(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 712 317 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.09.2020 Bulletin 2020/39

(51) Int Cl.:
D06F 39/00 *(2020.01)* ***A47L 15/42*** *(2006.01)*
D06F 34/22 *(2020.01)*

(21) Application number: **20162535.7**

(22) Date of filing: **11.03.2020**

(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

(30) Priority: **21.03.2019 IT 201900004153**

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(54) TURBIDITY SENSOR FOR A WASHING MACHINE, IN PARTICULAR FOR HOUSEHOLD USE, AND RELATED WASHING MACHINE INCLUDING SAID SENSOR

(57) The present invention relates to a turbidity sensor (1) for a washing machine, in particular for household use, said sensor (1) comprising:
- an enclosure (10) adapted to be positioned in the washing machine in such a way that it is at least partially surrounded by a washing liquid, said enclosure (10) being provided with a first housing (11) and a second housing (12);
- a first element (21) emitting/receiving an electromagnetic radiation, housed in the first housing (11) of the enclosure (10);
- a second element (22) receiving/emitting an electromagnetic radiation, housed in the second housing (12) of the enclosure (10),
wherein the first housing (11) and the second housing (12) are at least partially made of transparent material to allow said electromagnetic radiation to be transmitted/received by the first element (21), propagate between the first housing (11) and the second housing (12) externally to said enclosure (10), and be received/transmitted by the second element (12) for the purpose of detecting the degree of turbidity of the washing liquid that surrounds at least partially said enclosure (10) and that is located between the first housing (11) and the second housing (12).

The peculiar feature of the present invention consists in the fact that the first housing (11) and the second housing (12) develop substantially perpendicular to a longitudinal axis (X-X) of the enclosure (10) and in such a way as to face towards each other, in particular the enclosure (10) being designed to comprise a recess (13) between said first housing (11) and second housing (12).

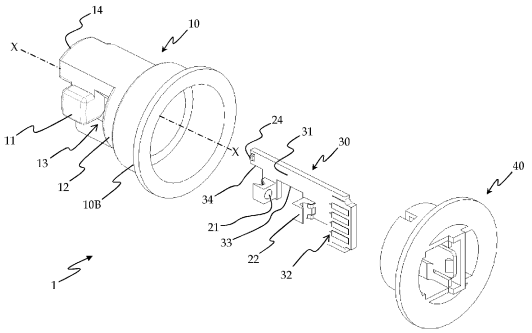

Fig. 1

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Description

[0001] The present invention relates to a turbidity sensor for a washing machine, in particular for household use, according to the preamble of claim 1. The present invention also relates to a washing machine comprising said sensor.

[0002] It is known in the state of the art that washing machines for household use, such as, for example, dishwashers and laundry washing machines, use a washing liquid usually comprising water and coming from the water main, which is combined with a detergent substance (e.g. liquid, powder, tablet, etc.) and possibly with other substances for treating crockery (e.g. rinse aid) or laundry (e.g. softener).

[0003] As a consequence, when the washing liquid is mixed with such substances and/or when it get mixed with the dirt coming off of the laundry (in the case of a laundry washing machine) or the crockery (in the case of a dishwasher), it undergoes a change in its turbidity.

[0004] Furthermore, it is known that in the washing machines known in the art also the temperature of the washing liquid can be changed during the various operating phases of the machine.

[0005] In this frame, the adoption of two separate sensors for measuring turbidity and temperature inevitably requires the use of more than one component, in addition to increased efforts and costs necessary for realizing the connection of each one of said separate sensors.

[0006] On the other hand, during the operating cycles of the machines known in the art, the control over some variables of the washing liquid (e.g. turbidity and temperature) is used in order to automatically manage some operations carried out by the machine, e.g. the wash cycle.

[0007] It is thus known at the state of the art to provide washing machines for household use with a sensor adapted to measure the properties of the washing medium, i.e. the turbidity and possibly also the temperature of the washing liquid.

[0008] In particular, the turbidity sensors known at the state of the art are realized to comprise a pair of optical elements for emitting and receiving, respectively, a light beam in order to measure the turbidity of the washing liquid, plus an optional additional sensor adapted to measure the temperature of said washing liquid.

[0009] In particular, document EP1335060A1 and document EP2004031A1 refer to a turbidity sensor for a washing machine, in particular for household use, comprising:

- an enclosure adapted to be positioned in the washing machine in such a way that it is at least partially surrounded by a washing liquid of said washing machine, said enclosure being provided with a first housing and a second housing;
- a first optical element positioned in the first housing of the enclosure;
- a second optical element positioned in the second housing,

wherein an optical radiation, in particular an infrared radiation, is transmitted by the first optical element and received by the second optical element and propagates between the first housing and the second housing outside said enclosure in order to detect the turbidity of the washing liquid that surrounds, at least partially, said enclosure.

[0010] The sensor further comprises a base or cover for coupling the sensor to said washing machine, said base being associated with said enclosure.

[0011] In documents EP1335060A1 and EP2004031A1, the first and second housings develop parallel to a longitudinal axis of the sensor enclosure; as a consequence, in documents EP1335060A1 and EP2004031A1 the first and second housings are also referred to as "fingers", since each one of said housings is substantially shaped like a finger of a hand, and each one of such housings extends longitudinally from the common base, just like fingers extend from a hand. The turbidity sensor shown in document EP1335060A1 comprises also a temperature sensor adapted to sense the temperature of the washing liquid, said temperature sensor being positioned in the second finger at a greater distance from the base compared to the second optical element.

[0012] Also the turbidity sensor shown in document EP2004031A1 comprises a temperature sensor adapted to detect the temperature of the washing liquid, said temperature sensor being positioned in an additional housing (or "finger") located between the housings for the elements constituting the turbidity sensor, wherein the temperature sensor is positioned at a shorter distance from the base compared to the distance of the first optical element and the second optical element from said base.

[0013] It is therefore apparent that, in the embodiments shown in documents EP1335060A1 and EP2004031A1, the so-called housings or "fingers" permit protecting the optical elements of the turbidity sensor and temperature sensor for detecting the properties, in particular in terms of turbidity and temperature, of the washing liquid interposed between said housings or "fingers".

[0014] The electronic components of the devices shown in the above-mentioned prior-art documents (i.e. the first optical element, the second optical element and the temperature sensor) are then positioned on a board, in particular an electronic board made of insulating material, and connected to a printed electric circuit of said board, which also comprises terminals to permit the board to establish the electric contact and connection with other components, typically via a plug-type connection.

[0015] In this frame, said first and second housings develop longitudinally and substantially parallel to the plane of the board whereon the first optical element, the second optical element and the temperature sensor are installed. As a consequence, the board is so designed

as to comprise appendices whereon the first optical element, the second optical element and the temperature sensor are installed, said appendices being adapted to be housed in the respective housings and also extending longitudinally and substantially parallel to the plane whereon the sensors are installed.

[0016] Moreover, the devices shown in the above-mentioned prior-art documents are provided with a base or cover constrained to the enclosure through the interposition of at least one sealing element (e.g. a gasket) to prevent the washing liquid from entering the enclosure that contains the board and the associated components (i.e. the first optical element, the second optical element and the temperature sensor).

[0017] The turbidity sensors shown in the above-mentioned prior-art documents suffer from some drawbacks, which are mainly due to the fact that the positioning of the housings necessarily binds the distance between the first housing and the second housing (in each one there being mounted a respective transmission/reception optical element) to the dimension of the outside diameter of the sensor, i.e. the distance between the emitter element and the receiver element defines the dimension of the diameter of the sensor and hence the minimum size of the hole in the washing machine for housing the whole sensor.

[0018] It is therefore apparent that, in the turbidity sensors shown in the above-mentioned prior-art documents, it is impossible to modify the distance between the housings (and, as a consequence, between the transmission and reception optical elements positioned in said housings) for the purpose of adapting it as necessary depending on the required sensitivity, and also to physically calibrate the reading output according to the measurement requirements of specific applications.

