.

A greater resolution of the digital pressure sensor 10 can also make it possible to increase the washing programs of a washing machine 11, thus further contributing to its optimization and rendering the washing machine 11 versatile and flexible, meeting the different needs of the user.

Moreover, since the components of the digital pressure sensor 10 can be miniaturized, it is possible that the overall volumetric bulk of the digital pressure

sensor 10 can also be in the order of a few millimeters.

Forms of embodiment, shown for example in fig. 2, are therefore possible in which the digital pressure sensor 10 is integrated in the motherboard 22 of the command and control unit 19.

This solution gives the advantage of reducing the internal bulk of the washing machine 11 and the advantage of simplifying the production process thereof, by reducing the number of independent components.

Indeed, the digital pressure sensor 10 can be made in the same production cycle as the command and control unit 19.

On the basis of the above, figs. 3 to 5 are used to describe preferential forms of embodiment of a digital pressure sensor 10, in which it is the capacitive type.

According to these solutions, the digital pressure sensor 10 comprises a container 24 provided with a containing body 25 that defines a first part, and with a closing body 26 that defines a second part.

The containing body 25 and the closing body 26 can be reciprocally attached to each other by means of gluing, welding, fixed-joint means or other means or stratagems that determine the connection, which can be the removable or irremovable type, depending on specific requirements.

In the case described by way of example in the attached drawings, the containing body 25 includes perimeter walls 45 in which fixed-joint seatings 46 are made, in this specific case through, but which can also be blind, internal or external.

In some forms of embodiment, the fixed-joint seatings 46 can be disposed on one or more rows, and can affect all or only some of the perimeter walls 45.

In the same way, the closing body 26 of the digital pressure sensor 10, made according to the forms of embodiment described with reference to figs. 3 to 5, includes attachment fins 50, equal to or fewer in number than that of the fixed-joint seatings 46 and conformed to each be inserted in a corresponding fixed-joint seating 46.

The digital pressure sensor 10 includes a detector unit 36, configured to detect the pressure inside the electrical appliance 11.

In the specific example described with reference to the attached drawings, the detector unit 36 includes a printed circuit or PCB 27, a conductive membrane 31

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and an insulating membrane 37, to which the PCB 27 and the conductive membrane 31 are connected.

Simplified forms of embodiment can provide there is no insulating membrane 37, and alternative systems are used to connect the conductive membrane 31 and the PCB 27, for example by housing seatings made in the containing body 25 and/or in the closing body 26.

On one surface of the PCB 27 a conductive plate 28 is made, which can even be only a few microns thick, for example if defined by a metal coating on the surface of the PCB 27, or a part of it.

In some forms of embodiment, like the one shown by way of example in figs. 3 and 4, the shape of the conductive membrane 31 is defined by a peripheral zone 32, or attachment zone, having a greater thickness than a central zone 33, deformable under flexion, which defines the sensitive element of the digital pressure sensor 10.

With reference to fig. 4, a conductive membrane 31 can also be provided having a central zone 33 with lightening apertures 51, through, with the function of lightening the structure and increasing its deformability.

As indicated by way of example in fig. 3, the embodiment of the detector unit 36 provides that the conductive plate 28 and the conductive membrane 31 lie on parallel lying planes.

Furthermore, the central zone 33 is located parallel to and substantially in correspondence with the conductive plate 28, and at a determinate distance from it, so that conductive membrane 31 and conductive plate 28 define the plates of a capacitor, when a desired difference in potential is set between them.

In this solution, therefore, the peripheral zone 32 acts as a spacer element between the conductive membrane 31, in this specific case between its central zone 33, and the conductive plate 28.

The distance between the central zone 33 of the conductive membrane 31 and the conductive plate 28 can even be only a few hundredths of a millimeter, so as to obtain an extremely low desired value of sensitivity of the digital pressure sensor 10.

