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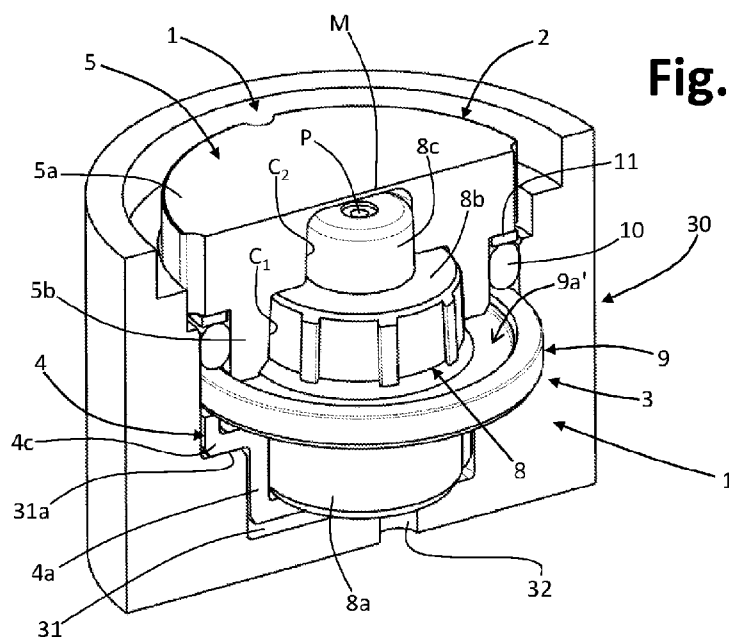


Fig. 15

(57) Abstract: A pressure-sensor assembly (1) for detecting the pressure of a fluid comprises: - a pressure-sensitive component (2), having a generally cup-shaped sensor body (5), which includes a bottom portion (5a) and a peripheral portion (5b) that define an axial cavity (C₁, C₂), the bottom portion (5a) including an elastically deformable membrane part, which closes the axial cavity (C₁, C₂) at one end of the sensor body (5), and the peripheral portion (5b) having a distal edge opposite to the bottom portion (5a), which delimits an inlet of the axial cavity (C₁, C₂), the bottom portion (5a) having associated thereto at least one element for detecting deformation of the membrane part; and - a compensation element (3), configured for compensating possible variations of volume of the fluid, comprising at least one compensation body (8), made of a first elastically deformable or compressible material, and a core (9) fixed on which is the at least one compensation body (8), the core (9) being made of a second material stiffer than the first material. The sensor body (5) and the compensation

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element (3) are configured as distinct parts, and at least one first portion (8b, 8c) of the compensation element (3) is configured for coupling with elastic interference on the sensor body (5), in such a way that the pressure-sensitive component (2) and the compensation element (3) can be handled as a single unit.

Pressure-sensor assembly, and corresponding device and insert**DESCRIPTION****Field of the invention**

5 The present invention relates to sensor devices for detecting the pressure of a fluid. The invention has been developed with particular reference to self-standing sensor assemblies for such devices, which comprise at least one pressure-sensitive element and one element for compensation of any possible increase in volume of the fluid. The invention finds preferred application in the field of self-standing sensors or sensor assemblies for use on vehicles, in particular in
10 hydraulic apparatuses and systems for vehicles.

Prior art

 From WO2008/078184 A2, filed in the name of the present Applicant, a pressure-sensor device is known, which comprises a pressure-sensitive
15 component, having a substantially cup-shaped sensor body, i.e., having a blind cavity the bottom of which is formed by a membrane part. The membrane part is elastically deformable, and associated thereto is a detection element, such as a bridge of resistive or piezoresistive elements. The device likewise comprises a casing, including a supporting body defining a duct, through which the fluid the
20 pressure of which is to be detected can reach the cavity of the sensor body and bring about possible elastic deformation of the corresponding membrane part.

 In some applications, the devices of the type referred to are designed to operate even in conditions of very low temperature. For this reason, it may occasionally happen that the fluid present within the device freezes, thus
25 increasing in volume: given that the membrane part of the sensor body is usually relatively thin and delicate, it is important to adopt solutions that will prevent its failure of and/or damage to the corresponding detection element following upon the increase in volume of the fluid due to freezing.

 The aforementioned prior document consequently proposes associating to
30 the supporting body of the device one or more compressible compensation elements, suitable for compensating any possible increase in volume of the fluid following upon freezing thereof, with each of such elements that may possibly define a portion of the aforesaid duct for the fluid. In some versions described, such a compensation element is mounted on the outside of the supporting body,
35 substantially at the cavity of the sensor body so as to project thereinto. In some

embodiments, the compensation element is fixed in position on the supporting body by exploiting a tubular positioning insert, made of relatively stiff material, which is partially inserted – for example via screwing – into the outlet of the duct that delivers the fluid towards the membrane part (see, for example, Figures 15-20
5 or 24 of the aforementioned prior document). In other embodiments, the compensation element is positioned on an insert, which is in turn held in position by a bottom arrest element, the insert and the arrest element being engaged in the aforementioned duct through its inlet end (see, for example, Figures 21-23 of the aforementioned document).

10 The sensor devices proposed in the aforementioned prior document are on average efficient from a functional standpoint, but present some drawbacks in terms of times and costs of production and installation of the corresponding compensation elements that it would be desirable to reduce. Installation of the compensation elements moreover presupposes a relatively complex construction
15 of the supporting body so as to define a duct into which the insert of a compensation element is designed to be fitted, with a dedicated operation.

From WO 2016/103171 A1, filed in the name of the present Applicant, there is also known a sensor assembly that comprises a pressure-sensitive component, which also has a substantially cup-shaped sensor body, directly
20 overmoulded on which is a body made of elastically compressible material that performs functions of compensation element, and possibly functions of sealing element and/or elastic supporting element. In some embodiments described (see, for example, Figures 37-39 of the aforementioned prior document), the aforesaid compressible body is overmoulded on the sensor body within the blind cavity of
25 the corresponding cup-shaped body. The above solutions according to WO 2016/103171 A1 prove advantageous in the production stage, in so far as they enable a self-standing or independent sensor assembly to be obtained, i.e., a sensor assembly that, albeit including both a pressure-sensitive element and a compensation element, can be handled as a single unit. Production of such
30 assemblies is, however, relatively complicated and costly, in terms of industrial process and manufacturing machinery, in view of the need to overmould in a safe and precise way the compliant material that is to form the compressible body within the cavity of the sensor body.

Summary of the invention

35 In its general terms, the present invention is aimed at providing a pressure

sensor, or a pressure-sensor assembly, in particular of a self-standing or independent type, that is simpler and less expensive to produce than those of the prior art. A related aim of the invention is to provide pressure-sensor devices and compensation elements that can be advantageously used with the aforesaid sensor assemblies.

One or more of the above aims are achieved, according to the present invention, by a pressure-sensor assembly, a pressure-sensor device, and a compensation element that present the characteristics referred to in the annexed claims, which form an integral part of the teaching provided herein in relation to the invention.

Brief description of the drawings

Further purposes, characteristics, and advantages of the invention will emerge clearly from the ensuing detailed description, which is provided with reference to the annexed schematic drawings, wherein:

- Figure 1 is a perspective view of a pressure-sensor assembly according to possible embodiments, with an optional shielding element;

- Figure 2 is a perspective view of the assembly of Figure 1, with the aforementioned shielding element coupled thereto;

- Figures 3 and 4 are exploded views from different angles of a sensor assembly of the type illustrated in Figures 1-2;

- Figures 5 and 6 are perspective views from different angles of a compensation element of a sensor assembly according to possible embodiments;

- Figures 7 and 8 are sectioned perspective views of a compensation element of a sensor assembly according to possible embodiments;

- Figures 9 and 10 are perspective views from different angles of a core or reinforcement of a compensation element of a sensor assembly according to possible embodiments;

- Figures 11 and 12 are perspective views from different angles of a shielding element for a sensor assembly according to possible embodiments;

- Figures 13 and 14 are perspective views from different angles of a pressure-sensor device, comprising a sensor assembly and a casing part of a first type, according to possible embodiments;

- Figures 15 and 16 are sectioned perspective views, from different angles, of a pressure-sensor device, comprising a sensor assembly and a casing part of a second type, according to possible embodiments;

- Figures 17 and 18 are partial cross-sectional views, according to mutually orthogonal planes, of a pressure-sensor device according to possible embodiments, including a sensor assembly and casing parts structurally similar to the ones illustrated in Figures 13-14 and 15-16;

5 - Figure 19 is a perspective view of a sensor assembly with a corresponding shielding element coupled thereto, according to further possible embodiments;

 - Figure 20 is a sectioned perspective view of the sensor assembly of Figure 19;

10 - Figures 21 and 22 are exploded views of a sensor assembly of the type illustrated in Figure 20;

 - Figures 23 and 24 are perspective views of a compensation element for a sensor assembly of the type illustrated in Figure 19, with the corresponding shielding element represented in exploded view;

15 - Figure 25 is a sectioned perspective view of just the compensation element of Figures 23-24;

 - Figures 26 and 27 are perspective views from different angles of a core or reinforcement of a compensation element of the type illustrated in Figure 25;

20 - Figures 28 and 29 are sectioned perspective views of a pressure-sensor device comprising a sensor assembly of the type illustrated in Figures 19-20 and a casing part according to possible embodiments;

 - Figures 30 and 31 are partial cross-sectional views, according to mutually orthogonal planes, of a pressure-sensor device comprising a sensor assembly of the type illustrated in Figures 19-20 and two casing parts according to possible
25 embodiments;

 - Figure 32 is a cross-sectional view similar to that of Figure 31, regarding a possible variant embodiment;

 - Figures 33 and 34 are exploded views of a sensor assembly according to further possible embodiments;

30 - Figures 35 and 36 are sectioned perspective views of a sensor assembly of the type illustrated in Figures 33-34;

 - Figure 37 is a sectioned perspective view of a pressure-sensor device with a sensor assembly of the type illustrated in Figures 35-36, and a casing part, according to possible embodiments;

35 - Figure 38 is a sectioned perspective view of a pressure-sensor device

with a sensor assembly of the type illustrated in Figures 35-36, and two casing parts, according to possible embodiments;

- Figure 39 is a partial cross-sectional view of a pressure-sensor device of the type illustrated in Figure 38;

5 - Figures 40 and 41 are sectioned perspective views of a sensor assembly according to possible variant embodiments;

10 - Figures 42 and 43 are partial cross-sectional views, according to mutually orthogonal planes, of a pressure-sensor device, comprising a sensor assembly of the type illustrated in Figures 40-41, and a casing part, according to possible embodiments, mounted on a generic functional component;

- Figures 44 and 45 are a sectioned perspective view and an exploded view, respectively, of the device and of the component of Figure 43;

- Figure 46 is a perspective view of a compensation element of a sensor assembly according to possible embodiments;

15 - Figure 47 is a perspective view of a core or reinforcement that can be used in a compensation element of the type illustrated in Figure 46;

- Figure 48 is a sectioned perspective view of a sensor assembly comprising a compensation element of the type illustrated in Figure 46;

20 - Figures 49 and 50 are partial cross-sectional views, according to mutually orthogonal planes, of a pressure-sensor device, comprising a sensor assembly of the type illustrated in Figure 48, and a casing part, according to possible embodiments, mounted on a generic functional component;

- Figure 51 is a perspective view of a core or reinforcement that can be used in a compensation element according to possible variant embodiments;

25 - Figure 52 is a perspective view of a compensation element comprising a core of the type illustrated in Figure 51;

- Figure 53 is a sectioned perspective view of a sensor assembly comprising a compensation element of the type illustrated in Figure 52;

30 - Figure 54 is an exploded view of a pressure-sensor device according to further possible embodiments, which is designed to be installed on a generic functional component;

- Figure 55 is a partial cross-sectional view of the device and of the component of Figure 54;

35 - Figure 56 is a cross-sectional view similar to that of Figure 55, regarding to a possible variant embodiment;

- Figures 57 and 58 are perspective views of shielding elements for a sensor assembly according to possible embodiments;

- Figure 59 is a partial cross-sectional view of a pressure-sensor device comprising a sensor assembly with a shielding element of the type illustrated in
5 Figure 58;

- Figure 60 is a partial cross-sectional view of a pressure-sensor device according to possible embodiments;

- Figure 61 is a perspective view of a compensation element of a sensor assembly according to possible embodiments; and

10 - Figure 62 is a partial cross-sectional view of a pressure-sensor device that uses a compensation element of the type illustrated in Figure 61.