[0019] In addition, in such sensors the housing that contain the transmission and reception optical elements have a considerable length compared to their width, resulting in the possibility of alignment errors between emitter and receiver, especially when said fingers have different lengths; it is evident that an alignment error between such components will compromise the correct reading of the degree of turbidity of the washing liquid.

[0020] A further drawback of the solutions shown in documents EP1335060A1 and EP2004031A1 lies in the fact that the sensor shown therein can only measure a narrow passage section; in particular, its geometry does not allow measuring large areas for a given sensor diameter, the latter being bound to specific orders of magnitude. It is therefore clear that, since the minimum distance between the housings is limited, the reading space is limited as well, inevitably resulting in lower measurement accuracy.

[0021] Moreover, the solutions shown in documents EP1335060A1 and EP2004031A17 do not permit obtaining measurements relating to entire passage sections and/or flows of different nature.

[0022] In this frame, it is the main object of the present invention to provide a turbidity sensor for a washing machine, in particular for household use, which is so designed as to overcome the drawbacks of the prior art.

[0023] In particular, it is one object of the present invention to provide a turbidity sensor for a washing machine, in particular for household use, so designed as to allow changing the distance between the transmission and reception optical elements as a function of the required sensitivity, and physically calibrating the reading output according to the measurement requirements of specific applications.

[0024] It is another object of the present invention to provide a turbidity sensor for a washing machine, in particular for household use, wherein the distance between the transmission and reception optical elements is adequate and permits avoiding any risk of alignment errors while ensuring a correct reading of the turbidity of the washing liquid.

[0025] It is a further object of the present invention to provide a turbidity sensor for a washing machine, in particular for household use, so designed as to allow measuring also large liquid passage sections, in particular the design of said sensor being such that it can accurately measure extended areas even with limited sensor diameter or width.

[0026] It is yet another object of the present invention to provide a turbidity sensor for a washing machine, in particular for household use, so designed as to allow obtaining accurate measurements over entire passage sections of the washing liquid and/or for flows of different nature.

[0027] Said objects are achieved by the present invention through a turbidity sensor for a washing machine, in particular for household use, and a related washing machine comprising said sensor, incorporating the features set out in the appended claims, which are an integral part of the present description.

[0028] Further objects, features and advantages of the present invention will become apparent from the following detailed description and from the annexed drawings, which are supplied by way of non-limiting explanatory example, wherein:

- Figure 1 shows an exploded perspective view of a first embodiment of a turbidity sensor for a washing machine, in particular for household use, according to the present invention;
- Figure 2a shows a front view of the sensor of Figure 1, whereas Figure 2b shows a sectional view along lines A-A of Figure 2a;
- Figure 3 shows a perspective view of a variant of the first embodiment shown in Figures 1 to 2b;
- Figure 4 shows an exploded perspective view of a second embodiment of a turbidity sensor for a washing machine, in particular for household use, according to the present invention;
- Figure 5a shows a side section of the sensor of Figure 4, whereas Figure 5b shows a sectional view

along lines B-B of Figure 5a;

- Figure 6 shows an exploded perspective view of a third embodiment of a turbidity sensor for a washing machine, in particular for household use, according to the present invention;
- Figure 7a shows a front view of the sensor of Figure 6, whereas Figure 7b shows a sectional view along lines C-C of Figure 7a.

[0029] With reference to the annexed drawings, reference numeral 1 designates as a whole a turbidity sensor for a washing machine, in particular for household use, according to the present invention. It should be noted that the washing machine is not shown in the annexed drawings; in this respect, note that the present invention especially refers to the technical field of washing machines for household use, such as, for example, dishwashers, laundry washing machines and other similar machines. It is therefore clear that the present invention is applicable to any machine requiring a measurement of the degree of turbidity of the liquid that is present therein.

[0030] The sensor 1 comprises an enclosure 10 adapted to be positioned in the washing machine in such a way that it is at least partially surrounded by a washing liquid, said enclosure 10 being provided with a first housing 11 and a second housing 12.

[0031] The sensor 1 also comprises:

- a first element 21 emitting/receiving an electromagnetic radiation, housed in the first housing 11 of the enclosure 10;
- a second element 22 receiving/emitting an electromagnetic radiation, housed in the second housing 12 of the enclosure 10,

wherein the first housing 11 and the second housing 12 are at least partially made of transparent material to allow said electromagnetic radiation, in particular an infrared radiation, to be transmitted/received by the first element 21, propagate between the first housing 11 and the second housing 12 externally to said enclosure 10, and be received/transmitted by the second element 22 for the purpose of detecting the degree of turbidity of the washing liquid that surrounds, at least partially, said enclosure 10 and that is located between the first housing 11 and the second housing 12.

[0032] In the course of the present description, and for the purposes of the present invention, it will become evident that the first element 21 and the second element 22 are respectively defined as emitter/receiver and as receiver/emitter because they form a pair of elements, in particular optical ones, for respectively emitting and receiving an electromagnetic radiation, so as to be able to measure the degree of turbidity of the washing liquid which surrounds, at least partially, said enclosure 10 and which is located between the first housing 11 and the second housing 12. As a consequence, for the purposes of the present invention, each one of said first element 21 and second element 22 may consist of, without distinction, an element emitting or an element receiving the electromagnetic radiation, in particular an infrared radiation. It should be noted that said electromagnetic radiation may be, for example, in the visible optical range or in the infrared range.

[0033] In this frame, as is known in the art, the emitter element 21, 22 transmits an electromagnetic radiation of a given intensity; depending on the degree of turbidity of the washing liquid situated between the first housing 11 and the second housing 12, such electromagnetic radiation will be absorbed or diffused in such a way that, the higher said degree of turbidity of the washing liquid, the lower the intensity of the electromagnetic radiation that will be received by the receiver element 21, 22. As a consequence, it is possible to evaluate the degree of turbidity of the washing liquid on the basis of the intensity of the electromagnetic radiation received by the receiver element 21, 22.

[0034] In accordance with the present invention, the first housing 11 and the second housing 12 develop substantially perpendicular to a longitudinal axis X-X of the enclosure 10.

[0035] Furthermore, in the embodiments of the sensor 1 according to the present invention, the first housing 11 and the second housing 12 are realized in such a way as to face towards each other, in particular the enclosure 10 being so realized to comprise a recess 13 interposed between said first housing 11 and second housing 12. It is clear that, in a normal operating condition of the sensor 1 according to the present invention, the washing liquid that surrounds, at least partially, said enclosure 10, the degree of turbidity of which is to be measured, is situated in said recess 13.

[0036] Moreover, in all embodiments of the sensor 1 according to the present invention, the first housing 11 is shaped substantially as a protuberance projecting perpendicularly relative to the longitudinal axis X-X of the enclosure 10.

[0037] In the first embodiment shown in Figures 1 to 2b and in the variant shown in Figure 3, the second housing 12 is shaped substantially as a circular sector in a plan view, i.e. when viewed in a direction substantially parallel to the longitudinal axis X-X of the enclosure 10.

[0038] In the second embodiment shown in Figures 4 to 5b, also the second housing 12 is shaped substantially as a protuberance projecting perpendicularly to the longitudinal axis X-X of the enclosure 10; in substance, its shape is similar to that of the first housing 11.

[0039] The sensor 1 according to the present invention comprises a board 30, in particular an electronic board made of insulating material, provided with a plane 31 whereon the first element 21 and the second element 22 are positioned, said board 30 being positioned within the enclosure 10 in a manner such that the first housing 11 and the second housing 12 develop substantially orthogonal to said plane 31. Such characteristics of the sensor

1 according to the present invention can be especially appreciated in Figures 2b, 5a and 7b.

[0040] In this frame, the first element 21 and the second element 22 are positioned on the plane 31 of the board 30 in such a way that the electromagnetic radiation will develop in a direction substantially parallel to said plane 31 of the board 30 and to the longitudinal axis X-X of the enclosure 10.

[0041] The board 30 further comprises a circuit (not shown in the annexed drawings), in particular a printed electric circuit, to which the first element 21 and the second element 22 are connected.