The conductive membrane 31 is configured to bend if subjected to a pressure applied in its central zone 33, thus increasing the capacity of the capacitor formed

by the conductive membrane 31 and the conductive plate 28.

In the form of embodiment shown by way of example in fig. 3, in correspondence with the central zone 33 of the conductive membrane 31, the containing body 25 is provided with an aperture 35 communicating with the measuring pipe 18 and having the function of transmitting the pressure of the water contained in the drum 12 to the central zone 33 of the conductive membrane 31, deforming it.

This increase in capacity, like other possible reductions in capacity that occur for example following the reduction in the pressure, are detected by a micro-controller 34, for example a microchip, which acts as a mean to measure the pressure.

In some forms of embodiment, the micro-controller 34 is integrated in the PCB 27.

The micro-controller 34 is configured to process the measurement of the variations in capacity and to generate a signal relating to said measurement.

In some implementations, the micro-controller 34 processes the signal to determine the real value of the pressure detected.

It may also be provided that, once the pressure value has been determined, the micro-controller 34 is configured to send said value to the command and control unit 19 with which it is electronically connected.

In other implementations, the micro-controller 34 is configured to transmit the signal generated to the command and control unit 19, while the command and control unit 19 has the function of processing the signal to determine the real value of the pressure detected.

Based on the processing of the signal generated by the micro-controller 34, the command and control unit 19 is configured to activate or de-activate functions of the washing machine 11 to perform the washing cycles.

The connection between the digital pressure sensor 10 and the command and control unit 19 can be carried out, after the digital pressure sensor 10 has been assembled, by means of a working connector 52 that connects the PCB 27 to the command and control unit 19.

In the forms of embodiment shown by way of example in figs. 3 to 5, the PCB 27 is provided with a connection portion 127 protruding toward the outside of the

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digital pressure sensor 10 through a connection cavity 146 made in the containing body 25.

Each working connector 52 is configured to cooperate with the connection portion 127, after the digital pressure sensor 10 has been assembled.

Each working connector 52 can be provided with a plurality of electric conductors, which in the example in fig. 3 are flexible foils 53.

Each flexible foil 53 is configured to contact, when the working connector 52 is installed, a corresponding connection terminal made on the PCB 27.

The number of flexible foils 53 of the working connector 52 can be lower than that of the connection terminals made on the PCB 27.

The connection terminals made on the PCB 27 can be, as in figs. 3 and 4, conductive strips 54 integrated in the PCB 27, or welded, glued or printed on its surface, or they can be pegs, feet or pins, protruding therefrom and/or enclosed in a housing shell.

Fig. 3 shows schematically a working connector 52 of the RAST type (Raster Anschluss Steck Technik), of a known type and normally used to connect electronic components in the field of electrical appliances or in the field of IT.

The working connector 52 can be the RAST 2.5 type, or RAST 5 type, depending on whether its electric conductors are distanced by 2.5 mm or 5 mm, respectively.

The contact between a flexible foil 53 of the working connector 52 and a corresponding conductive strip 54 on the PCB 27 allows to transmit a corresponding electric or electronic signal between the PCB 27 and the command and control unit 19.

In the forms of embodiment shown by way of example in figs. 3 and 4, in a totally innovative way compared to the state of the art, the PCB 27 includes a total of six connection terminals.

In this specific case, the connection terminals are defined by three conductive strips 54 located on a surface of the PCB 27, and three conductive strips 54 located on an opposite surface.

Each conductive strip 54 defines a terminal end of a conductive track 54a having the opposite end connected to a component of the detector unit 36, which can be the conductive membrane 31, the conductive plate 28 or the micro-

controller 34, or again zones of the PCB 27 having specific functions.

Depending on said specific functions, for example determined by the final intended use of the digital pressure sensor 10 or the particular requirements of a user, each of the conductive strips 54 is programmable separately.