Description of embodiments of the invention

Reference to “an embodiment” or “one embodiment” in the framework of the present description is intended to indicate that a particular configuration,
15 structure, or characteristic described in relation to the embodiment is comprised in at least one embodiment. Hence, phrases such as “in an embodiment”, “in one embodiment” and the like that may be present in various points of this description do not necessarily refer to one and the same embodiment, but may instead refer to different embodiments. Moreover, particular conformations, structures or
20 characteristics defined in the framework of the present description may be combined in any adequate way in one or more embodiments, even different from the ones represented. The reference numbers and spatial references (such as “upper”, “lower”, “top”, “bottom”, etc.) are here used merely for convenience and hence do not limit the sphere of protection or the scope of the embodiments. In the
25 present description and in the attached claims, the generic term “material” is to be understood as comprising mixtures, compositions, or combinations of a number of different materials (for example, multilayer structures or composite materials). In the figures, the same reference numbers are used to designate elements that are similar or technically equivalent to one another.

30 Represented schematically in Figures 1 and 2 is a sensor assembly for a pressure-sensor device according to possible embodiments. The assembly, designated as a whole by 1, comprises a pressure-sensitive component 2, referred to hereinafter and identified for simplicity also as “pressure sensor” or “sensor”, and a compensation element 3, made at least in part of an elastically compressible
35 or deformable material to enable compensation of a possible increase in volume of

a fluid being detected, as explained in the introductory part of the present description. In the example illustrated, the assembly 1 further includes a shielding element, designated by 4, which constitutes, however, an optional and non-essential component of a sensor assembly according to the invention.

5 With reference also to Figures 3 and 4, in various embodiments, the sensor 2 comprises a sensor body 5, for example made of ceramic material, including a membrane part M, which is elastically deformable as a function of the pressure of the fluid to be measured. In what follows, for simplicity the part M will also be defined simply as “membrane”. The membrane M may be obtained integrally in
10 the sensor body 5 or else be configured as a distinct part associated at one end of a generally tubular body, for example via welding or gluing, in order to define therein a blind cavity, i.e., a cavity closed at one end.

As per the known technique, the sensor 2 has associated to it at least one element designed to detect deformation of the membrane M. This detection
15 element, designated by 6 only in Figure 3, may comprise a plurality of resistances or piezoresistive elements, for example connected in bridge configuration, preferably obtained on the side of the membrane M not exposed to the fluid of which the pressure is to be measured. In other embodiments, the detection element 6 may comprise electrodes and/or capacitive elements, such as two facing
20 electrodes, at least one of which provided on a side of the membrane M not exposed to the fluid. In the example, the detection element 6 is electrically connected to terminals, one of which designated by 7, for example fixed to the wall of the body 5 that defines the membrane M, in a peripheral position with respect to the latter. In the example, the terminals 7 are configured as elastic
25 contacts, but this is not an essential characteristic.

In various embodiments, the sensor body is generally cup-shaped, meaning thereby a body having a peripheral wall closed at one end by a bottom wall, so as to define an axial cavity. In the case exemplified in Figures 3 and 4, the sensor body 5 includes a bottom portion, such as the one designated by 5a, and a
30 peripheral portion, such as the one designated by 5b, which define an axial blind cavity, such as the one designated as a whole by C in Figure 4.

The sensor body 5 is preferably monolithic, for example made of a ceramic material (such as alumina): as has been said, this does not constitute in any case an essential characteristic. The bottom portion 5a includes the membrane
35 M, which closes the cavity C at one end of the sensor body 5, whereas the

peripheral portion 5b has a distal or lower edge opposite to the bottom portion 5a, which delimits an inlet of the cavity C itself. The cavity C hence has a peripheral surface and a bottom surface, with the latter belonging to the membrane M (in particular, to the inner side of the latter).

5 In various embodiments, such as the one exemplified, the cavity C includes at least two regions of different diameter, for example a lower cavity region C₁, of larger diameter, and an upper cavity region C₂, of smaller diameter. In embodiments of this type, the cavity C of the sensor body 5 hence has at least one intermediate restriction (see the surface of transition designated by C₃ in
10 Figure 60), so as to define the lower region C₁, which is wider, and the upper region C₂, which is narrower. An embodiment of this sort proves advantageous in so far as it enables a reduction in the dimensions of the membrane M, which in this case forms the bottom of the narrower region C₂, and to which the corresponding deformation-detection element is in any case associated.

15 In various embodiments, the sensor body 5 includes at least two portions that have a different outer diameter, here corresponding, by way of example, to the portions 5a and 5b, which have a larger diameter and a smaller diameter, respectively. In this way, defined between the two portions 5a and 5b is a step 5c. Preferably, at the peripheral profile of the body 5 – here at the portion 5a of
20 greater diameter – axial recesses 5d are defined, the functions of which will likewise be clarified hereinafter.

 In various embodiments, the compensation element 3 includes at least one respective compensation body, which is at least in part elastically deformable or compressible, such as the one designated as a whole by 8, and a reinforcement or
25 core, fixed on which is the at least one compensation body, such as the reinforcement or core designated by 9.

 In general terms, the compensation body 8 is made of a first elastically deformable or compressible material, for example an elastomer, hereinafter also defined as “elastically deformable body” or “deformable body”, whereas the core
30 or reinforcement 9 is made of a material relatively stiffer than the material of the body 8, for example a plastic, such as a thermoplastic or thermosetting polymer.

 As per the known technique, the main function of the body 8 is to absorb any possible volumetric expansion of the fluid the pressure of which is to be measured, in particular in the event of freezing. However, as explained
35 hereinafter, to the body 8, or to at least one of its parts, there may be assigned

additional functions, for example that of elastic support of the assembly 1.

On the other hand, the main function of the reinforcement or core 9 is to keep the elastically deformable body 8 in a correct position and prevent – for example as a result of the pressure of the fluid or of an increase in volume thereof following upon freezing – the compliant material of the body 8 from undergoing any excessive deformation or extrusion against the membrane M, thus vitiating the signal of the sensor.

To clarify the question, it is to be considered that the compensation elements of a known type (such as those described in the aforementioned prior documents) are made of a relatively compliant material: axial and/or radial thrusts of the fluid on such an element that extends in the cavity of the sensor body could bring about over time a displacement of at least part of the compliant material towards the detection membrane, i.e., a sort of extrusion of at least part of this material. For instance, in particular conditions (such as occasional high pressures of the fluid in the system to which the sensor is connected) the thrust of the fluid under high pressure could exceed the limit of compression of the compliant material, the internal structure of which could be compacted to the point of undergoing a displacement following upon the thrust of the fluid, which in turn transfers the thrust onto other internal areas of the structure of the sensor. In other words, the displacement or extrusion of at least part of the compensation body could give rise to a deformation of the compliant material such as to cause a thrust of the material itself directly on the membrane of the sensor, with consequent alterations of the reliability of measurement or failure of the membrane. The use of the core 9 is also aimed at countering such phenomena and/or facilitating installation in the body 2.

The materials chosen for the body 8 and the core 9 are preferably materials that can be injection-moulded according to techniques that are widely used and inexpensive. For instance, the body 8 may be moulded with a silicone material, such as a silicone elastomer or a liquid-silicone rubber (LSR) or fluoro-liquid-silicone rubber (FLSR). The core 9 may be moulded with a polymer or a copolymer or a thermoplastic material, such as a polyamide PA or a polyphthalamide PPA, or a polypropylene PP.

The body 8 and the core 9 may be moulded separately and then assembled together, or else may be co-moulded, or else again the body 8 may be overmoulded on the previously moulded core 9.

In various applications of the sensor assembly 1, at least one elastically deformable or compressible annular element may be operatively associated to the sensor 2, which is designed to exert a sealing action between an outer surface of the sensor body 5 and a housing or seat in which the body itself is at least partially inserted. In the example illustrated, such a sealing element, in particular in the form of an annular gasket or O-ring, preferably made of elastomeric material, is designated by 10 and is designed to be fitted on the portion 5b of smaller diameter of the body 5.

As has been said, in various embodiments, the portion 5a of larger diameter of the body 5 has axial recesses or grooves 5d, which, as may be noted, for example, in Figure 4, have one end located at the step 5c formed between the portions 5a and 5b of the body 5. In order to guarantee an optimal seal of the gasket 10 at said step 5c, notwithstanding the presence of the recesses 5d on the portion 5b of the body 5, there may advantageously be fitted a ring or flat washer 11, made of metal or plastic material, between the step 5c and the gasket 10: in this way, as may be noted, for example, in Figures 1 and 2, the washer 11 covers the corresponding end of the recesses 5d, thus providing an adequate surface for resting of the gasket 10 in an axial direction, also in order to improve the radial seal.

In use, for the pressure-sensor assembly 1 to be able to function adequately, it must be positioned within a corresponding final housing or seat of a device, provided with an inlet port for the fluid to be measured. Preferably, installation of the sensor assembly in the aforesaid seat should not be too tight (for example, because excessive mechanical stresses or residual stresses in the ceramic of the body 5 could cause major detection errors), nor too loose (for example, to prevent any possible micro-movements of the sensor 2, with the consequent possibility of seepage of the fluid and/or faulty electrical contacts and/or erroneous detections).

For these reasons, in various embodiments, the sensor assembly envisages an elastic supporting system. As will be seen, this system may be obtained either by exploiting the elastically deformable body 8 of the compensation element 3 or by exploiting the elastic properties of an additional element.

With reference to the latter case referred to, in various embodiments associated to the sensor assembly 1 is at least one annular elastically deformable or compressible supporting element, preferably made of elastomeric material,

which is designed to exert a function of elastic support of the assembly itself. In various embodiments, the aforementioned elastic support is provided prevalently in an axial direction, between a surface of the core 9 and a surface of a shielding element (designated hereinafter by 4), or else between a surface of the core 9 and
5 a surface (designated hereinafter by 31a) belonging to a seat into which the assembly 1 is at least partially inserted.

In the example illustrated in Figures 1-2, such an annular supporting element, on which the core 9 is designed to rest, is designated by 12. The element 12, for example of an O-ring type, does not necessarily perform sealing functions
10 (it possibly in any case performing also the function of a gasket).

An example of compensation element 3 is represented in different views in Figures 5-8, whereas represented in Figures 9-10 is an example of core 9.

With initial reference to Figures 9-10, in various embodiments the core 9 has a preferably substantially disk-shaped main portion 9a, having a major face –
15 here referred to conventionally as “upper face” – from which there preferably rises a central tubular portion 9b, defining a corresponding axial cavity 9’; in what follows, the portion 9a will also be defined as “flange portion” or “disk portion”. The upper face of the flange portion 9a may be provided with a peripheral edge in relief 9c. The tubular portion 9b preferably opens also at the opposite face of the
20 portion 9a (here referred to conventionally as “lower face”), upon which the annular element 12 is designed to bear, as will be seen hereinafter. In variant embodiments (not represented), the tubular portion 9b may extend from the opposite face of the flange portion 9a, or else a central tubular portion may extend both downwards and upwards starting from the portion 9a.

In various embodiments, the core 9 comprises one or more passages for corresponding parts of the material that forms the body 8, in particular in view of anchorage of the latter to the core itself. For instance, with reference to the example illustrated, defined at the disk portion 9a are one or more through openings 9d, in particular in a peripheral position with respect to the tubular
30 portion 9b. Possibly, within the tubular portion 9b there may be provided a transverse wall 9e, which may have peripheral through openings 9f (Figures 9-10), and preferably at least one central through hole 9g.

In various preferential embodiments, the top of the tubular portion 9b is shaped so as to define a sort of crenellation 9h, i.e., an alternation of projections
35 and recesses along the circumference of the portion 9b itself. The portion 9b

preferably has a substantially circular cross section, possibly with stretches of different diameter, as in the example illustrated.