[0042] In addition, the board 30 comprises at least one terminal 32 to allow said board 30 to be connected to other components, in particular of a washing machine. In a preferred embodiment, said connection is implemented by means of a plug-type and/or RAST connection (like the one shown in the annexed drawings); it is however clear that the connection between the board 30 and the washing machine can also be accomplished otherwise.

[0043] The board 30 further comprises a notch 33 located in a portion of the board 30 comprised between the first element 21 and the second element 22, said notch 33 being adapted to match the recess 13 of the enclosure 10 when the board 30 is positioned within said enclosure 10.

[0044] In a preferred embodiment, the enclosure 10 comprises a chamber 10A adapted to house the board 30, and from which the first housing 11 and the second housing 12 extend, in particular said chamber 10A prevalently developing along said longitudinal axis A-A.

[0045] The peculiar features of the sensor 1 according to the present invention make it possible to overcome the drawbacks of prior-art sensors.

[0046] In fact, the particular design of the first housing 11 and second housing 12, which develop substantially perpendicular to a longitudinal axis X-X of the enclosure 10, allows positioning the first emitter/receiver element 21 and the second receiver/emitter element 22 (which form a pair of optical elements for detecting the degree of turbidity of the washing liquid) at a mutual distance that does not depend on the dimension of the outside diameter of the sensor 1. It follows that the distance between the first emitter/receiver element 21 and the second receiver/emitter element 22 does not imply any dimensional constraints as concerns either the diameter of the sensor 1 or the hole to be made in the washing machine for housing the complete sensor 1.

[0047] As a consequence, the features of the present invention make it possible to modify, as a function of the required sensitivity, the distance between the first housing 11 and the second housing 12, and also between the first emitter/receiver element 21 and the second receiver/emitter element 22, as well as to physically calibrate the liquid turbidity reading output according to the measurement requirements of specific applications. For example, the teachings of the present invention permit adjusting the distance between the first emitter/receiver element 21 and the second receiver/emitter element 22 on the basis of the different characteristics of the different types of sensors that may be used, in particular such characteristics concerning voltage intensity, optimum distance, etc.

[0048] It should be noted that the provisions of the present invention make it possible to realize the first housing 11 and the second housing 12 in such a way that they have adequate dimensions in terms of length-to-width ratio, thus facilitating the alignment between the first emitter/receiver element 21 and the second receiver/emitter element 22 and avoiding possible alignment errors.

[0049] It inevitably follows from this that the provisions of the sensor 1 according to the present invention make it possible to obtain a correct reading of the turbidity of the liquid.

[0050] The sensor 1 according to the present invention also allows measuring large liquid passage sections, thus making it also possible to measure very extended areas, the diameter of the sensor 1 being equal; in fact, in accordance with the provisions of the present invention, the distance between the housings 11, 12 (and also between the associated emitter/receiver elements 21, 22) can be changed as necessary by modifying at will the longitudinal distance between such elements, without however requiring any interventions on the dimension of the outside diameter of the sensor 1.

[0051] It is therefore clear that, since the distance between the housings 11, 12 and between the associated emitter/receiver elements 21, 22 can be quite long, the space subject to reading can be ample as well, to advantage of the accuracy and precision of the measurement taken.

[0052] It is also apparent that the solution provided by the present invention permits obtaining accurate and precise measurements on entire liquid passage sections and/or for flows of different nature.

[0053] In accordance with the present invention, the sensor 1 comprises a temperature sensor 24 adapted to sense the temperature of the washing liquid that surrounds, at least partially, the enclosure 10.

[0054] Said temperature sensor 24 is housed in a third housing 14 of the enclosure 10, in particular said third housing 14 being such as to prevalently develop in a direction substantially parallel to the longitudinal axis X-X of the enclosure 10. In this regard, it should be noted that, in the variant shown in Figure 3 of the first embodiment of the sensor 1 according to the present invention, the third housing 14 is so realized as to comprise:

- a first portion 14A developing along said direction substantially parallel to the longitudinal axis X-X of the enclosure 10;
- a second portion 14B developing from said first portion 14A along a direction substantially perpendicular to the longitudinal axis X-X of the enclosure 10,

i.e. developing along a direction substantially parallel to the development of said first housing 11 and second housing 12.

[0055] In a preferred embodiment, the temperature sensor 24 is positioned on the plane 31 of the board 30; in particular, said temperature sensor 24 is positioned on a branch 34 of said board 30 that extends along a direction substantially parallel to the longitudinal axis X-X of the enclosure 10.

[0056] It is apparent that the fact that the sensor 1 according to the present invention is realized to comprise also the temperature sensor 14 makes it possible to obtain complete and thorough detections of the properties of the washing liquid, in particular by combining the results obtained in terms of turbidity and temperature of the liquid that surrounds, at least partially, the enclosure 10 of the sensor 1.

[0057] Because the temperature sensor 14 according to the present invention is exposed to contact with the liquid on more than one side, it also ensures better precision of the liquid temperature reading and a faster and more efficient reaction to changes thereof, since better heat transmission is allowed from the washing liquid to the temperature sensor 14.

[0058] Furthermore, the provisions of the present invention make it possible to position the temperature sensor 14 in a way independent of the positions of the turbidity sensing elements 21, 22, and this permits configuring each one of said components optimally to ensure better measurements of both parameters (turbidity and temperature).

[0059] The sensor 1 according to the present invention further comprises a base (or cover) 40 associated with the enclosure 10; preferably, said base 40 comprises fastening means (not shown in detail) ensuring a stable coupling between the board 30 and the base 40.

[0060] In this frame, the enclosure 10 comprises a connecting portion 10B, in particular having a shape complementary (as especially visible in Figures 2b, 5a and 5b) to that of the base 40 for establishing the connection between such components.

[0061] As shown in the annexed drawings, the second housing 12 is preferably so realized as to join said connecting portion 10B; this is provided in both the first embodiment shown in Figures 1 to 3 (wherein the second housing 12 is shaped substantially as a circular sector in a plan view) and in the second embodiment shown in Figures 4 to 5b (wherein the second housing 12 is shaped substantially as a protuberance projecting perpendicularly to the longitudinal axis X-X of the enclosure 10).

[0062] It is however clear that the second housing 10 may also be implemented in such a way that it is distinctly separated from the connecting portion 10B of the enclosure 10, without joining it.

[0063] Moreover, the base 40 is preferably provided with coupling means (not shown), which allow coupling the sensor 1 to a washing machine.

[0064] Preferably, in the first embodiment (shown in Figures 1 to 3) and in the second embodiment (shown in Figures 4 to 5b), the main components of the sensor 1 (i.e. the enclosure 10 and/or the board 30 and/or the base 40) are manufactured by moulding, in particular by injection moulding.

[0065] In particular, the enclosure 10 is preferably obtained by injection moulding of a plastic material transparent to infrared and visible light (e.g. polypropylene), and the base 40 is obtained by injection moulding of plastic materials such as polybutylene terephthalate (PBT) and/or polyamide (PA) and/or polypropylene (PP), optionally added with fibres (e.g. glass fibres).

[0066] In this frame, the coupling between the enclosure 10 and the base 40 occurs through interposition of at least one sealing element (not shown in detail in the annexed drawings) in order to allow the washing liquid to penetrate into the enclosure 10.

[0067] As far as the third embodiment of the sensor 1 according to the present invention is concerned (shown in Figures 6 to 7b), the enclosure 10 is associated with the board 30 and/or with the base 40 by overmoulding, in particular by low pressure overmoulding (LPM). This provision allows preserving the component whereon the overmoulding process is carried out, in addition to implying lower tooling costs and speeding up the product production, testing and performance phases.

[0068] Preferably, in the third embodiment of the present invention the temperature sensor 14 is immersed in a medium having high thermal conductivity. In addition to ensuring a faster and more precise reading of the temperature of the washing liquid, this feature provides savings in terms of the heat conductive paste that would otherwise be required.

[0069] Furthermore, in the third embodiment the overmoulding of the enclosure 10 is preferably carried out in such a way as to reduce the thickness of said enclosure 10 around the temperature sensor 14, thus correspondingly reducing the distance between said temperature sensor 14 and the washing liquid, and hence further increasing the precision of the washing liquid temperature reading.