Each of the conductive strips 54 can be selectively configured to carry, for example, different values of tension or current to the digital pressure sensor 10, or to allow to exchange signals relating to the measurement of the capacity or pressure between micro-controller 34 and command and control unit 19.

Furthermore, the digital pressure sensor 10 shown in fig. 3 includes a single working connector 52 provided with two overlapping rows of flexible foils 53, only two of which can be seen in the drawing.

Alternative forms of embodiment may be provided in which two working connectors 52 are included, provided with flexible foils 53.

Generally, a working connector 52 comprises three flexible foils 53 and is used during the normal functioning of the washing machine 11 and the digital pressure sensor 10.

As we said before, the connection between the digital pressure sensor 10 and the command and control unit 19 is made after the digital pressure sensor 10 has been assembled, which can be carried out as described hereafter.

Figs. 3 and 4 are used to describe forms of embodiment in which the insulating membrane 37 is made of a flexible polymer material, such as for example rubber or other material that can combine properties of flexibility, impermeability and insulation, and is provided with a plan bulk greater than that of the conductive membrane 31 and the PCB 27.

The insulating membrane 37 can be provided with a peripheral connection edge 38 and a flexible zone 39, in this specific case central, protruding from the peripheral connection edge 38 and connected to it.

The flexible zone 39 is positioned, after assembly, substantially in correspondence with the central zone 33 of the conductive membrane 31.

The containing body 25 includes a plurality of spacer protuberances 47 which protrude toward the inside of the containing body 25 and surround its aperture 35.

The spacer protuberances 47 are configured to come into contact with the

flexible zone 39 of the insulating membrane 37 and to keep it distanced from the containing body 25. Consequently, a chamber 48 is created (fig. 3) in which the air arriving from the measuring pipe 18 is distributed to exert an uniform pressure on the flexible zone 39 of the insulating membrane 37. This pressure causes the flexible zone 39 to bend, and consequently the central zone 33 of the conductive membrane 31 to which it is connected.

In this way, as the distance between the conductive membrane 31 and the conductive plate 28 is reduced, and hence the capacity of the capacitor of which they represent the plates increases, the digital pressure sensor 10 is able to measure the pressure of the water contained in the drum 12 as described above.

The implementations shown by way of example in figs. 3 and 4 provide that the measuring pipe 18 is integrated into the containing body 25, but it is not excluded that simplified implementations may provide that the measuring pipe 18 is connected to the containing body 25 at a later time, at the end of assembly.

The detector unit 36 of the digital pressure sensor 10 can also include an attachment ring 49, with sizes mating with those of the peripheral connection edge 38 of the insulating membrane 37 and configured to be inserted into the containing body 25. The attachment ring 49 can be made of an insulating material, for example a polymer material such as rubber or other plastic material, or composite, or other materials impermeable to air and water.

To assemble the detector unit 36, the attachment ring 49 is positioned in correspondence with the peripheral connection edge 38 of the insulating membrane 37 and subsequently the conductive membrane 31 and the PCB 27 are connected to the insulating membrane 37, as described hereafter.

Fig. 4 shows an exploded and three-dimensional view of the detector unit 36, and is used to describe a possible method to assemble its forms of embodiment.

In these forms of embodiment, the insulating membrane 37 is provided with attachment means, in this specific case attachment pegs 40, the function of which is to connect both the conductive membrane 31 and the PCB 27 to the insulating membrane 37.

The attachment pegs 40 can be positioned in the insulating membrane 37 internally with respect to the peripheral connection edge 38 and can have a ring-like or frame-like distribution, surrounding the central zone of the insulating

membrane 37.

In the specific case of fig. 4, the attachment pegs 40 are located in the flexible zone 39 of the insulating membrane 37, and protrude from it. The attachment pegs 40 can have a rod 41 and a free end 42, bigger than the rod 41.

Attachment is obtained by inserting the attachment pegs 40 into first through holes 43 made in the peripheral zone 32 of the conductive membrane 31 and into second through holes 44 made in the PCB 27.