With reference now to Figures 5-8, in various embodiments, the elastically deformable body 8 is configured as body overmoulded on the core 9, preferably so as to leave in any case exposed at least one area of the core itself, preferably but not necessarily a peripheral area of its disk part 9a. For this purpose, in various preferential embodiments, the dimension of maximum lateral encumbrance (or maximum diameter) of the core 9 is greater than the dimension of maximum lateral encumbrance (or maximum diameter) of the body 8.

In the case exemplified, the body 8 is overmoulded in a single piece but so as to present at least two different parts that each extend at a respective major face of the disk portion 9a of the core 9, such as the two body parts designated by 8a and 8b in Figures 5-8. In the example represented, the body part 8a extends axially from the lower face of the portion 9a. In various embodiments, the aforesaid body part 8a, preferably having a substantially cylindrical shape, defines at its distal end face or lower face a recess 8a', the function of which will emerge clearly hereinafter.

The body part 8b extends axially from the upper face of the part 9a of the core 9, preferably so as to englobe within it at least part of the tubular portion 9b.

In various embodiments, such as the one exemplified, the elastically deformable body 8 defines in a single piece a further body part 8c, which extends over the top of the body part 8b and, preferably but not necessarily, englobes a respective top part of the tubular portion 9b of the core 9. Preferably, the body part 8b has dimensions of lateral encumbrance or diameter greater than the body part 8c, one or both of these body parts possibly having an at least slightly frustoconical conformation. The presence of the further body part 8c of the compensation body 8 is preferable when the cavity C of the sensor body 5 includes, as in the case exemplified, two regions C₁ and C₂ of different diameter.

In various preferential embodiments, the dimension of maximum lateral encumbrance or diameter of the body part 8b is smaller than the corresponding dimension of maximum lateral encumbrance or diameter of the flange portion 9a of the core 9, in such a way that a part of the latter defines a surface for resting of the distal end of the sensor body 5. With reference, in particular, to the example currently described, defined between the body part 8b and the outer diameter of the portion 9a of the core 9, i.e., its peripheral edge in relief 9c, is a seat –

designated by 9a' in Figures 5 and 8 – for positioning and resting of the lower edge of the portion 5b of the sensor body 5. In various embodiments, at least one portion of the core 9 (such as the portion 9a and/or the seat 9a') also provides a positioning and/or reference element, in particular with respect to the sensor body 5.

The aforesaid resting of the sensor body 5 on the corresponding surface of the core 9 prevents the risk that, in the assembly stage, the upper portion of the compensation element 3 (here the parts 8b and 8c of the body 8) may be inserted excessively into the cavity C of the sensor body 5: this prevents, for example, the risk of the top of the portion 8c possibly coming into contact with the inner side of the membrane M, and thus causing subsequent errors of detection of pressure by the sensor 2.

In this perspective, the height of the aforesaid upper portion of the compensation element (here understood as distance between the upper face of the disk part 9a and the top of the body part 8c) is less than the depth of the cavity C (understood as distance in a vertical direction between the lower surface of the body part 5a and the inner surface of the membrane M).

The presence of the disk part 9a of the core 9, or the presence of the aforesaid positioning and/or reference element, on which the sensor body 5 rests, also has the effect of preventing any excessive deformation or extrusions of the compliant material constituting the body 8, as explained above.

The body 8 is preferably overmoulded on the core 9 so that part of the material that constitutes it penetrates through the openings 9d of the core 9 and through the corresponding tubular portion 9b, thus ensuring fixing of the body 8 on the core 9, as may be clearly noted in Figures 7 and 8. From these figures it may likewise be noted that, when the tubular portion 9b is provided inside with the transverse wall 9e, part of the overmoulded material also penetrates through the openings 9f of the wall, further improving fixing thereof. The overmoulding equipment will be conceived – in a way in itself known – in order to prevent the overmoulded material from obstructing the central hole 9g of the transverse wall 9e, if this is envisaged.

In various embodiments, the body 8 is overmoulded so as to present at least one - preferably central - passage, designated by P, which extends between the two axial ends of the body 8 itself. If the core 9 envisages the transverse wall 9e inside the tubular portion 9b, the passage P is substantially coaxial to the

respective hole 9g of this wall, preferably located in a central position: in this way, with reference to the example illustrated, a part of the passage P traverses axially the body part 8a, whereas the remaining part of the passage axially traverses the body parts 8b and 8c, as may be clearly noted from Figures 7-8.

5 From the same figures it may be noted how, preferentially, the entire tubular portion 9b is embedded in the material constituting the body parts 8b and 8c, with the top crenellation 9h of the tubular portion that contributes further to fixing between the overmoulded material and the core 9.

10 As already mentioned, in various embodiments, at least one of the two portions of the elastically deformable body that extend on opposite sides of the core is designed to be received at least partially within the cavity C (Figure 4) of the sensor body 5. In the example, the portion in question is the one formed by the body parts 8b and 8c. As has been said, the part 8c is to be understood as optional, albeit particularly useful for the purposes of compensation in the case of sensors
15 with a cavity C that has two regions C_1 and C_2 of different diameter.

According to an important aspect, at least part of the portion of the elastically deformable body, for example a part that is designed to be housed at least partially within the cavity of the sensor body, is configured so as to enable mounting by elastic interference within the cavity itself.

20 In various embodiments, for this purpose, the aforesaid portion of the elastically deformable body has at least one positioning and/or fixing element, in particular between the compensation element and the sensor body, for example a plurality of peripheral ribbings or reliefs, distributed along or according to a circumferential wall of the portion itself, where the ribbings or reliefs facilitate
25 positioning and also correct assembly between the compensation element and the sensor body.

With reference to the case exemplified in Figures 6-8, the aforesaid positioning and/or fixing elements comprise axial reliefs, which are designated by 8d and are defined at the peripheral wall of the body part 8b. In addition or as an
30 alternative, similar elements or reliefs could be provided in the body part 8c. In general terms, the outer surface of the various reliefs 8d identifies a circumference wider than the corresponding part of the cavity C (it being, obviously, understood that the cavity part C_1 and the body part 8b may have a frustoconical or at least partially inclined peripheral profile).

35 In various embodiments, the reliefs 8d are defined integrally by the

compensation element 3, in particular by the body 8, and enable insertion with slight elastic interference of the portion 8b-8c of the body 8 within the cavity C of the sensor body 5, in any case in a way sufficient to guarantee positioning and coupling of the former with respect to the latter.

5 This characteristic proves particularly advantageous in the production stage in so far as it enables pre-assembly between the sensor 2 and the compensation element 3, that is, the production of a self-standing or independent sensor assembly 1, which can be easily handled as a single unit; i.e., it can be stored, or transported, or mounted as a single component.

10 Hence, an assembly according to the invention may be easily produced and assembled via automatic lines belonging to a first entity (for example, a manufacturer of pressure-sensor devices) as a single device, without its parts separating from one another during handling, albeit in the absence of an outer casing. This assembly may then be easily transported to a second entity (for
15 example, a manufacturer of vehicle components) in order to be assembled or integrated in a different apparatus, without prejudice to ease of handling of the assembly on automatic assembly lines belonging to the second entity.

 As has been said, the compensation element 3 may likewise define a surface or a seat (9a', Figures 5 and 8) for positioning and resting of the sensor
20 body 5, or of the distal end of the portion 5b, where fitted on the portion 5b are the resting ring 11 and the sealing element 10, which is preferably mounted with elastic radial interference on the portion 5b: in this way, following upon coupling between the parts in question, the ensemble that includes the components 2, 3, 10 and 11 may be easily handled as a single unit.

25 The reliefs 8d enable the aforementioned insertion with elastic inference in a convenient and precise way, with only modest local deformations of the body 8, practically only at the reliefs themselves: in this way, there is prevented the possibility, in the course of insertion, of excessive and/or undesirable deformations of the body 8 as a whole. As has been said, the flange part 9a of the
30 core 9 may advantageously constitute a reference or positioning element or mechanical end-of-travel for the aforesaid insertion.

 As mentioned previously, the sensor assembly of a device according to the invention may optionally include a shielding element, designated as a whole by 4, which is illustrated in isolation in Figures 11 and 12.

35 The element 4 has a body preferably formed via moulding of a polymer or

plastic material, for example a thermoplastic or thermosetting material, including a generally cup-shaped part, preferably having a substantially circular cross section, including a bottom wall that has at least one opening, possibly provided at one end with a radially projecting flange part.

5 In the example illustrated, the generally cup-shaped part includes a substantially cylindrical peripheral wall 4a and a bottom wall 4b, which delimit a cavity or seat designated by S only in Figure 12. The bottom wall 4b is provided with one or more through openings 4b' and possibly, on its inner side with respect to the seat S, with one or more reliefs 4b''. In the example, a series of openings
10 4b' and a series of reliefs 4b'' are interspersed with one another according to a circumference, in particular in a central region of the wall 4b. Preferentially, in the condition where the element 4 is assembled on the body 8, the opening 4b' or each opening 4b' is in an axial position staggered with respect to the passage P of the compensation element 3, for the reasons that will be clarified hereinafter.

15 In various embodiments, a flange 4c projects radially outwards from the peripheral wall 4a of the element 4, preferably just slightly underneath the end edge 4a' of the wall 4a itself that delimits the mouth of the seat S, where the preferably circular flange has a surface on which the annular element 12 can rest.

In the example illustrated, the aforesaid flange 4c has a peripheral edge in
20 relief 4c', on the same side as the edge 4a'. In this way, defined between the two edges 4a' and 4c' is a groove or seat 4c'', for positioning of the annular element 12, in particular of the part thereof opposite to the one resting on the lower face of the core 9 of the compensation element 3.

In various preferential embodiments, defined on the inner side of the
25 peripheral wall 4a of the element 4 are means for positioning and/or coupling with respect to the compensation element 3, in particular with respect to the body 8. In various embodiments, these means comprise axial reliefs or ribbings, such as the one designated by 4a'' in Figure 12. Similar positioning and/or coupling means, such as reliefs and/or ribbings, could possibly be provided on the compensation
30 element, in particular on its body 8 (in particular, the corresponding part 8a).

The reliefs 4a'' identify a circumference slightly smaller than that of the part 8a of the elastically deformable body 8 of the compensation element 3: in this way, the shielding element 4 can be fitted with slight interference on this part 8a on the compensation element 3. Hence, also in this case, the reliefs 4a'' enable
35 insertion of the part 8a of the body 8 with a slight elastic interference within the

seat S of the shielding element 4, in any case in a way sufficient to guarantee positioning and coupling of the former with respect to the latter.

Also this characteristic proves particularly advantageous in so far as it enables pre-assembly between the sensor 2, the compensation element 3, and the shielding element 4, for the purposes of subsequent joint manipulation, i.e.,
5 handling as a single component, albeit without outer casing.

As has been said, the shielding element 4 can define a surface or seat (4c" in Figure 12) for positioning of a respective part of the annular element 12: in this way, following upon coupling between the parts, the sensor assembly 1 –
10 including the components 2, 3, 4, 10, 11 and 12 – can be easily handled as a single component. The assembled condition of the aforesaid assembly is visible in Figure 2, where it may be noted how the sealing element 10 is set between the resting ring 11 (which is in turn fitted on the part 5b of the sensor body 5) and the upper face of the core 9, substantially at its peripheral edge in relief 9c, and how
15 the annular element 12 is set between the flange 4c (i.e., the seat 4c" of Figure 12) of the shielding element 4 and the lower face of the flange part 9a of the core 9.

In various embodiments, a pressure-sensor device according to the invention includes a structure configured for housing at least partially the component sensitive to the pressure to be detected, i.e., the sensor 2 of the
20 assembly 1. This structure may even form part of a different device, for example a hydraulic device or a pneumatic device.

In various preferential embodiments, the housing structure may be configured like a casing, which houses practically completely the assembly and may comprise at least two coupled parts, which preferably perform also
25 positioning and/or supporting functions. In various embodiments, one of the two parts preferably performs also functions of electrical connection, and the other part preferably performs also functions of hydraulic connection. In other embodiments, the aforementioned structure may, instead, house the sensor assembly only partially and may comprise for this purpose even just one casing
30 part, for example performing functions of electrical connection or else hydraulic connection: in embodiments of this type, a device according to the invention can be coupled to a different functional component (for example, a fluid pump), the body of which defines a seat or housing that is designed to receive a corresponding part of the device, in particular of its sensor assembly 1.