[0070] It should be noted that, in said third embodiment, the moulding of the enclosure 10 over the board 30 makes it possible to manufacture said enclosure 10 in a manner such that it has small dimensions, especially in terms of thickness, i.e. dimensions only slightly greater than those of said board 30, since it is no longer necessary to make the undercuts that are typically necessary for moulding traditional components.

[0071] As a result, the sensor 1 made in accordance with the third embodiment permits measuring flows of liquid coming from different directions; for example, the sensor 1 shown in Figures 6 to 7b is realized in such a way to be able to take a measurement of a flow of fluid coming from a direction substantially perpendicular to the plane 31 of the board 30 and also a measurement of a flow of fluid coming from a direction substantially par-

allel to said plane 31 of the board 30.

[0072] The features of the sensor 1 according to the present invention, as well as the advantages thereof, are apparent from the above description.

[0073] In fact, the provisions of the present invention allow positioning the first element 21 and the second element 22 forming the pair of optical elements at a mutual distance wholly independent from the dimension of the outside diameter of the sensor 1. It follows that the distance between the first emitter/receiver element 21 and the second receiver/emitter element 22 implies no dimensional constraint as concerns either the diameter of the sensor 1 or the hole in the washing machine for housing the whole sensor 1.

[0074] As a consequence, the features of the present invention permit changing the distance between the first housing 11 and the second housing 12 (and, hence, also between the first emitter/receiver element 21 and the second receiver/emitter element 22) as a function of the required sensitivity, and physically calibrating the liquid turbidity reading output according to measurement requirements of specific applications.

[0075] It should be noted that the provisions of the present invention make it possible to realize the first housing 11 and the second housing 12 in such a way that they have adequate dimensions (in particular, in terms of length-to-width ratio), thus facilitating the alignment between the first emitter/receiver element 21 and the second receiver/emitter element 22 and avoiding possible alignment errors. It inevitably follows that the provisions of the sensor 1 according to the present invention make it possible to obtain a correct liquid turbidity reading.

[0076] The sensor 1 according to the present invention also allows measuring large liquid passage sections, while also making it possible to measure very extended areas, the diameter of the sensor 1 being equal.

[0077] In fact, in accordance with the provisions of the present invention, the distance between the housings 11, 12 (and also between the respective emitter/receiver elements 21, 22) can be changed according to specific requirements and necessities, in particular by modifying at will the longitudinal distance between such elements, without however requiring any interventions on the dimension of the outside diameter of the sensor 1. It is therefore apparent that, since the distance between the housings 11, 12 and between the respective emitter/receiver elements 21, 22 may be quite long, the space subject to reading may be very large as well, to advantage of the accuracy and precision of the measurement taken.

[0078] It is also apparent that the solution provided by the present invention permits obtaining accurate and precise measurements on entire liquid passage sections and/or for flows of different nature.

[0079] It should also be noted that the peculiar provisions concerning the temperature sensor 14 according to the present invention make it possible to expose it to contact with the liquid on more than one side, resulting in better precision of the liquid temperature reading and a faster and more efficient reaction to changes thereof, since better heat transmission from the liquid to the temperature sensor 14 is ensured.

[0080] Furthermore, the provisions of the present invention make it possible to position the temperature sensor 14 in a way independent of the positions of the turbidity sensing elements 21, 22, and this permits configuring each one of said components optimally to ensure better measurements of both parameters.

[0081] An additional advantage of the sensor 1 according to the present invention is due to the possible association of the enclosure 10 with the board 30 and/or with the base 40 by overmoulding, in particular by low pressure overmoulding (LPM). This provision allows preserving the component whereon the overmoulding process is carried out, in addition to implying lower tooling costs and speeding up the product production, testing and performance phases.

[0082] It should also be noted that, in addition to ensuring a faster and more precise reading of the temperature of the washing liquid, the fact that the temperature sensor 14 is immersed in a medium having high thermal conductivity provides savings in terms of the heat conductive paste that would otherwise be required. Moreover, the precision of the reading of the washing liquid temperature is further improved due to the fact that the thickness of said enclosure 10 around the temperature sensor 14 is reduced when overmoulding the enclosure 10. Also, the fact that the sensor 1 according to the present invention is manufactured by overmoulding the enclosure 10 on the board 30 makes it possible to manufacture said enclosure 10 in a manner such that it has small thickness dimensions, i.e. dimensions only slightly greater than those of said board 30, since it is not necessary to make the undercuts that are typically required for moulding traditional components. As a consequence, the sensor 1 realized in accordance with said third embodiment allows taking measurements on flows of liquid coming from different directions.

[0083] The sensor 1 described herein by way of example may be subject to many possible variations without departing from the novelty spirit of the inventive idea; it is also clear that in the practical implementation of the invention the illustrated details may have different shapes or be replaced with other technically equivalent elements.

Claims

1. Turbidity sensor (1) for a washing machine, in particular for household use, said sensor (1) comprising:

   - an enclosure (10) adapted to be positioned in the washing machine in such a way that it is at least partially surrounded by a washing liquid, said enclosure (10) being provided with a first housing (11) and a second housing (12);

- a first element (21) emitting/receiving an electromagnetic radiation, housed in the first housing (11) of the enclosure (10);
- a second element (22) receiving/emitting an electromagnetic radiation, housed in the second housing (12) of the enclosure (10),

wherein the first housing (11) and the second housing (12) are at least partially made of transparent material to allow said electromagnetic radiation to be transmitted/received by the first element (21), propagate between the first housing (11) and the second housing (12) externally to said enclosure (10), and be received/transmitted by the second element (12) for the purpose of detecting the degree of turbidity of the washing liquid that surrounds at least partially said enclosure (10) and that is located between the first housing (11) and the second housing (12), **characterized in that**

the first housing (11) and the second housing (12) develop substantially perpendicular to a longitudinal axis (X-X) of the enclosure (10) and in such a way as to face towards each other, in particular the enclosure (10) being so realized as to comprise a recess (13) between said first housing (11) and second housing (12).

2. Sensor (1) according to claim 1, **characterized in that** the first housing (11) is shaped substantially as a protuberance projecting perpendicularly relative to the longitudinal axis (X-X) of the enclosure (10).

3. Sensor (1) according to one or more of the preceding claims, **characterized in that** the second housing (12) is shaped substantially as a circular sector in a plan view, i.e. in a direction substantially parallel to the longitudinal axis (X-X) of the enclosure (10).

4. Sensor (1) according to one or more of claims 1 to 3, **characterized in that** the second housing (12) is shaped substantially as a protuberance projecting perpendicularly to the longitudinal axis (X-X) of the enclosure (10).

5. Sensor (1) according to one or more of the preceding claims, **characterized in that** it comprises a board (30), in particular an electronic board made of insulating material, provided with a plane (31) whereon the first element (21) and the second element (22) are positioned, said board (30) being positioned within the enclosure (10) in a manner such that the first housing (11) and the second housing (12) develop substantially orthogonal to said plane (31).

6. Sensor (1) according to claim 5, **characterized in that** said board (30) comprises a notch (33) located in a portion of the board (30) comprised between the first element (21) and the second element (22), said notch (33) being adapted to match the recess (13) of the enclosure (10) when the board (30) is positioned within said enclosure (10).

7. Sensor (1) according to one or more of claims 5 and 6, **characterized in that** said board (30) comprises:

- a circuit, in particular a printed electric circuit, to which the first element (21) and the second element (22) are connected;
- at least one terminal (32) to allow said board (30) to be connected to other components.

8. Sensor (1) according to one or more of claims 5 to 7, **characterized in that** the enclosure (10) comprises a chamber (10A) adapted to house the board (30), and from which the first housing (11) and the second housing (12) extend, in particular said chamber (10A) prevalently developing along said longitudinal axis (A-A).

9. Sensor (1) according to one or more of the preceding claims, **characterized in that** it comprises a temperature sensor (24) adapted to sense the temperature of the washing liquid that surrounds at least partially the enclosure (10), said temperature sensor (24) being housed in a third housing (14) of the enclosure (10), in particular said third housing (14) being such as to prevalently develop in a direction substantially parallel to the longitudinal axis (X-X) of the enclosure (10).