The first 43 and second 44 through holes constitute complementary attachment means to the attachment means 40 of the insulating membrane 37.

In some forms of embodiment, described with the aid of fig. 4, the first and second through holes 43, 44 can have a smaller diameter than the width of the free end 42, and are at least equal in number to that of the attachment pegs 40.

To assemble the detector unit 36, provided that first of all the attachment pegs 40 are aligned axially with the first through holes 43 and the second through holes 44, and then the free end 42 of the attachment pegs 40 is deformed so as to force it to pass through the first and second through holes 43, 44. Subsequently, the deformation is released to allow a stable attachment of the three components of the detector unit 36, since the greater size of the free end 42 with respect to the through holes 43, 44 prevents the attachment pegs 40 from becoming detached.

The assembly as described above allows to stack or superimpose the flexible zone 39 of the insulating membrane 37, the central zone 33 of the conductive membrane 31 and the conductive plate 28, in correspondence with each other inside the detector unit 36.

According to some forms of embodiment, the flexible zone 39 and the central zone 33 are in reciprocal contact, so that they are solidly mobile.

As indicated in figs. 3 and 4, the attachment ring 49 is disposed around the PCB 27 and the conductive membrane 31.

Furthermore, after assembly, the attachment ring 49 is in contact with the peripheral connection edge 38 of the insulating membrane 37 and presses it against the containing body 25. Apart from guaranteeing the attachment and the correct positioning of the detector unit 36 in the containing body 25, this also contributes to keeping the chamber 48 insulated from the outside, except for the measuring pipe 18.

In this way the conductive membrane 31 and the PCB 27 are substantially suspended inside the container 24 and have respective perimeter edges free from mechanical constraints, so that they can dilate thermally, at least on their lying planes, independently from the containing body 25.

Based on the above description, the container 24 determines a first insulation of the detector unit 36 contained therein, from the outside of the digital pressure sensor 10.

Furthermore, the insulating membrane 37 of the detector unit 36 is used to insulate the conductive membrane 31 from the outside and to prevent it having direct contact with the air arriving from the measuring pipe 18.

In particular, the insulating membrane 37 can have a function of second insulation for the digital pressure sensor 10, thus guaranteeing that the latter belongs to the category of class 2 (or class II) electrical devices.

Fig. 5, above, shows a condition of normal use of the digital pressure sensor 10 which, once assembled, can be mounted in the washing machine 11. Subsequently, the working connector 52 is connected to the connection portion 127 of the PCB 27, so that the six flexible foils 53 contact the six conductive strips 54.

This connection allows to provide electric power to the detector unit 36, and hence to the digital pressure sensor 10, and to transmit signals from the micro-controller 34 to the command and control unit 19 during normal use.

Fig. 5, below, shows a condition of calibration of the digital pressure sensor 10, in this specific case after it has been mounted in the washing machine 11.

The following considerations are also valid, however, if calibration is carried out at the end of the production process, before the digital pressure sensor 10 is mounted in the washing machine 11.

The calibration process occurs when the digital pressure sensor 10 is assembled, therefore irrespective of its positioning or installation.

The calibration process provides to use a calibration connector 152, like the working connector 52, but comprising as many flexible foils 53 as there are conductive strips 54.

The calibration connector 152 is connected to the connection portion 127 of the PCB 27 to determine six connections each defined by a pair consisting of

flexible foil 53 – conductive strip 54.

The calibration connector 152 is configured to be connected to a calibration apparatus 55 as well, which in fig. 5 includes by way of example a connection interface 56 and an electronic processor 57.

The function of the connection interface 56 is to connect the calibration connector 152, and hence the digital pressure sensor 10, to the electronic processor 57 which is configured, for example by the execution of one or more codes pre-memorized inside it, to receive, process and transmit data or signals to the digital pressure sensor 10.