35 Figures 13 and 14 exemplify the second case referred to above, where the

housing structure of the device includes a body 20, hereinafter referred to also as “closing body”, which preferably performs positioning and electrical-connection functions. It should be noted that in these figures the representation of the shielding element 4, which is in any case optional, is omitted.

5 In the example illustrated, the body 20 defines a central seat 21, at least partially inserted within which is the sensor 2, i.e., its body 5. The body 20 may be made of electrically insulating material, for example moulded with plastic material, and have, as in the example, at least one bracket 22 for fixing to a different component, for example the body of a fluid pump, or else a hydraulic
10 assembly of an SCR (Selective Catalytic Reduction) system or of a Water Injection system of a vehicle. In the example, the body 20 has a wall in relief 21a, preferably cylindrical, which defines at least part of the seat 21. Preferentially, on the inner side of the wall 21a axial reliefs 21b are provided, which are designed to couple to the axial recesses 5d of the part 5a of the sensor body 5 in order to
15 guarantee correct mutual angular positioning.

 The components 2, 3, 10, 11, 12 (and 4, when envisaged) may then be assembled together in the way described above, and the self-standing sensor assembly thus obtained can be handled – possibly in an automated way – in order to position the sensor body 5 within the seat 21 of the body 20, as illustrated in
20 Figures 13 and 14. From Figure 14 it may be noted how the body 20 can define, on its side opposite to the one where the seat 21 opens, a passage 23 for access to the terminals 7 of the sensor, here configured as spring contacts. In the body 20 there may also be defined a cavity 24, at the seat 21, where the contacts 7 are at least partially received (see Figures 17-18). This cavity 24, which may possibly
25 have a peripheral profile substantially corresponding to that of the seat 21, is preferably provided with one or more abutment surfaces 24a for the upper face of the sensor body 5.

 Figures 15 and 16 exemplify the case where the housing structure of a device according to the invention includes, instead, a body 30, hereinafter also referred to as “casing body”, which performs positioning and hydraulic-
30 connection functions.

 In the example, the body 30 is substantially cup-shaped and defines a housing or seat 31, at least partially inserted in which is the sensor assembly 1, here including the components 2-4 and 10-12. The body 30 may be made of
35 electrically insulating material, for example moulded with thermoplastic material,

and may have, as in the example, an inlet passage for the fluid 32, preferably at a bottom wall thereof.

The seat 31 is preferably shaped and sized according to the shape and size of the components of the assembly 1 to be housed. For instance, in various
5 embodiments, the seat 31 defines at least one intermediate step 31a, which provides a rest for the flange 4c of the shielding element 4 (or else for the annular supporting element 12). In this way, as may be noted, for example, in Figure 16, the step 31a supports the shielding element 4, which in turn elastically supports the compensation element 3 by way of the supporting element 12, which is housed
10 in the seat 4c'' of the flange 4c itself and on which the lower face of the core 9 (i.e., of its part 9a) rests. Preferably, the shielding element 4 is sized in such a way that, in the condition illustrated, its bottom wall 4b is at least slightly raised, i.e., at a distance, with respect to the bottom wall of the seat 31, where the inlet
15 passage 32 of the fluid is located, for example to prevent the wall 4b possibly obstructing the inlet 32 of the seat 31 and/or to maintain in any case a passage or a chamber in the lower region of the seat 31 in order to enable distribution of the liquid from the inlet 32 towards the passages 4b' of the shielding element 4.

The aforementioned distance is guaranteed by the resting of the part 9a on the step 31a, and possibly also by the presence of reliefs, such as the ones
20 designated by 4b''' in Figure 11, defined on the outer side of the bottom wall 4b of the shielding element. In the case of particularly unfavourable dimensional tolerances, these reliefs 4b''' can come to rest on the bottom of the seat 31, thus keeping the shielding element 4 slightly raised, in such a way as in any case to guarantee that the fluid will flow from the inlet 32 towards the passages 4b'.

25 Once again from Figure 16 it may be noted how, preferably, in the assembled condition, the openings 4b' and the reliefs 4b'' present on the inner side of the aforesaid bottom wall 4b are located at the recess 8a' defined in the lower-end face of the part 8a of the body 8 of the compensation element. It may be noted in particular how the bottom of the recess 8a' rests on the aforesaid reliefs 4b'', so
30 that between the inlet of the passage P of the body 8 and the openings 4b' of the element 4 there exists in any case a free space, designed to enable passage of the fluid.

From Figures 15 and 16 it may likewise be noted how, in the assembled condition, the sealing element 10, fitted on the part 5b of the sensor body 5
35 together with the resting ring 11, exerts a radial seal with respect to the peripheral

surface of the seat 31. From the same figure it may be clearly noted how the two regions C_1 and C_2 of the cavity of the sensor body 5 are occupied by the parts 8b and 8c of the deformable body 8 of the compensation element, the top of the part 8c being in any case at a distance from the membrane M.

5 The partially sectioned views of Figures 17 and 18 represent the case of a device according to the invention the housing structure of which includes a closing body 20 of the type illustrated in Figures 13-14 and a casing body 30 of the type illustrated in Figures 15-16, coupled together with interposition of the sensor assembly.

10 Also from these figures there may be clearly noted the relative positioning between the step 31a of the seat 31 and the flange 4c of the shielding element 4 so as to keep the sensor assembly – and, in particular, the bottom wall 4b of the shielding element 4 – at a distance from the bottom surface of the seat 31 of the body 30, and with the lower part 8a of the compressible body 8 that preferably
15 rests on the inner side of the bottom wall 4b and on the corresponding reliefs 4b”: in this way, as explained, fluid communication between the inlet passage 32 of the fluid and the axial passage P of the compensation element 3 is in any case ensured. Once again from Figures 17-18 it may be noted how the annular supporting element 12 is positioned within the corresponding seat 4c” of the
20 flange 4c, and how the lower face of the flange part 9a of the core 9 rests on the element 12: as has been said, in this way, the compensation element, and hence the sensor body 5, are supported in an elastic way with respect to the body 30. The presence of the annular element 12 may prove advantageous in those embodiments in which the sensor body 5 and the compensation element
25 associated thereto are constantly urged into the seat 31 of the casing body 30, for example via the action of the elastic contact elements 7 or of the abutment or contrast surfaces 24a of the body 20. The presence of the element 12 hence enables an “elastic assembly” to be obtained, i.e., an assembly that renders possible slight variations or compensation of the axial positioning of the sensor
30 body 5 and of the compensation element, for example for compensating possible dimensional variations of the various elements or parts of the device, or else for preventing excessive stresses during the steps of assembly and/or during operation.

35 From the same figures there may be noted the position of radial seal between the gasket 10, possibly resting on the corresponding ring 11, and the

peripheral surface of the seat 31 of the body 30, and it may likewise be noted how the lower end of the portion 5b of the sensor body 5 rests, instead, on the upper face of the flange part 9a of the core 9, within the seat 9a'.

5 It should be noted that, in the condition exemplified in Figures 17-18, the sealing element 10 is located at a certain distance from the upper surface of the peripheral edge in relief 9c of the flange 9, but this does not constitute an essential characteristic, in so far as the components could be sized in such a way that the element 10 rests on the edge 9c.

10 The shielding element 4 can, for example, be used in applications in which the volume of just the compensation element 3 (i.e., of its elastically deformable body 8) is deemed insufficient to compensate for the increase in volume of the liquid undergoing freezing: in these cases, the frozen fluid could exert a significant stress on the membrane M of the sensor 2. In this perspective, the element 4 also performs the function of a labyrinth in so far as it enables passage
15 of the fluid through its openings 4b' in a position staggered with respect to the central passage P of the compensation element: this geometry in effect generates a labyrinthine path for the fluid between the inlet 32 and the passage P, thus limiting the risk of a high axial force exerted by the frozen fluid, through the same passage P, directly on the membrane M of the sensor 2.

20 Exemplified in Figures 19-31 are possible alternative embodiments of one or more components of a sensor assembly 1 according to the invention.

In the case exemplified, the assembly 1 includes a shielding element 4, which, according to possible embodiments, has a body without the flange designated previously by 4c; i.e., it includes just the peripheral wall 4a and the
25 bottom wall 4b, provided with the openings 4b' and the internal reliefs 4b'', and possibly the external reliefs 4b''', as may be clearly noted from Figure 20.

Also in this case, as may be noted from Figure 24, on the inner side of the peripheral wall 4a positioning and/or fixing means may be provided, such as the axial reliefs 4a'', for installation with slight interference with respect to the
30 deformable body 8 of the compensation element 3.

In various embodiments, such as the one exemplified in Figures 19-31, the core 9 of the compensation element 3, in particular its part 9a, is configured so as to define a seat for the annular element 12 at its lower face.

35 With reference, for example, to Figures 20, 23 and 25-27, the core 9 has a structure substantially similar to the one illustrated in Figures 9-10, with the

corresponding disk part 9a provided, at its upper face, with the peripheral edge in relief 9c, which is, however, optional. In this case, the part 9a has a similar peripheral edge in relief also at its lower face, designated by 9i, there being provided on the bottom face also a cylindrical wall in relief 9j, having a diameter smaller than that of the edge 9i, which here circumscribes a region within which the through openings 9d and/or an end of the cavity 9' of the tubular portion 9b may possibly be located. In this way, delimited between the edges 9i and 9j is a seat, designated by 9k, for positioning of the annular supporting element 12, as may be seen, for example, in Figure 20.

Also in the case exemplified in Figures 19-31, the elastically deformable body 8 of the compensation element 3 is overmoulded on the core 9, according to what has already been described previously. The part of the body 8 that extends from the lower face of the core 9 may present, as in the example illustrated, two portions of different diameter, and in particular – with reference, for example, to Figures 20, 23 and 25 – a portion 8a₁ of larger diameter, closer to the disk part 9a of the core 9 and a portion of smaller diameter 8a₂, which extends from the portion 8a₁, where the diameter of the portion 8a₂ is such as to enable fitting thereon, with slight elastic interference, of the shielding element 4, as may be noted, for example, from Figure 20. From Figure 20 it may be noted how, preferably, the peripheral wall 4a of the element 4 bears upon the step defined between the portions 8a₁ and 8a₂ of the elastically deformable body 8.

Figures 28 and 29 exemplify the case of installation of the sensor assembly in a casing body 30 substantially similar to the one already illustrated previously in Figures 15-16, which defines the corresponding seat 31 provided with an inlet passage 32 for the fluid. As may be noted, in embodiments of this type, the compensation element 3, i.e., its core 9, is set resting on the step 31a of the seat 31 by way of the annular element 12, with the compensation element itself and the sensor body 5 associated thereto that are then elastically supported with respect to the casing body 30, thus enabling the aforementioned elastic assembly. The operating position of the shielding element 4 is similar to the one already described previously, i.e., with its bottom wall 4b at a distance from the bottom wall of the seat 31.

Figures 30 and 31 illustrate, via views similar to those of Figures 17-18, a device according to the invention basically comprising a sensor assembly according to Figures 19-27 mounted within a structure that includes a closing

body and a housing body, of the same type as those already designated above by 20 and 30, respectively. As may be noted, the device illustrated is similar to the one already described above, with the differences represented by the type of construction and installation of the shielding element 4 (and hence with the different portions 8a₁ and 8a₂ of the compressible body 8), and the modified shape of the main disk part 9c of the core 9 of the compensation element, with the corresponding seat 9k for the annular element 12, with the latter resting on the step 31a of the housing 31.

As has been said, the shielding element 4 constitutes an optional element of a sensor assembly 1 or of a device according to the invention. For instance, Figure 32 illustrates schematically, with a cross-sectional view similar to that of Figure 31, a variant in which the use of the aforesaid element 4 is not envisaged. In various embodiments of this type, the deformable body 8 of the compensation element 3 has a part 8a that is sized so as to rest directly on the bottom surface of the seat 31 of the body 30. In these embodiments, the part 8a of the compensation element 3 may possibly also perform the function of elastic support.