10. Sensor (1) according to claim 9, **characterized in that** said third housing (14) is so realized as to comprise:

- a first portion (14A) developing along said direction substantially parallel to the longitudinal axis (X-X) of the enclosure (10);
- a second portion (14B) developing from said first portion (14A) along a direction substantially perpendicular to the longitudinal axis (X-X) of the enclosure (10) and along a direction substantially parallel to the development of said first housing (11) and second housing (12).

11. Sensor (1) according to one or more of claims 9 and 10, **characterized in that** the temperature sensor (24) is positioned on the plane (31) of the board (30), in particular said temperature sensor (24) being positioned on a branch (34) of said board (30) that extends along a direction substantially parallel to the longitudinal axis (X-X) of the enclosure (10).

12. Sensor (1) according to one or more of the preceding claims, **characterized in that** it comprises a base (40) associated with the enclosure (10), and the enclosure (10) comprises a connecting portion (10B)

having a shape complementary to that of the base (40) for connecting such components.

13. Sensor (1) according to one or more of the preceding claims, **characterized in that** the enclosure (10) is associated with the board (30) and/or with the base (40) by overmoulding, in particular by low pressure overmoulding.

14. Washing machine comprising a sensor (1) according to one or more of the preceding claims.

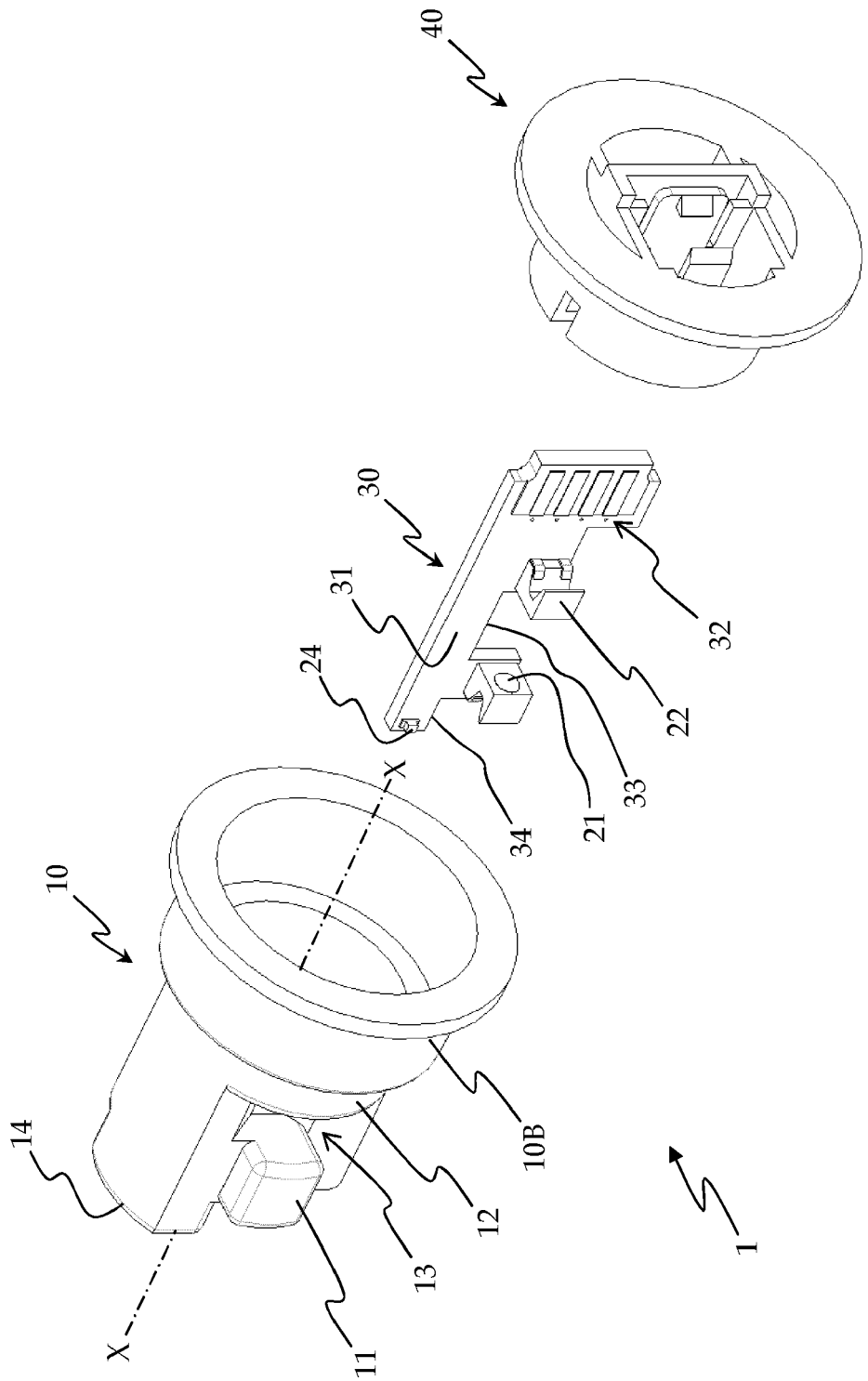

Fig. 1

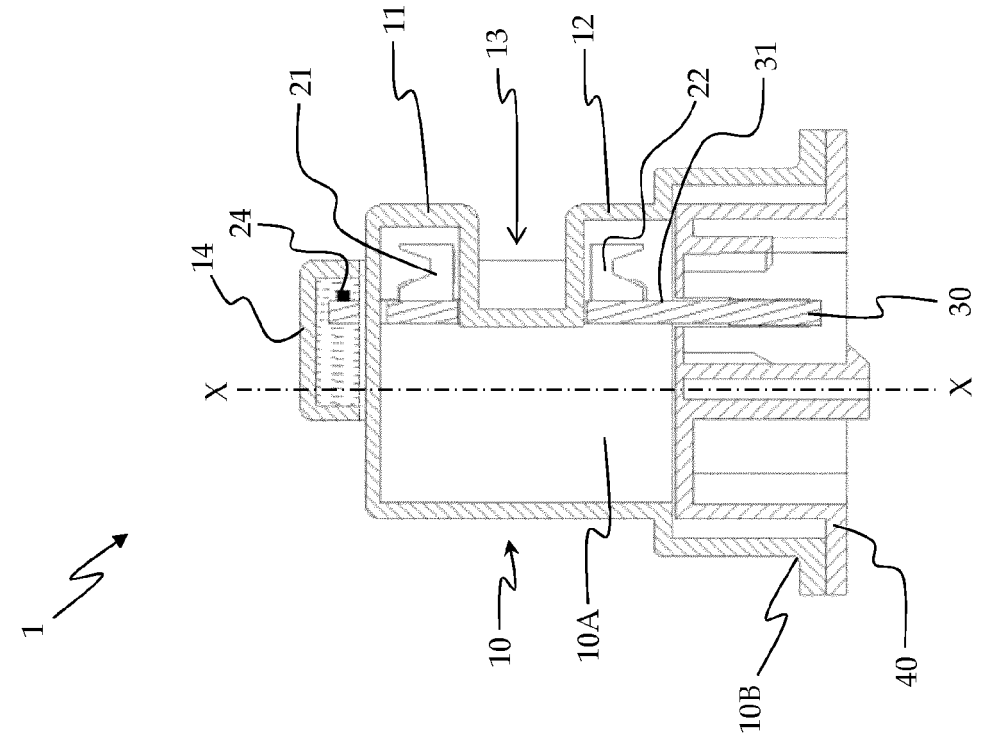

Fig. 2b

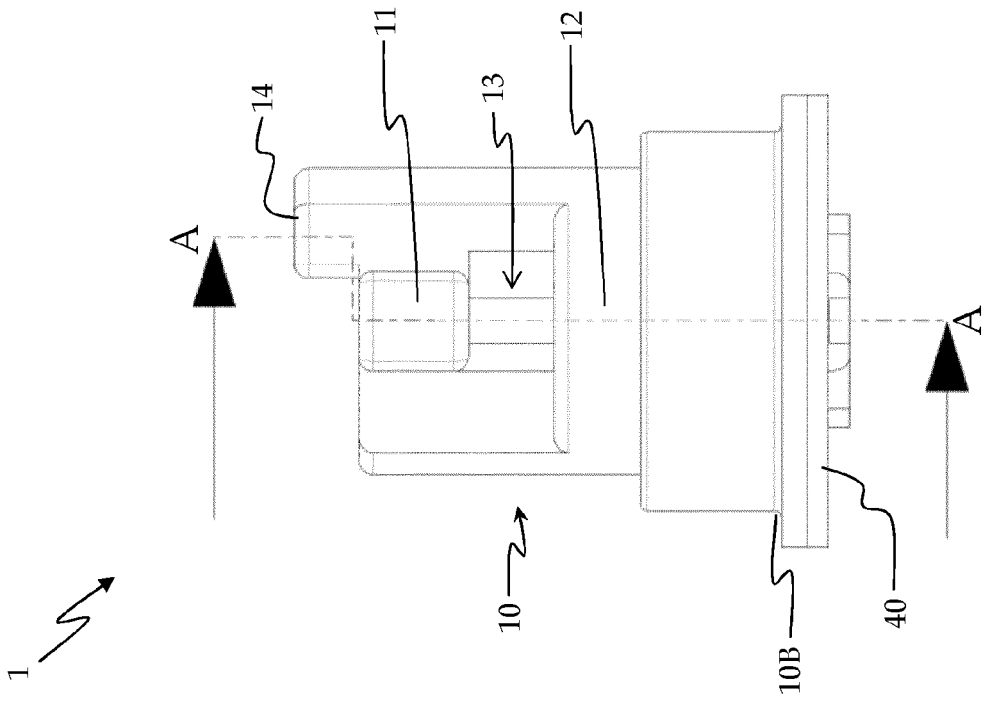

Fig. 2a

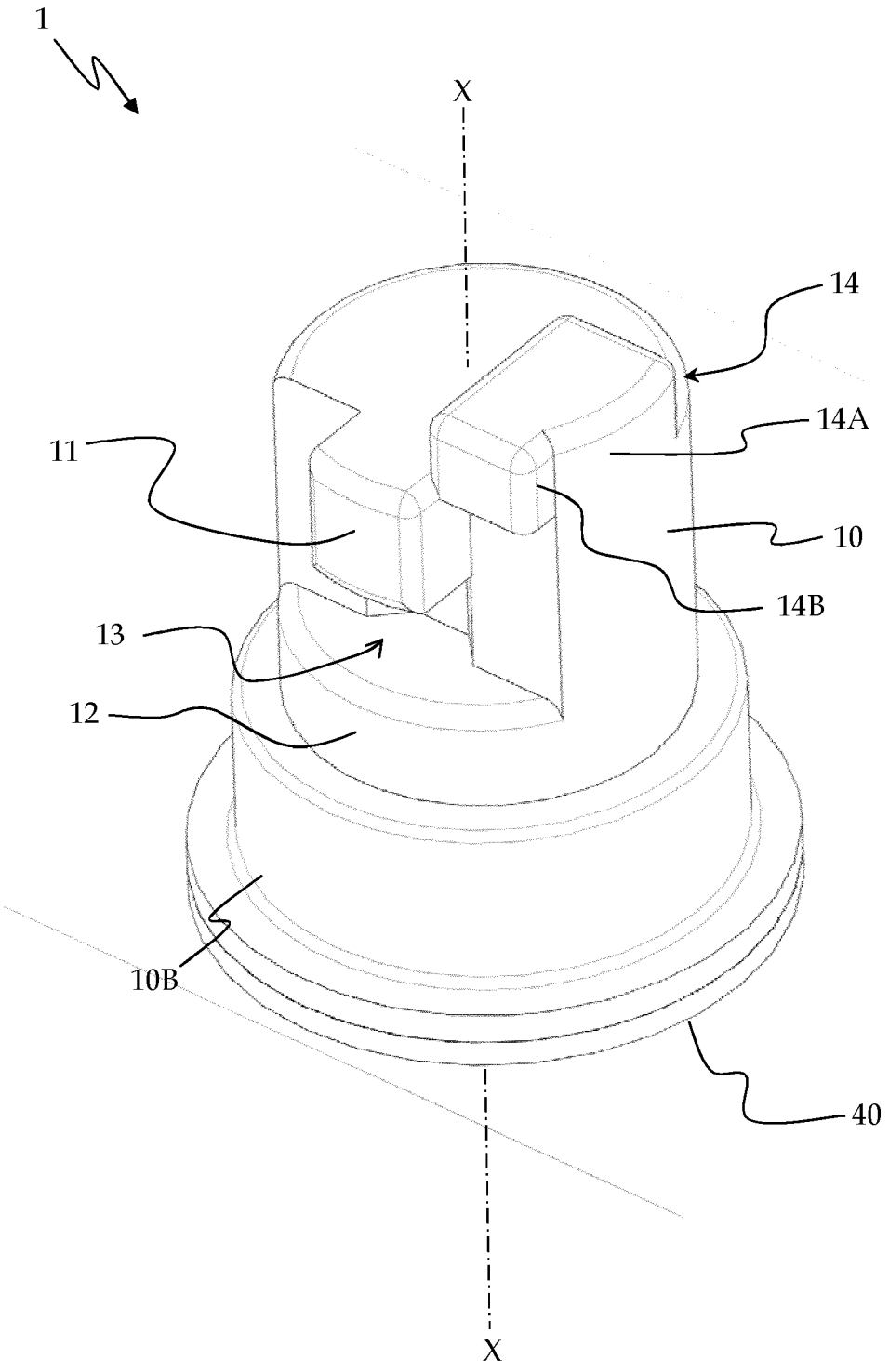

Fig. 3

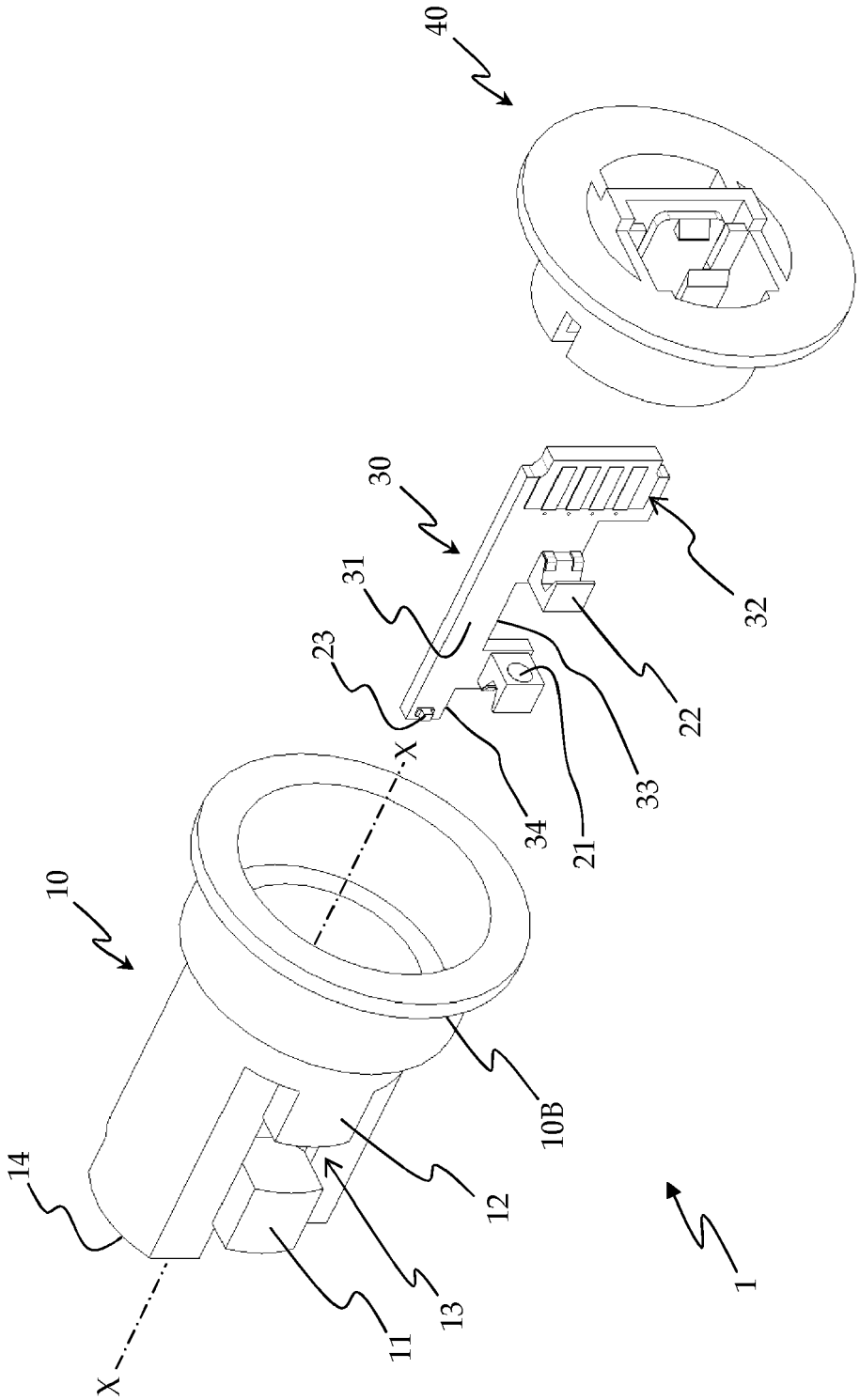

Fig. 4

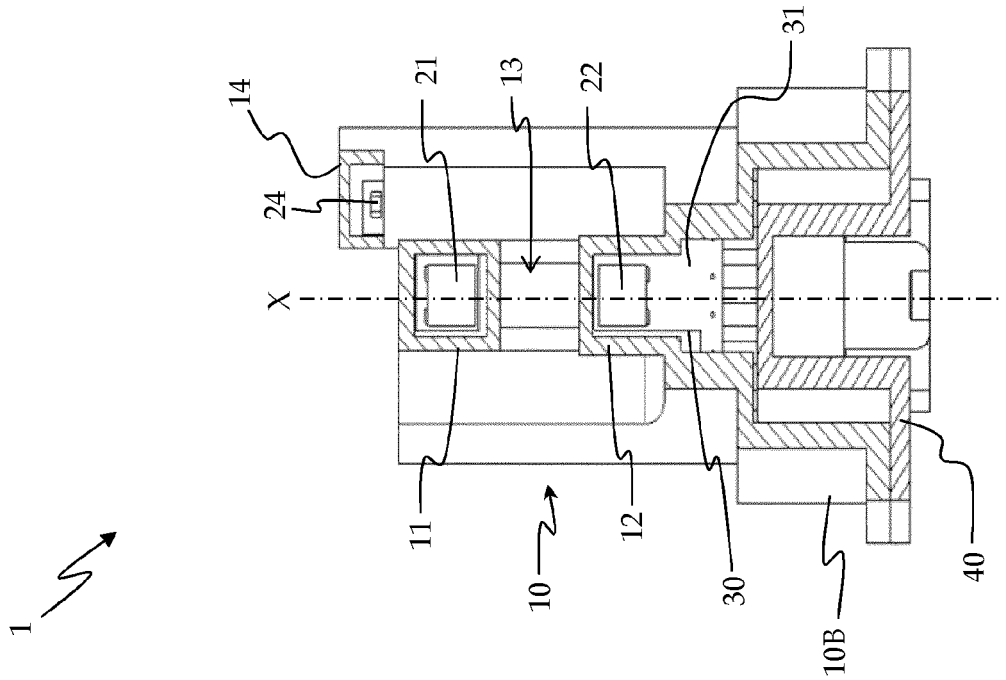
1
14
24
21
13
22
31
X
11
10
12
30
10B
40

Fig. 5b

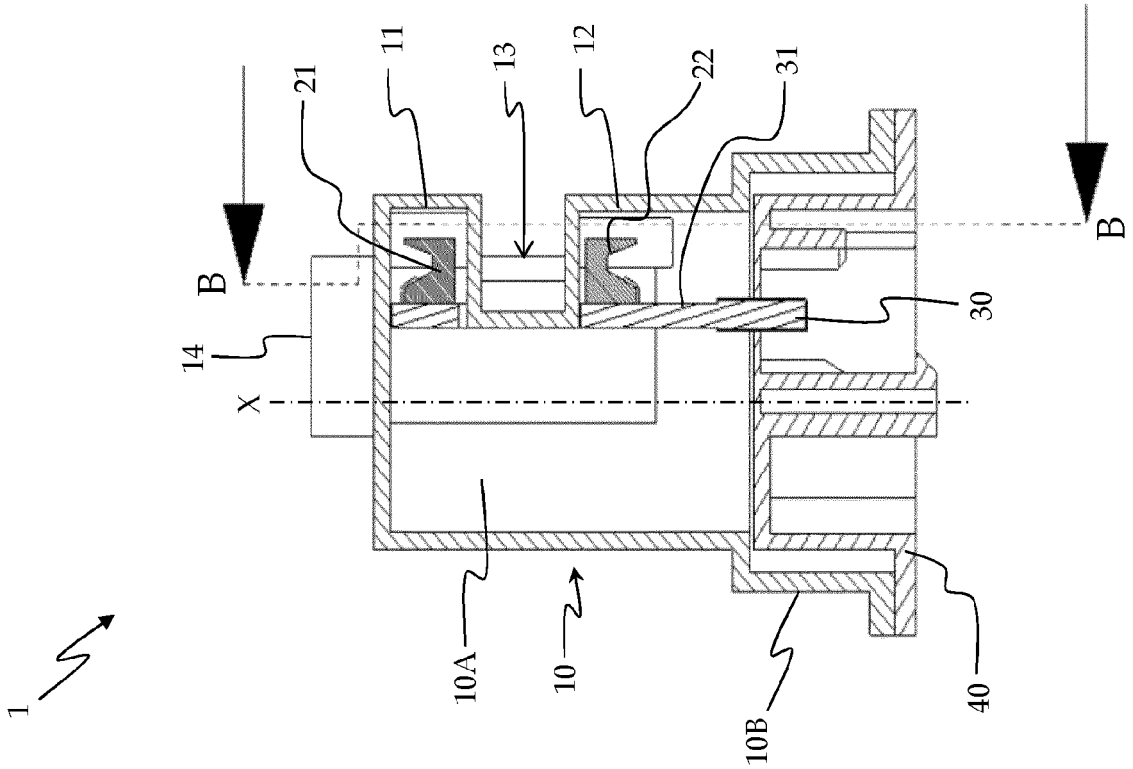
1
B
B
14
X
21
11
13
12
22
31
30
10A
10
10B
40