In particular, thanks to the presence of six distinct pairs defined by a flexible foil 53 and a conductive strip 54, the electronic processor 56 can act independently on each of the conductive strips 54 so as to manage a particular function thereof.

Among the particular functions that can be attributed to the conductive strips 54 there are the known ones of supplying electric power and reading signals from the micro-controller 34, but also new functions, such as for example transmitting signals in writing on the micro-controller 34, connecting to the membrane 31 and to the conductive plate 28 in order to detect the capacity of the capacitor directly.

Furthermore, the six conductive strips 54 are configured to manage eight distinct, electrical or electronic data transfer signals.

It is therefore possible for the electronic processor 57 to detect the variations in capacity due to variations in pressure to be measured directly by the components of the detector unit 36, and to analyze them in real time, making a comparison between reference values.

At the same time, based on this comparison, the electronic processor 57 is able to program or reprogram the micro-controller 34, inserting therein suitable calibration parameters or constants, so as to obtain the correct calibration of the digital pressure sensor 10.

These operations can be carried out when the digital pressure sensor 10 is closed and assembled, thanks to the presence of a plurality of connection terminals (conductive strips 54), the functions of which can be managed independently in calibration conditions, that is, by means of a calibration connector 152.

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This allows to perform the calibration of the digital pressure sensor 10 without any invasive intervention which requires it to be dis-assembled or that can damage components. Furthermore, calibration performed as described above is extremely reliable, since the calibration apparatus 55 leaves the pressure detector 36 unchanged, and does not use instruments that could introduce perturbations of the measurement during the calibration operations.

In conditions of use, that is, when the PCB 27 is connected to the working connector 52, it may be provided that two or more flexible foils 53 and/or conductive strips 54 are short circuited, or de-activated, to exclude unnecessary functions during the normal functioning of the digital pressure sensor 10.

It is clear that modifications and/or additions of parts may be made to the digital pressure sensor 10 and corresponding calibration 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 digital pressure sensor and calibration method, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

CLAIMS

1. Digital pressure sensor of the capacitive type comprising at least a pressure detector unit (36) to detect at least a pressure in an electrical appliance (11), said pressure detector unit (36) comprising at least a conductive plate (28) of a printed circuit (27) and a conductive membrane (31) disposed parallel and distanced with respect to each other to define a capacitor with variable capacity due to the effect of said pressure, and pressure measuring means (34) configured to detect variations in said capacity and to generate a signal relating to the variations detected, **characterized in that** said printed circuit (27) comprises at least a connection portion (127) provided with at least six connection terminals (54) each defining an end of a conductive track (54a), said conductive track (54a) being connected, at the opposite end with respect to said connection terminals (54), to one and/or the other of said conductive plate (28), a part of said printed circuit (27) other than said connection portion (127), said conductive membrane (31), said pressure measuring means (34).
2. Sensor as in claim 1, **characterized in that** said connection terminals (54) are made on opposite surfaces of said connection portion (127).
3. Sensor as in claim 2, **characterized in that** said connection terminals (54) are integrated in, or distinct from and connected to, said opposite surfaces of said connection portion (127).
4. Sensor as in any claim from 1 to 3, **characterized in that** said connection terminals (54) and said connection portion (127) are configured to connect to at least a connector (52, 152) of the RAST 2.5 or RAST 5 type.
5. Sensor as in any claim from 1 to 3, **characterized in that** said six connection terminals (54) are configured to transmit and receive at least eight electric or electronic signals, for the electric power supply of said detector unit (36) and for the reading and writing of data from and on said pressure measuring means (34).
6. Electrical appliance provided with a digital pressure sensor made according to one or other of claims from 1 to 5.
7. Method for calibrating a capacitive digital pressure sensor comprising at least a pressure detector unit (36) to detect at least a pressure in an electrical appliance (11), said pressure detector unit (36) comprising at least a conductive plate (28) of a printed circuit (27) and a conductive membrane (31) disposed parallel and