In this way, even in the absence of the annular element 12, the sensor body 5 and the compensation element associated thereto would in any case be mounted in an elastic way within the seat 31, in a way similar to what has been described previously. Preferentially, the part 8a of the deformable body 8 has in any case at its distal end the recess 8a', the bottom of which can rest on one or more reliefs 33 defined on the bottom surface of the housing 31 in order to guarantee also in this case the presence of a chamber or passage between the seat 31 and the deformable body 8, i.e., guarantee fluid communication between the inlet passage 32, preferably set in a staggered or lateral position, and the central passage P of the compensation element 3.

The elastically compressible or deformable body of a compensation element provided according to the invention does not have to be necessarily overmoulded on the respective core. Figures 33-39 illustrate for this purpose possible embodiments in which at least one such compressible or deformable body is elastically coupled to a corresponding core.

With initial reference to Figures 33-34, in the case exemplified the compensation element 3 includes a core 9, coupled in an elastic way to which are two elastically compressible or deformable bodies, designated by 8₁ and 8₂, respectively. Also in this embodiment, the core 9 includes a main part,

substantially disk-shaped or flange-shaped 9a, from the upper face of which there rises a shaped tubular portion, preferably including a plurality of stretches of different diameter, such as those designated by 9b₁ and 9b₂, where the tubular stretch 9b₁ has a maximum diameter greater than that of the tubular stretch 9b₂, the latter extending from the top of the former. Preferably, provided at the top of the stretch 9b₂ is a further stretch, or head, designated by 9b₃, the maximum diameter of which is greater than that of the intermediate stretch 9b₂. Preferably, at least the stretches 9b₁ and 9b₂ have a peripheral profile at least in part flared or frustoconical, even though this is not an essential characteristic. The tubular portion formed by the aforesaid stretches 9b₁, 9b₂ and 9b₃ comprises an axial cavity 9', peripherally delimited by the tubular stretch 9b₁, whilst the intermediate tubular stretch 9b₂ and the head 9b₃ are traversed by a through hole 9g' (see also Figure 39).

Preferentially, the compressible body 8₁ has a generally disk-shaped or cap-shaped main part, functionally similar to the body part 8a of the embodiments described previously, from which there rises an upper projection 8a₃. The body 8₁ likewise has a central through hole, designated by P'. As may be appreciated from Figures 33-34 and as may be noted in Figure 39, the upper projection 8a₃ of the body 8₁ is designed to be engaged, preferably with elastic interference, within the cavity 9' peripherally delimited by the tubular stretch 9b₁. Hence, in other words, the projection 8a₃ can be withheld elastically inside the aforesaid cavity. More in general, in various embodiments, the body 8₁ of the compensation element 3, in particular the upper projection 8a₃, may be provided with means for positioning and/or coupling with respect to the core 9.

On the other hand, the deformable body 8₂ substantially defines two body parts functionally similar to the ones designated previously by 8b and 8c, the part 8b being preferably provided with the corresponding axial reliefs 8d, as may be clearly noted in Figures 33-34. From Figure 34, as well as from Figure 39, it may be noted how the body 8₂ is axially traversed by a corresponding cavity, designated by H, defined by a shaped surface having a profile substantially corresponding to the outer profile of the stretches 9b₁, 9b₂ and 9b₃ of the core 9, possibly with slightly smaller peripheral dimensions. In this way, as may be appreciated from Figure 39, the cavity H of the body 8₂ can be elastically fitted on the tubular stretches 9b₁, 9b₂, and 9b₃, with the terminal stretch 9b₃ that guarantees relative positioning between the two coupled parts. For this purpose, preferably

the terminal portion of the cavity H, designated by H' only in Figure 33, is shaped and sized for housing the tubular terminal stretch or head 9b₃ of the core 9.

Hence, in various embodiments, the body 8₂ of the compensation element 3, in particular at least part of the corresponding cavity H, may be provided with means for positioning and/or coupling with respect to the core 9; likewise, preferably, at least part of the core 9, such as the terminal stretch 9b₃, may be provided with positioning and/or coupling means with respect to the body 8₂.

From Figure 39 it may be noted how, in the assembled condition of the compensation element, the through hole P' of the body 8₁ is axially aligned to the through hole 9g' of the core 9.

The assembled condition of the compensation element 3, with the sensor 2 coupled thereto, is illustrated in Figures 35 and 36: as for the previous embodiments, the compensation element 3 may be coupled to the cavity of the sensor body 5, in particular in an elastic way, by exploiting at least the presence of the axial reliefs 8d of the portion 8b of the deformable body 8₂. From the above figures it may be noted how, also in this case, the distal end of the portion 5b of the sensor body 5 can be set resting on the upper face of the disk portion 9a of the core 9. In the embodiment illustrated, the upper face of the portion 9a is not provided with an edge in relief, which, however, could be provided in other embodiments (not illustrated).

Figure 37 exemplifies installation of the sensor assembly 1 of Figures 35-36 in the seat 31 of a housing body substantially similar to the ones designated previously by 30, whereas in Figures 38 and 39 the same assembly 1 is illustrated in the condition mounted between such a housing body 30 and a closing body substantially similar to those designated previously by 20. From these figures, it may be noted how installation is substantially similar to some of the other embodiments already been described previously. It should, however, be noted that, in embodiments of this type, the presence of an elastic supporting element of the same type as the ones designated previously by 12 is not indispensable. In this case, the portion 8a of the deformable body 8₁ of the compensation element is sized so as to rest directly on the bottom surface of the seat 31 of the body 30. Also in this case, preferably, the portion 8a has at its distal end the recess 8a', the bottom of which can rest on reliefs 33 defined on the bottom surface of the housing 31 in order to guarantee fluid communication between the inlet passage 32 of the body 30 and the central passage P' of the deformable body 8₁, which is

axially aligned to the passage 9g' of the core 9.

Also in embodiments of this type, the seat 31 of the housing body 30 may include at least one intermediate step 31a, which in this case is in a position substantially corresponding to that of the sealing element 10. It should be noted that, in the condition exemplified in Figures 38-39, the sealing element 10 is at a certain distance from the aforesaid step 31a, but this does not constitute an essential characteristic in so far as the components could be sized in such a way that the aforesaid element 10 is set resting on the step 31a. In the condition of resting of the sealing element 10 on the step 31a and on the ring 11, the sealing element 10 could possibly operate also as elastic supporting element.

Of course, the solution of providing at least one compensation body fixed to the corresponding core, preferably in an elastic way, of a conception similar to the body 8₁ and/or the body 8₂, may be applied also to the other embodiments described herein. Moreover, in the case exemplified in Figures 33-39, the sensor assembly 1 is without the annular element 12 and the shielding element 4, but obviously at least one of these elements could be provided, if so required.

Figures 40-45 illustrate a variant embodiment substantially similar to that of Figures 33-39, where, however, the compressible body of the compensation element is overmoulded on the corresponding core.

As may be noted, the general outer shape of the compensation element 3, and hence of the assembly 1, is substantially similar to the one illustrated in Figures 35-36, apart from a slightly modified peripheral profile of the part 8a of the compressible body. In this embodiment, as has been said, the body 8 is overmoulded on the core, and for this purpose, as may be seen in particular in Figures 42 and 43, the core 9 may include the corresponding central tubular part 9b, possibly provided at the top with the crenellation 9h and provided, on the inside of the transverse wall 9e, with the corresponding peripheral openings 9f and central hole 9g; likewise, also the flange part 9a of the core 9 may envisage the corresponding through openings 9d.

Figures 42 and 43 are designed to illustrate how, in possible variant embodiments, the closing body 20 of a sensor device according to the invention may include electrical terminals that are designed to come into electrical contact with the elastic contacts 7 associated to the sensor body 5. In the example, each electrical terminal, one of which is designated by 25, includes a part 25a that extends on the outside of the body 20, and a part 25b having a surface facing the

inside of the cavity 24, elastically resting on which is the end of a respective elastic contact 7 of the pressure sensor; as an alternative, the elastic contacts 7 could be replaced by electrical wires soldered between purposely provided pads of the sensor body 5 and the electrical terminals 25.

5 As mentioned previously, a sensor assembly according to the invention may be mounted within a corresponding seat defined by a different functional component, for example a pump for the fluid, or a hydraulic device comprising a hydraulic pump, or else any other device or hydraulic or pneumatic apparatus, in particular for vehicles, that require the presence of a pressure sensor.

10 Figures 42 and 43 are likewise designed to illustrate such a case, where the aforesaid different functional component is designated by 30'. With reference also to Figures 44-45, in the aforesaid component 30', represented schematically, a seat of the type designated previously by 31 is defined, the inlet 32 of which is connected to a duct for passage of the fluid 34, for example a delivery of the fluid.

15 In the example, the sensor assembly 1 is mounted within the seat 31 and is held in position via a closing body of the type designated previously by 20, which is, for example, fixed to the component 30' via screws 35 engaged in corresponding threaded holes 36 of the component itself.

20 Of course, what has been described with reference to the construction of the body 20, provided with the terminals 25, and to mounting thereof in relation to a different functional component of the type designated by 30' applies also to all the other embodiments here described. In Figures 40-45, the sensor assembly 1 is without the annular element 12 and the shielding element 4, but obviously at least one of these elements could be provided, if so required.

25 In various embodiments, the compensation element 3 may be coupled in an elastic way to the sensor body 5 by exploiting the shape of the core 9, instead of the elastically deformable body 8, as in the embodiments described previously. An example of this sort is illustrated in Figures 46-50.

30 As in various previous embodiments, the element 3 comprises a core 9, fixed, for example overmoulded, on which is the body 8. Of course it is also possible to envisage elastic mounting of at least one deformable body 8 on the core 9, for example a body of a conception similar to the bodies 8₁ and 8₂ described previously.

35 In the case illustrated, and as may be seen in particular in Figure 47, the core 9 further defines a plurality of positioning and/or fixing elements, for

example constituted by axial appendages, which are at least in part elastically flexible, designated by 9x, which rise from the flange portion 9a of the core itself. In the example illustrated, the appendages 9x rise from the upper face of the portion 9a and are arranged substantially according to a circumference, for example but not necessarily interspersed with the openings 9d, in particular a circumference substantially concentric with respect to the tubular portion 9b, i.e., in a position peripheral with respect thereto.

The elastically deformable body 8 is overmoulded on the core 9 with modalities similar to the ones already described previously, but so that at least the outer side of the appendages 9x (with respect to the tubular portion 9b) is at least partially exposed at the peripheral profile of the body 8, in particular of at least the part 8b. This type of embodiment is clearly visible in Figure 46, where it may in fact be noted how the appendages 9x are arranged substantially according to the circumference of the part 8b of the body 8, and how a part of each appendage 9x projects in a radial direction with respect to the peripheral surface of the part 8b.

In an embodiment of this sort, it is not necessary for the peripheral profile of the body part 8b to be provided with the axial reliefs designated previously by 8d in so far as their function is basically performed by the exposed part of the appendages 9x.

The concept is clearly visible in Figures 48 and 50, where it may be noted how, in the assembled condition between the sensor 2 and the compensation element 3, the outer side of the appendages 9x interferes with the inner surface of the cavity of the sensor body, in particular the surface that peripherally delimits the cavity portion C₁. Also in this case, the interference between the parts is basically elastic, thanks to the flexible nature of the appendages 9x and to the fact that, in any case, the material of the body 8 (i.e., of its part 8b) that is located behind the inner side of the appendages 9x themselves is elastically compressible or deformable. Also in this case, then, the appendages 9x and the deformable nature of the body 8 enable an insertion with slight interference of the portion 8b-8c of the body 8 within the cavity C of the sensor body 5, which is in any case sufficient to guarantee positioning and coupling of the former with respect to the latter, with the advantages already explained linked to the possibility of providing a self-standing or independent sensor assembly 1, which can be easily manipulated as a single unit.

The type of embodiment described with reference to Figures 46-50 may of

course be applied also to the other embodiments. Also in the case exemplified in Figures 46-50, the sensor assembly 1 is without the annular element 12 and the shielding element 4, but at least one of these elements could be provided, if so required.