Fig. 5a

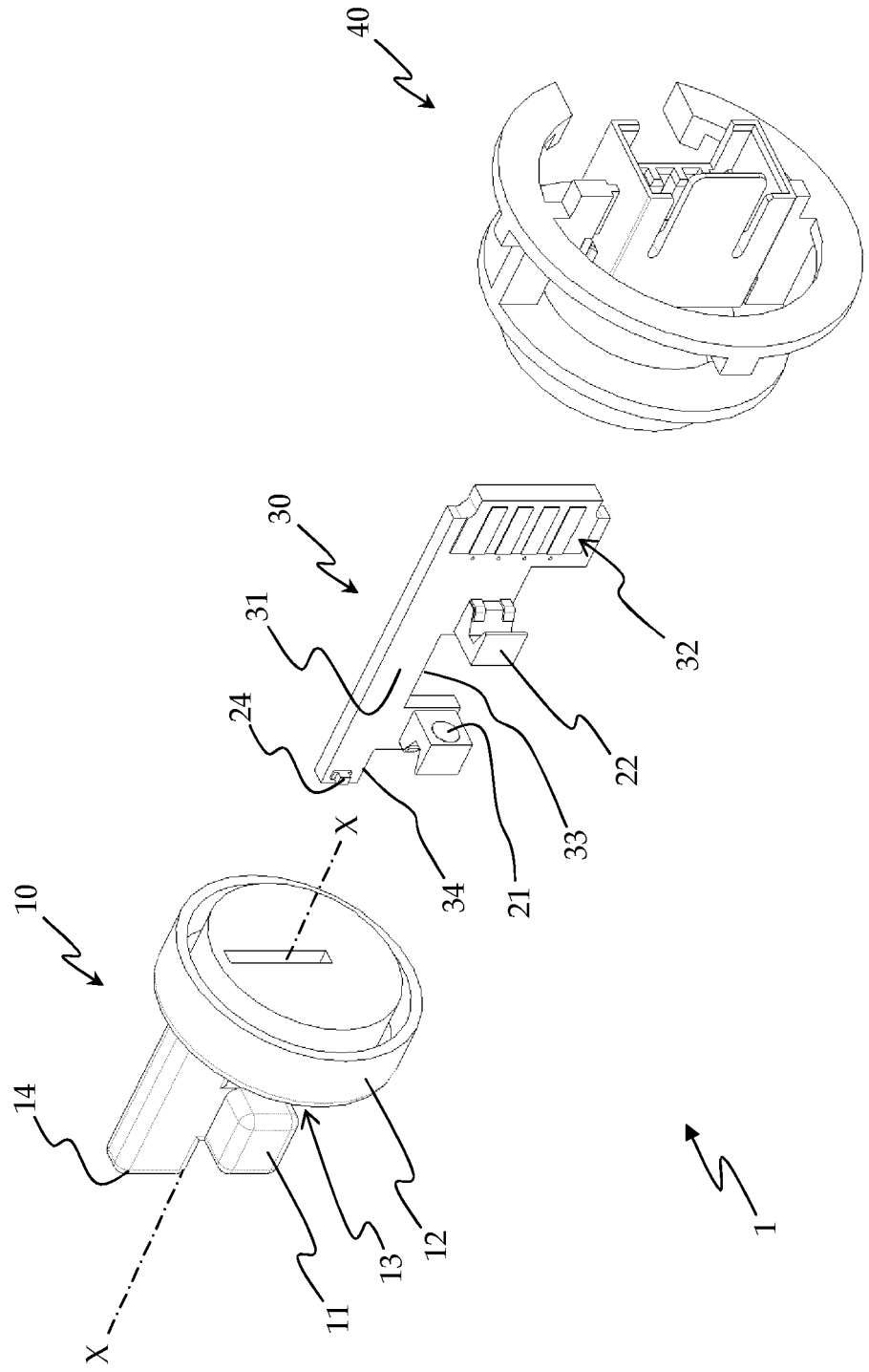

Fig. 6

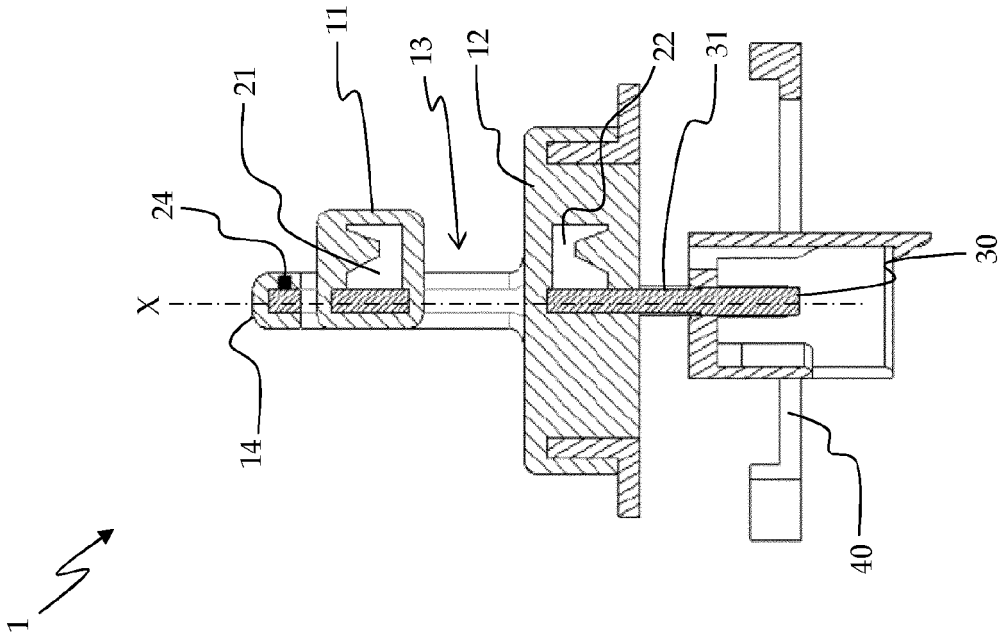

Fig. 7b

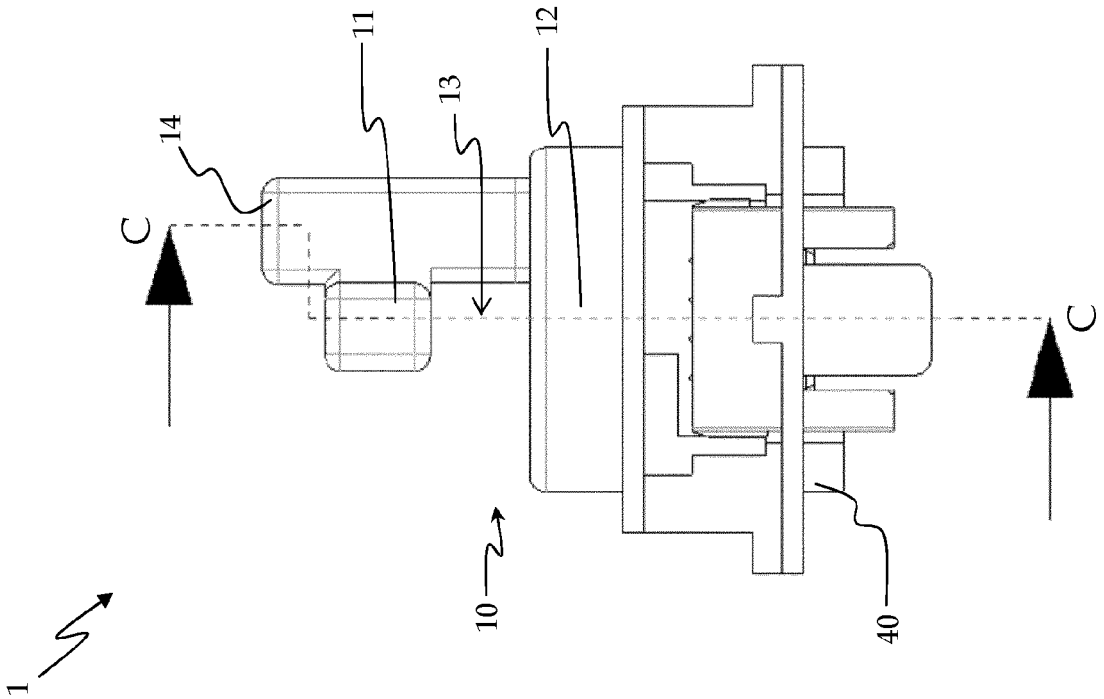

Fig. 7a

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EUROPEAN SEARCH REPORT

Application Number
EP 20 16 2535

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 208 537 395 U (FOSHAN CHUANDONG MAGNETOELECTRICITY CO LTD) 22 February 2019 (2019-02-22)	1,12,14	INV. D06F39/00 A47L15/42
A	* figures *	2-11,13	D06F34/22
X	WO 2017/002032 A1 (BITRON SPA [IT]) 5 January 2017 (2017-01-05)	1,14	
A	* pages 5-7; figures *	2-13	
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A	* figures *	2-13	

TECHNICAL FIELDS SEARCHED (IPC)

D06F
A47L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 July 2020	Stroppa, Giovanni

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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06-07-2020

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- EP 2004031 A1 **[0009] [0011] [0012] [0013] [0020]**
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