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distanced with respect to each other to define a capacitor with variable capacity, and pressure measuring means (34) configured to detect variations in said capacity and to generate a signal relating to the variations detected, **characterized in that** it comprises:

- assembling said digital pressure sensor by inserting said detector unit (36) inside a container (24) so that a connection portion (127) provided with at least six connection terminals (54) is accessible from a connection cavity (146) made in said container (24);
- preparing a calibration apparatus (55) comprising a connection interface (56) and an electronic processor (57);
- connecting to said connection portion (127) a calibration connector (152) of the RAST 2.5 or RAST 5 type, in turn connected to said connection interface (56);
- transmitting, by means of one or more of said connection terminals (54), electric power supply to said detector unit (36);
- simultaneously with said electric power supply, detecting the variations in said pressure by means of one or more of said connection terminals (54) and by means of said electronic processor (57);
- during the detection of said variations, reading the signal generated by said pressure measuring means (34) by means of one or more of said connection terminals (54) and by means of said electronic processor (57);
- after reading, comparing said signal generated with a reference signal and, after said comparison, possibly writing calibration parameters or constants in said pressure measuring means (34), by means of one or more of said connection terminals (54) and by means of said electronic processor (57).

8. Calibration method as in claim 7, **characterized in that** it provides to manage, by means of said calibration apparatus (55), each of said connection terminals (54) independently of each other.

9. Calibration method as in claim 7 or 8, **characterized in that**, after the possible writing of calibration parameters or constants in said pressure measuring means (34), it provides to disconnect said calibration connector (152) and to connect a working connector (52) of the standard RAST 2.5 or RAST 5 type.

10. Calibration method as in any claim from 7 to 9, **characterized in that** connecting said working connector (52) provides to short-circuit one or more

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pairs of said connection terminals (54).

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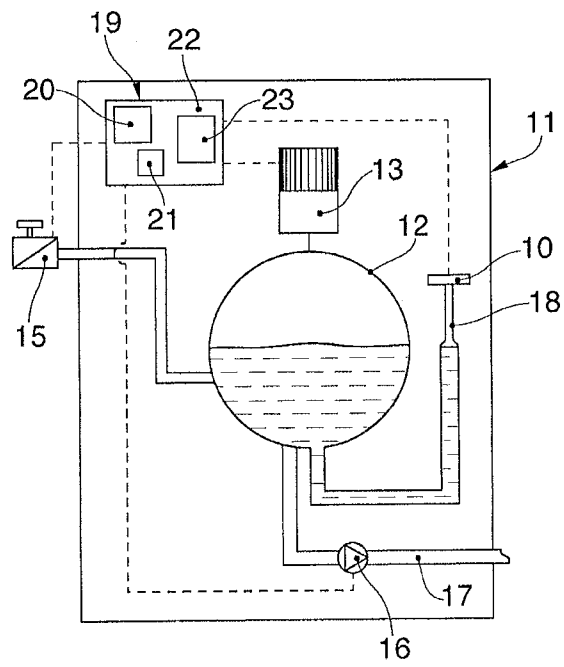