5 Figure 51 illustrates a variant embodiment of the core 9 of a compensation element, according to which provided on the inner side of the peripheral edge 9c are axial reliefs or ribbings, some of which are designated by 9c', which are able to co-operate with the outer surface of the tubular wall of the sensor body, in particular of its portion 5b.

10 Figure 52 illustrates a compensation element 3 comprising such a core 9, in the case of an overmoulded compressible body 8, where it may be noted how, basically, distributed along the inner circumference of the seat 9a' are the axial reliefs 8d of the body part 8b, whereas distributed along the outer circumference of the same seat 9a' are the axial reliefs 9c'.

15 The next Figure 53 shows the assembled condition between sensor body 5 and compensation element 3, with the lower-end region of the body portion 5b inserted in the seat 9a', with the reliefs 8d of the body part 8b that interfere in an elastic way with the inner surface of the portion 5b, whilst its outer side interferes in a relatively rigid way with the reliefs 9c'. Such a type of embodiment may
20 prove advantageous to improve further coupling between the sensor 2 and the compensation element 3, for the purposes of handling of the self-standing assembly 1. The reliefs 9c' may be provided in all those embodiments in which the core 9 includes an edge in relief of the type designated by 9c.

 In various embodiments, a device integrating a sensor assembly of the type
25 described herein may include an annular element of the type designated previously by 12, which is mounted within the seat 31 of a body 30 or of a component 30', instead of directly on the sensor assembly (as, for example, in the embodiments represented in Figures 1-18 or 19-32).

 Figures 54-55 show schematically such a case, in relation to a generic
30 functional component 30' (it being, however, understood that the same concepts can be applied also to the case of a casing body 30).

 Figure 54 shows schematically in exploded view the device, with parts 2, 3, 10, 12 and 20 substantially of a type already described previously. Also the component 30' can have a structure similar to the ones already exemplified
35 previously, where, however, the peripheral profile of the seat 31 is modified. In

particular, with reference to Figure 55, it may be noted how, basically at the step 31a, a seat 31b is defined for positioning of the annular supporting element 12, on which the lower face of the core 9 rests in order to guarantee elastic mounting of the sensor body and of the associated compensation element. As has been said, the presence of the element 12 may prove advantageous in those embodiments in which the sensor body and the compensation element are constantly urged into the seat 31, for example via the action of the elastic contact elements 7, as in the case exemplified in the figure. In the example illustrated, also the part 8a of the compressible body 8 rests on the bottom of the seat 31, but this does not constitute an essential characteristic, as already mentioned.

Figure 56 illustrates a similar case, but referring to a casing body 30, and where associated, preferably in an elastic way, to the body part 8a of the deformable body 8 is also a shielding element 4. The body part 8a and the shielding element 4 may, for example, be of type similar to the ones described with reference to Figures 19-31.

As already mentioned, in various embodiments, the bottom wall of a shielding element of the type described previously may envisage, on its outer side, one or more reliefs or projections, which are designed to rest on the bottom surface of the seat that is to receive the sensor assembly.

Figures 57 and 58 illustrate, for this purpose, two shielding elements 4, of the type represented in Figures 1-18 and Figures 19-31, respectively, the bottom wall 4b of which has on the outside a series of projections 4b'', here substantially in the form of embossings, for example arranged according to a circumference, for resting on the bottom of the seat 31. As may be appreciated from Figure 59, the presence of the projections 4'' prevents the bottom wall 4b from being completely in contact with the bottom surface of the seat 31, limiting the passage of the fluid through the inlet 32. Hence, in other words, the presence of the projections 4b'' guarantees in any case the presence of a free space through which the fluid that penetrates into the seat 31 through the inlet 32 can reach the through openings 4b' present in the aforesaid wall 4b.

Of course, the projections 4b'' may be envisaged in all the embodiments described herein, in particular to prevent the risk of an excessive thrust on the sensor assembly, for example by the elastic contacts 7, from exceeding the elastic resistance of the annular element 12 and/or of the part 8a of the deformable body 8, and thus from bringing about direct contact between the entire outer surface of

the wall 4b and the bottom surface of the seat 31.

Figure 60 illustrates further possible embodiments of the invention, in particular in relation to resting of the sensor body 5 on the core 9 of the compensation element and in relation to elastic mounting of the sensor body 5 and
5 of the associated compensation element within a corresponding seat 31.

In the embodiments described previously, the body 8 or bodies 8₁ and 8₂, on the one hand, and the core 9, on the other hand, of a compensation element are structured substantially in such a way that the lateral dimension or maximum diameter of the core exceeds the lateral dimension or maximum diameter of the
10 elastically compressible body 8. In this way, a peripheral part of the disk-shaped wall 9a of the core 9 can be exposed, to provide a resting surface for the lower end of the portion 5b of the sensor body; as has been seen, the peripheral part may be provided with the edge in relief 9c (see, for example, Figures 5-9 and 17-18) and/or with the edge in relief 9i (see, for example, Figures 27-31).

However, in various embodiments, for example of the type illustrated in Figure 60, the core 9 may have a lateral dimension or maximum diameter smaller than the lateral dimension or maximum diameter of the elastically compressible body 8, and in particular of its body part 8a, with the disk part 9a of the core that is to a major extent embedded in the corresponding elastically deformable
15 material. As may be noted from Figure 60, in embodiments of this type a small area of the upper face of the disk part 9a may in any case be exposed, and at least a corresponding area of the lower end of the portion 5b of the sensor body 5 can bear thereupon. Also this solution thus prevents the risk of the compensation element, in particular the parts 8b and 8c of its elastically deformable body 8,
20 being inserted excessively within the cavity C of the sensor body 5 and possibly coming into contact with the membrane M.

In the embodiments described previously, the compensation element is mounted in an elastic way within the seat 31 by virtue of the presence of the annular element 12 or else of a body part 8a sized so as to rest directly on the
30 bottom of the seat itself. In alternative embodiments, however, even in the presence of a shielding element 4 and in the absence of an annular element 12, the aforesaid elastic mounting may be obtained. In particular, in embodiments of this type, the shielding element 4 may be mounted resting directly within the seat (i.e., without interposition of some elastic element), and the same elastically
35 deformable body 8 is exploited for the purposes of at least partial elastic

mounting. Figure 60 is designed to illustrate also such an embodiment, where it may be noted how the flange 4c of the shielding element 4 rests directly on the step 31a of the seat 31, i.e., in a substantially rigid way, and the lower part of the body 8, in particular its portion 8a, rests on the wall 4b of the shielding element 4, guaranteeing elastic mounting of the sensor body 8 and of the associated compensation element 8-9.

In a further possible variant embodiment, the part of the body 8 that is designed to remain on the outside of the cavity C of the sensor body 5 may be provided so as to have at least one portion that projects further up than the upper surface of the disk part 9a of the core 9 and in such a way that on this projecting portion at least an area of the lower end of the portion 5b of the sensor body 5 can rest. Such a portion projecting in height of the body part 8a may correspond, for example, to the part designated by 8a'' in Figure 60, and may have an annular profile. This portion 8a'' preferably extends in a position radially more external than the maximum diameter of the disk part 9a of the core 9. It should be noted that, in Figure 60, the top of the aforesaid portion 8a'' appears at the same height as the upper surface of the disk part 9a, but for the purposes of an understanding of the present variant it may be assumed that – in the condition illustrated – the portion 8a'' of the body 8 is already elastically compressed on account of the thrust exerted downwards on the sensor body 5, for example as a result of the abutment surfaces 24a present on the closing body 20 and/or of the stress exerted by the elastic contacts 7 (in the embodiment of Figure 60, when elastic mounting is guaranteed by resting of the body 8 on the shielding element 4, the portion 8a'' may in any case be prearranged in such a way that its top is flush with the upper surface of the disk part 9a of the core).

In the example, then, if the projecting portion 8a'' is envisaged, its compression may be considered maximum, with the lower end of the portion 5b of the sensor body 5 that is then partially resting on the disk part 9a of the core 9. However, the degree of compression may be less than what is exemplified, with the upper surface of the portion 8a'' that extends further up than the upper surface of the exposed area of the disk part 9a, i.e., with a partial compression of the portion 8a''.

It will be appreciated that, in addition and/or as an alternative, an elastic mounting may be obtained also by exploiting the part 8b of the elastically deformable body 8, in particular in view of the fact that on its upper area there

may possibly rest the surface of transition between the two parts of different diameter of the cavity C of the sensor body: this transition surface is designated by C₃ only in Figure 60; for such a case, the height of the body 8b and/or of the portion 5b of the sensor body 5 may be sized in such a way as to enable the
5 aforesaid elastic mounting.

In any case, the risk of excessive insertion of the compensation element within the cavity C of the sensor body 5 is prevented by the abutment or stop surface provided by the exposed upper area of the disk part 9a of the core 9.

In various embodiments described previously, the compensation element 3
10 is configured for coupling with the sensor body 5 with elastic coupling of the compensation element within the axial cavity C. In other embodiments, however, in addition or as an alternative, elastic coupling may be provided at an outer profile of the sensor body 5, preferably the outer profile of its portion 5b.

With reference, for example, to Figure 61, a compensation element 3 is for
15 example illustrated, the elastically deformable body 8 of which – here configured as body overmoulded on the core 9 – is built in a way substantially similar to what is illustrated in Figure 60, but formed so as to comprise a peripheral part 8e, in particular having a generally cylindrical shape, which rises upwards from the body part 8a. The peripheral part 8e could, however, even have a shape different
20 from a cylindrical wall, such as a shape at least in part complementary with a portion of the sensor body 5, in particular of the corresponding lower portion 5b. Preferably, the inner diameter or dimension of the peripheral part 8e is smaller than at least part of the outer diameter or dimension of the sensor body 5, i.e., of the corresponding lower portion 5b, in particular for the purpose of mutual fixing.

25 In this way, defined between the body part 8b and the inner surface of the wall that forms the body part 8e is a seat – designated by 8' in Figure 61 – for positioning and resting of the lower edge of the portion 5b of the sensor body 5.

As in the case of Figure 60, then, the core 9 has a lateral dimension or maximum diameter smaller than the lateral dimension or maximum diameter of
30 the elastically compressible body 8, and in particular of its body part 8e, with the disk part 9a of the core that is to a major extent embedded in the corresponding elastically deformable material. Also in embodiments of this type, it is in any case preferable for at least an area of the upper face of the disk part 9a to be exposed, so that at least a corresponding area of the lower end of the portion 5b of the
35 sensor body 5 can bear thereupon in order to prevent the compensation element 3

from being fitted excessively on the sensor body 5, for example in order to prevent the part 8c of the elastically deformable body 8 from being inserted excessively within the cavity C of the sensor body 5, until it comes into contact with the membrane M.

5 It should be noted, however, that in a compensation element of this type it is not strictly indispensable for its parts to project within the cavity C of the sensor body 5, it being sufficient for the compensation element to be located in the proximity of said cavity.

10 This is particularly true, for example, when the sensor body 5 is as a whole very thin (in the direction of height) and hence also the corresponding cavity C is shallow; i.e., it has a volume that can be filled by the fluid that is so small as not to require the presence of a compensation element that projects within the cavity itself. In applications of this type, then, the compensation insert can extend completely or prevalently on the outside of the aforesaid cavity, the insert having
15 the main function – in addition to guaranteeing elastic mounting of the assembly as already described above – of reducing the free volume that can be occupied by the fluid in the seat in which the assembly itself is installed, as well as compensating the possible increase in volume of the fluid following upon freezing.

20 Visible in Figure 62 is a device on which a sensor assembly including the compensation element 3 of Figure 61 is mounted.

 As may be noted, the body part 8e is fitted in an elastic way on the outer surface of the body portion 5b, with the lower end of the latter resting on the exposed surface of the disk part 9a of the core 9, which functions as end-of-travel
25 in regard to insertion.

 The elastic coupling between the body 5 and the body 8 is improved by the presence of the body part 8e, in a way similar to what has been described above: as has been said, however, in other embodiments the compensation element might not present parts projecting into the cavity of the sensor body.

30 What has been explained in relation to Figures 61-62, as regards the possibility of coupling in an elastic way the compensation element also, or exclusively, at an outer profile of the sensor body, i.e., on the outside of the corresponding cavity, may of course be applied also to all the other embodiments described herein or to sensors having a different shape.

35 From the foregoing description, the characteristics and advantages of the

present invention emerge clearly, which are mainly represented by the ease of production of the self-standing or independent sensor assembly described, which is fast, inexpensive, and precise. The sensor body 5 may be obtained with classic technologies employed in the sector of manufacture of pressure sensors. In a similar way, the compensation element is obtained with the use of moulding technologies and materials that are widely used and reliable. The fact that the compensation element can be elastically coupled in a well-defined and precise position to the pressure sensor enables, as explained, convenient handling of the components of the assembly as a single unit, in particular during movement on automatic assembly lines and/or during transport and/or warehousing. The fact that the hydraulic seal is provided via an annular element mounted on the outer periphery of the sensor body enables pre-mounting also of the component on the sensor assembly, to the further advantage in terms of handling, transport, and warehousing.

It is clear that, for the person skilled in the art, numerous variations are possible to the sensor assemblies and to the sensor devices described by way of example, without thereby departing from the scope of the invention. As mentioned, for the purposes of production of such further variants one or more of the characteristics described previously also with reference to different embodiments may be combined in any adequate way.

As per a known technique in the field, the passage P or P' of the compensation body 8 or 8₁ does not have to be necessarily configured as a duct that axially traverses the element itself, in so far as the passage for the fluid could be at least in part delimited between an outer surface profile of the body 8 itself and/or of the corresponding core 9, on the one hand, and a surface profile of the housing or seat 31, on the other. For instance, the compressible body 8 and/or the core 9 may have at least one surface groove that delimits, with a respective surface of the seat 31, at least part of a passage for the fluid, or conversely a surface of the seat 31 may have at least one surface groove that delimits a corresponding passage for the fluid with a respective outer surface of the body 8 and/or of the core 9, or else again both the compensation element 3 and the seat 31 may have respective grooves facing one another or coupled to form at least part of a passage for the fluid.

The passage for the fluid could be at least in part delimited between a surface profile of the elastically deformable body and a surface profile of the

corresponding core.

The core of the compensation element could be provided in a number of parts, possibly driven into one another or engaged or welded together, between which there could be possibly be set at least a part of the corresponding elastically
5 deformable body.

The elastically deformable body and the corresponding core could be configured to define a number of passages or a passage with parts staggered with respect to one another, for example as described in WO2017/182962, filed in the name of the present Applicant.

CLAIMS

1. A pressure-sensor assembly for detecting the pressure of a fluid, the sensor assembly (1) comprising:

- a pressure-sensitive component (2), having a generally cup-shaped sensor body (5), which includes a bottom portion (5a) and a peripheral portion (5b) that define an axial cavity (C), the bottom portion (5a) including an elastically deformable membrane part (M), which closes the axial cavity (C) at an end of the sensor body (5), and the peripheral portion (5b) having a distal edge opposite to the bottom portion (5a), which delimits an inlet of the axial cavity (C), the bottom portion (5a) having associated thereto at least one detection element (6) for detecting deformation of the membrane part (M);

- a compensation element (3), configured for compensating possible variations of volume of the fluid, comprising at least one compensation body (8; 8₁, 8₂), made of a first elastically deformable or compressible material, and a core (9), fixed on which is the at least one compensation body (8; 8₁, 8₂), the core (9) being made of a second material stiffer than the first material,

wherein the sensor body (5) and the compensation element (3) are configured as distinct parts, and at least one part of the compensation element (3) extends in a position corresponding, or close, to the axial cavity (C) of the sensor body (5),

the pressure-sensor assembly (1) being characterized in that at least one first portion (8b, 8c; 9b, 8e) of the compensation element (3) is configured for coupling with the sensor body (5) in such a way that the pressure-sensitive component (2) and the compensation element (3) are manipulable as a single unit.

2. The sensor assembly according to Claim 1, wherein the at least one first portion (8b, 8c; 9b, 8e) of the compensation element (3) is configured for an interference coupling or an elastic coupling of the compensation element (3) on the sensor body (5), within the axial cavity (C) and/or at an outer profile of the peripheral portion (5b) of the sensor body (5).

3. The sensor assembly according to Claim 1 or Claim 2, wherein the core (9) of the compensation element (3) has a respective portion (9a) that defines a reference surface for fitting the compensation element (3) on the sensor body (5), the reference surface being preferably an abutment surface or stop surface for said distal edge of the peripheral portion (5b) of the sensor body (5).

4. The sensor assembly according to any one of Claims 1-3, wherein the at

least one first portion (8b, 8c; 9b; 8e) of the compensation element (3) comprises an engagement part of the compensation body (8; 8₁, 8₂) having respective positioning and/or fixing means (8d; 8e) suitable to interfere with a peripheral surface of the sensor body (5), the positioning and/or fixing means (8d) preferably
5 comprising a plurality of axial reliefs (8d) which are distributed along a peripheral wall of said engagement part and suitable to elastically interfere with a peripheral surface of the axial cavity (C) of the sensor body (5).

5. The sensor assembly according to any one of Claims 1-4, wherein the at least one first portion (8b, 8c) of the compensation element (3) comprises an
10 engagement of the core (9) having respective positioning and/or fixing means (9x) suitable to interfere with a peripheral surface of the sensor body (5), the positioning and/or fixing means (8d) preferably comprising a plurality of flexible axial appendages of the core (9) which are distributed according to a peripheral wall of the compensation body (8; 8₁, 8₂) and suitable to elastically interfere with
15 a peripheral surface of the axial cavity (C) of the sensor body (5).

6. The sensor assembly according to any one of Claims 1-5, wherein the sensor body (5) includes at least two respective portions of different outer diameter (5a, 5b), there being fitted on a portion having a smaller diameter (5b) at least one of an annular sealing element (10) and the at least one first portion (8e)
20 of the compensation element (3).

7. The sensor assembly according to Claim 6, wherein the sensor body (5) has a plurality of axial recesses at a peripheral surface of a portion thereof having a greater diameter (5a), and wherein at a transition (5c) between the portion having the greater diameter (5a) and the portion having smaller diameter (5b) a
25 ring (11) is arranged for possible resting thereon of the annular sealing element (10).

8. The sensor assembly according to any one of Claims 1-7, wherein the compensation element (3) comprises a second portion (8a) designed to extend outside the axial cavity (C) of the sensor body (5), in a position generally opposite
30 to said first portion (8b, 8c), the second portion (8a) including a respective part of the compensation body (8; 8₁, 8₂) and at least one respective part (9a) of the core (9).

9. The sensor assembly according to Claim 8, further comprising a shielding element (4), including a peripheral wall (4a) and a bottom wall (4b) that
35 define a respective cavity (S), in which said respective part of the compensation

body (8; 8₁, 8₂) is at least partially inserted with interference, the bottom wall (4b) of the shielding element (4) including one or more through openings (4b') for the fluid.

5 **10.** The sensor assembly Claim 9, wherein the shielding element (4) includes a generally flange-shaped part (4c), which defines one of a seat and a resting surface for an annular elastic supporting element (12) of the sensor assembly (1).

10 **11.** The sensor assembly according to any one of Claims 1-10, wherein the core (9) of the compensation element (3) has a part (9a), which defines a resting surface for an annular elastic supporting element (12) of the sensor assembly (1).

12. The sensor assembly according to any one of Claims 1-9, further comprising at least one elastic supporting element, configured for elastic mounting of the sensor assembly (1) within a corresponding housing (31), the at least one elastic supporting element comprising at least one of:

15 - an annular element (12) designed for resting on a corresponding surface of the core (9) of the compensation element (3) that is generally opposite to said first portion (8b, 8c),

20 - a part (8a) of the compensation body (8) designed to extend outside the axial cavity (C) of the sensor body (5), in a position generally opposite to said first portion (8b, 8c).

13. The sensor assembly according to any one of Claims 1-12, wherein the compensation body comprises at least one of a body (8) moulded over the core (9) and a body (8₁, 8₂) coupled in an elastic way on the core (9).

25 **14.** The sensor assembly according to any one of Claims 1-13, wherein the compensation element (3) comprises at least one axial passage (P'; P') for the fluid.

15. A pressure-sensor device having:

30 - a pressure-sensitive component (2), having a generally cup-shaped sensor body (5), which includes a bottom portion (5a) and a peripheral portion (5b) that define an axial cavity (C), the bottom portion (5a) including an elastically deformable membrane part (M) that closes the axial cavity (C) at an end of the sensor body (5), and the peripheral portion (5b) having a distal edge opposite to the bottom portion (5a) that delimits an inlet of the axial cavity (C), the bottom portion (5a) having associated thereto at least one detection element (6) for
35 detecting deformation of the membrane part (M);

- a compensation element (3), configured for compensating possible variations of volume of the fluid, comprising at least one compensation body (8; 8₁, 8₂), made of a first elastically deformable or compressible material, and a core (9), fixed on which is the at least one compensation body (8; 8₁, 8₂), the core (9) being made of a second material stiffer than the first material, at least one portion (8b, 8c, 9b) of the compensation element (3) extending in a position corresponding, or close, to the axial cavity (C) of the sensor body (5);

- a housing structure (20, 30; 20, 30'), comprising at least one first structure part (30; 30') and one second structure part (20), the first structure part (30; 30') defining a seat (21, 31) having an inlet (32) for a fluid a pressure of which is to be detected, the seat (31) being configured for receiving the compensation element (3) and at least part of the pressure-sensitive component (5),

wherein at least one of the seat (31) and the compensation element (3) defines at least part of a passageway for the fluid, which is in fluid communication with the inlet (32) of the seat (31) and with the axial cavity (C) of the sensor body (5) in such a way that the membrane part (5a) of the sensor body (5) is exposed to the fluid,

wherein the sensor body (5), the compensation element (3), and the housing structure (20, 30; 20, 30') are configured as distinct parts free from mutual constraints,

wherein preferably the sensor body (5) rests on the core (9) of the compensation element (3), and the compensation element (3) is elastically supported within the seat (31).

16. A compensation element configured for coupling with a sensor body (5) of a pressure-sensor device (20, 30; 20, 30'), the compensation element (3) comprising at least one compensation body (8; 8₁, 8₂) made of a first elastically deformable or compressible material, and a core (9), fixed on which is the at least one compensation body (8; 8₁, 8₂), the core (9) being made of a second material stiffer than the first material, the compensation element (3) being configured as a distinct part with respect to the sensor body (5) and to a casing of the pressure-sensor device (20, 30; 20, 30'), wherein:

- at least one first portion (8b, 8c; 9b, 8e) of the compensation element (3) is configured for coupling within an axial cavity (C) of the sensor body (5) and/or at an outer profile of the sensor body (5), preferably with elastic interference, in

such a way that the sensor body (5) and the compensation element (3) can be handled as a single unit; and/or

- the core (9) of the compensation element (3) comprises a respective portion (9a) that defines an abutment surface for a distal edge of the sensor body (5), in particular for limiting insertion of the compensation element (3) on the sensor body (5).

17. A hydraulic device or system, comprising at least one from among a sensor assembly according to any one of Claims 1-14, a pressure-sensor device according to Claim 15, a compensation element according to Claim 16.