fig. 1

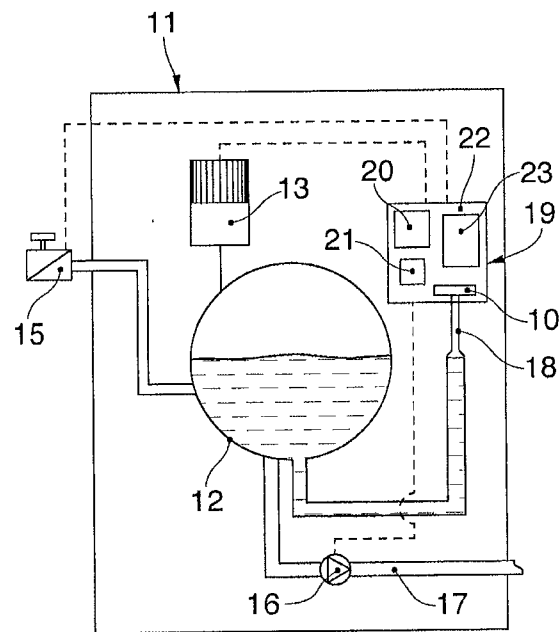


fig. 2

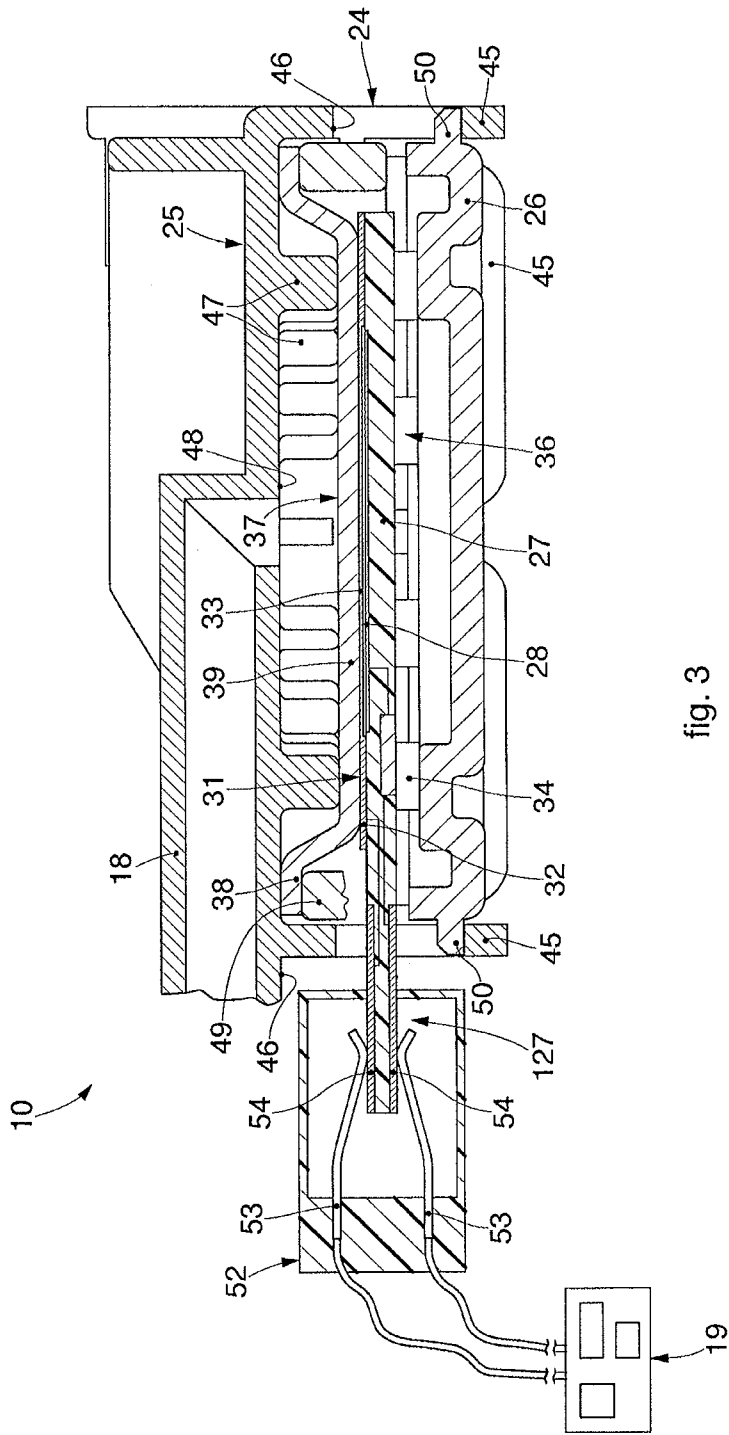


fig. 3

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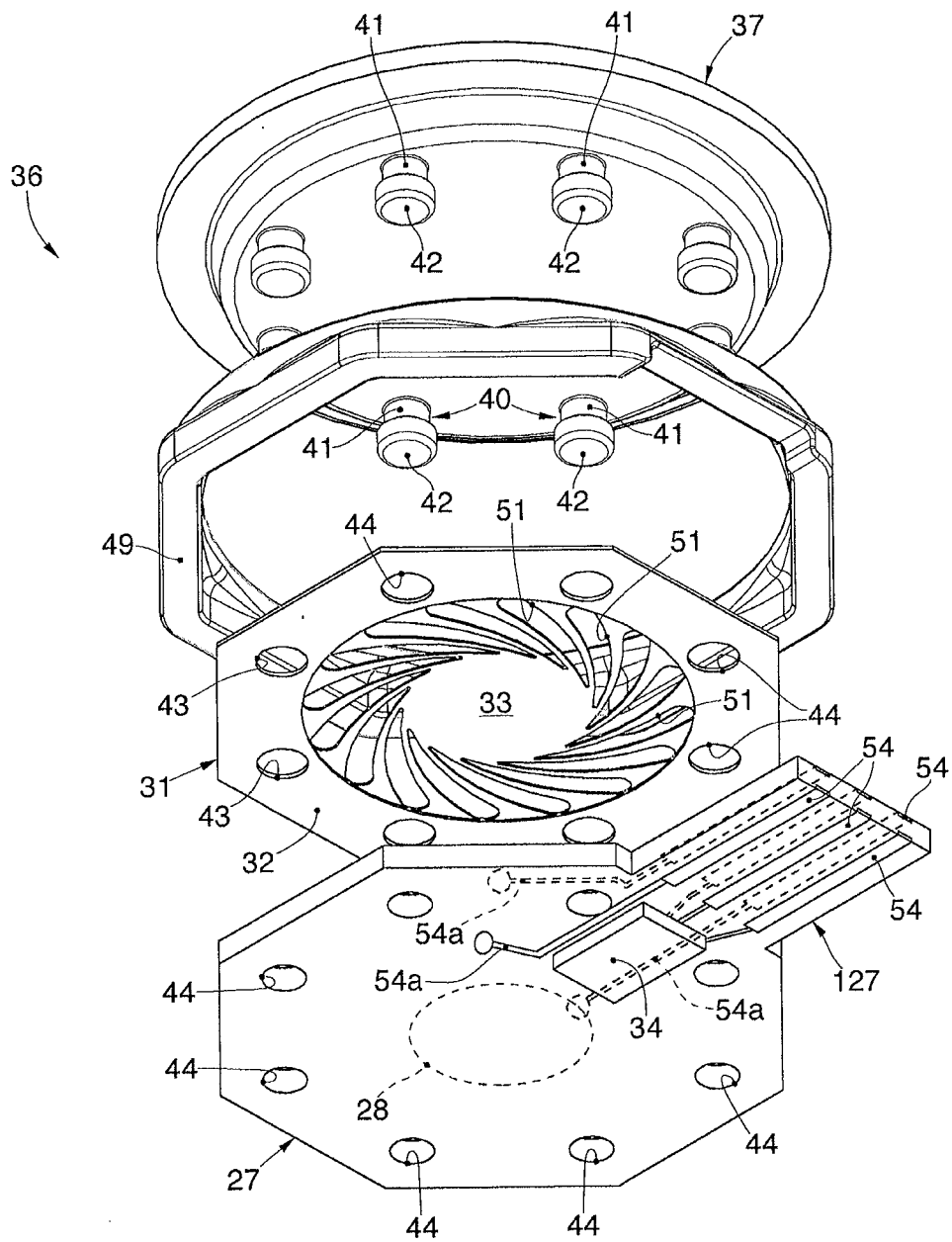


fig. 4

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