1/28

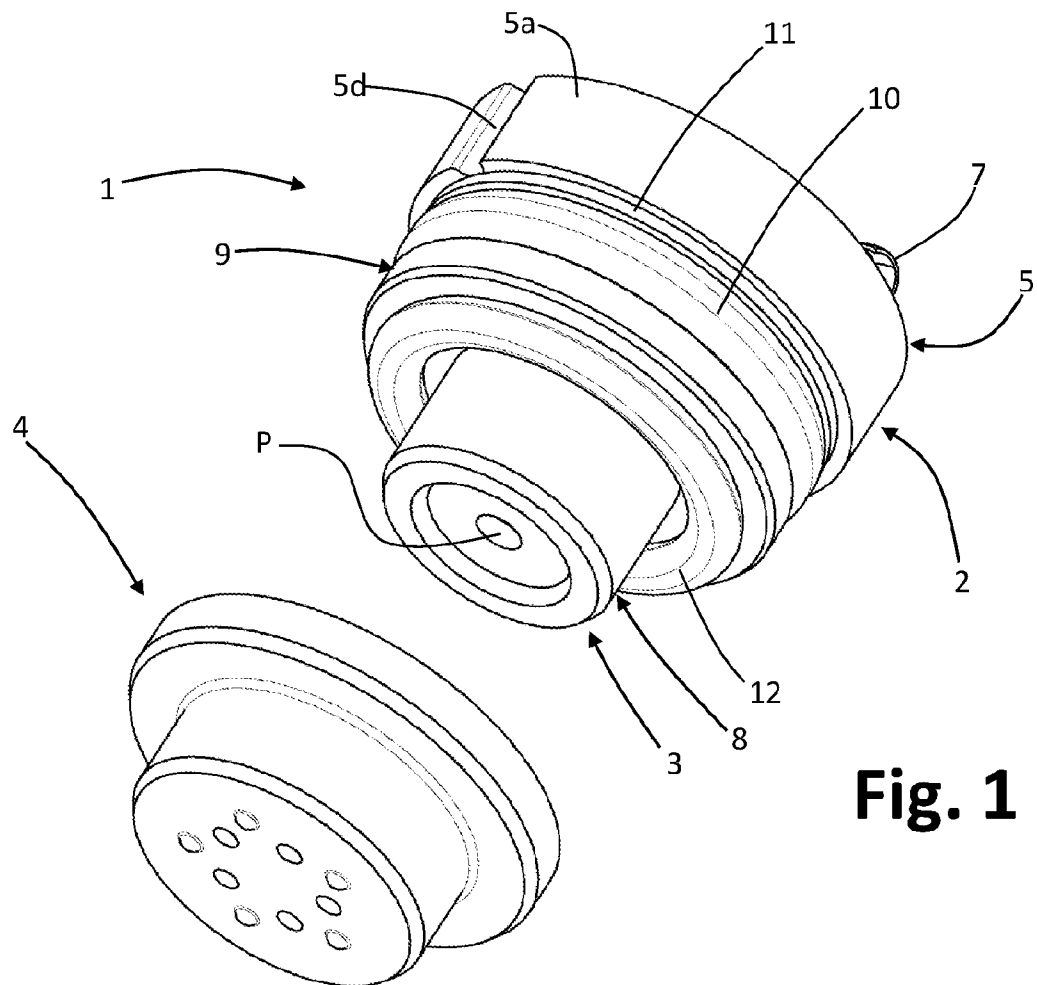


Fig. 1

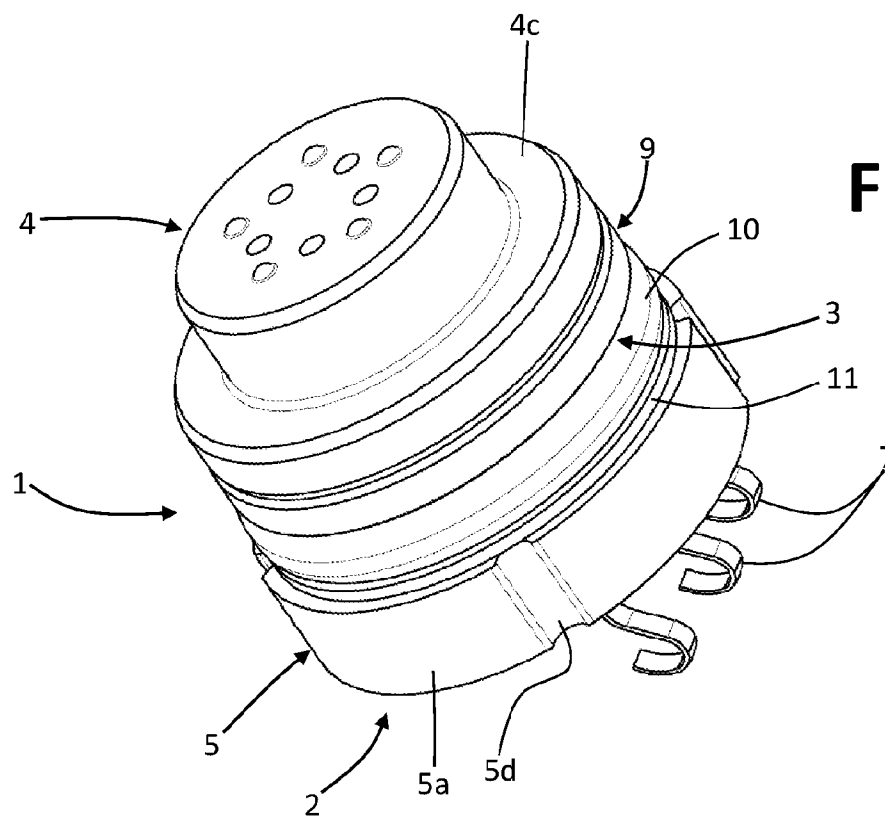


Fig. 2

Fig. 3

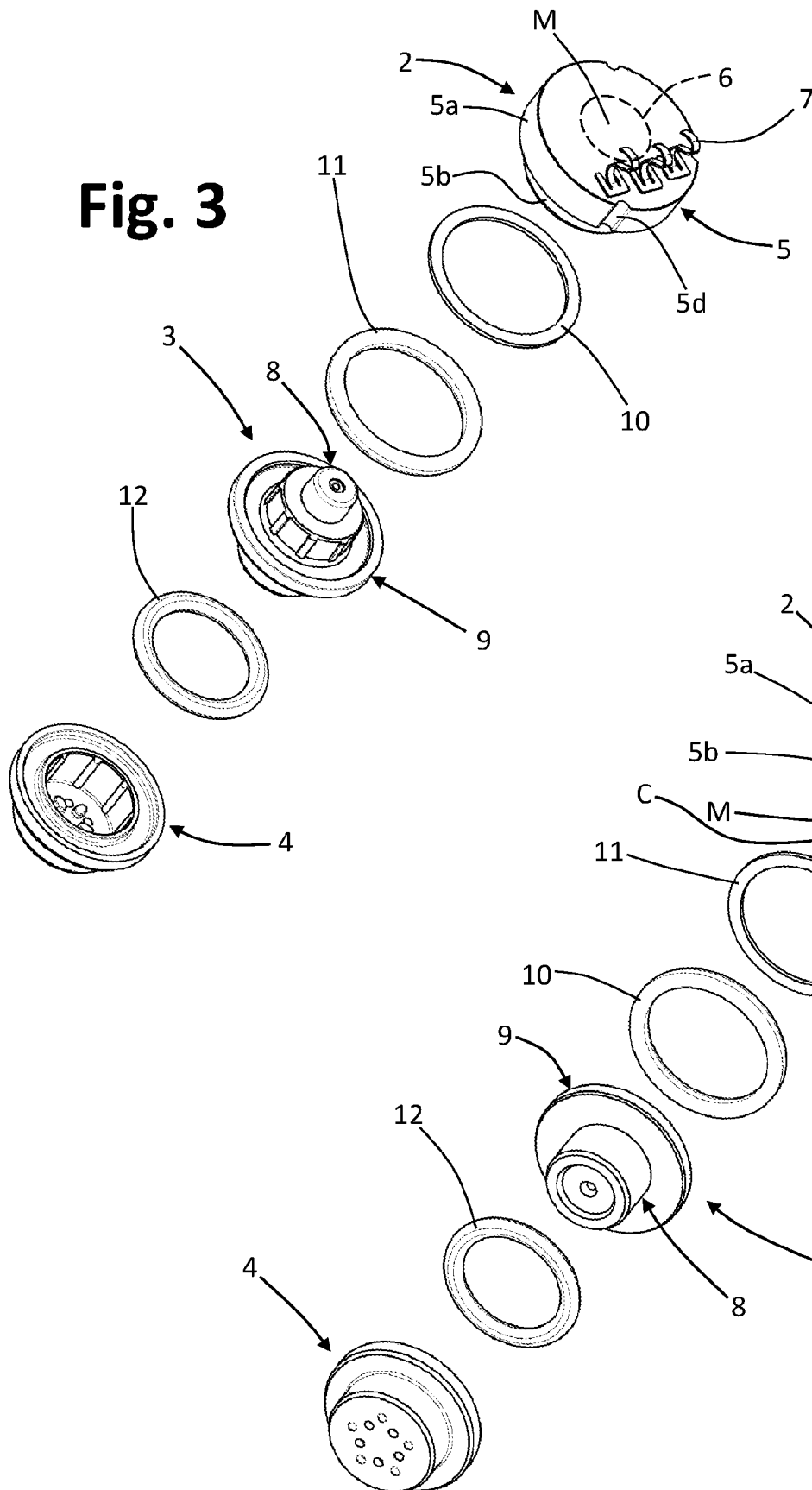


Fig. 4

Fig. 5

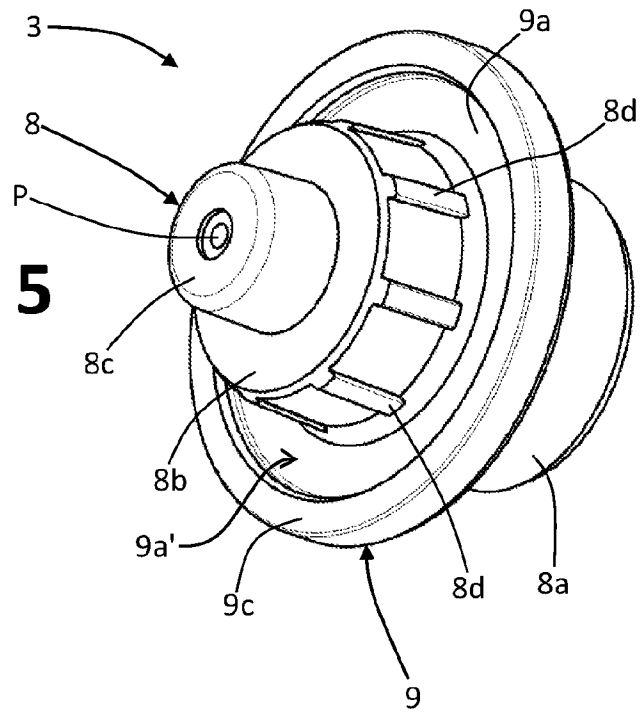


Fig. 6

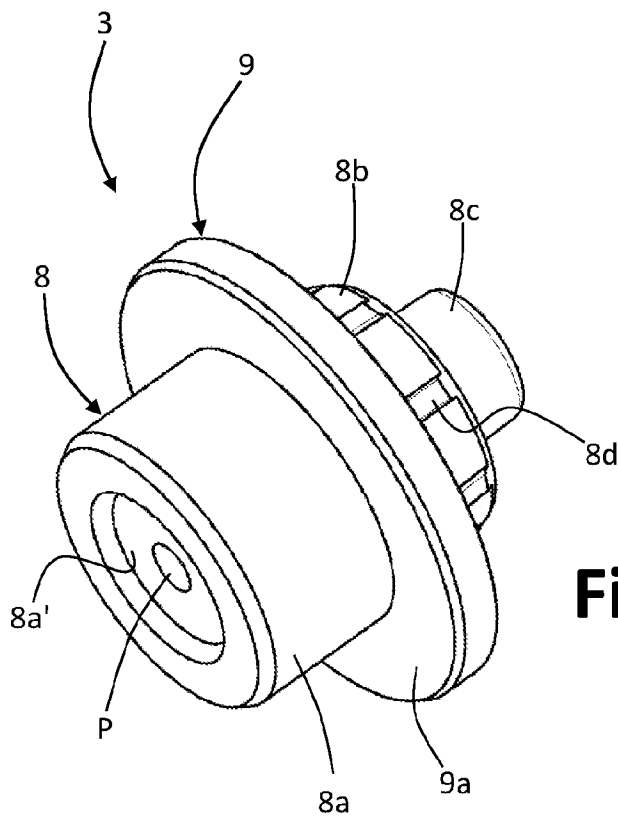
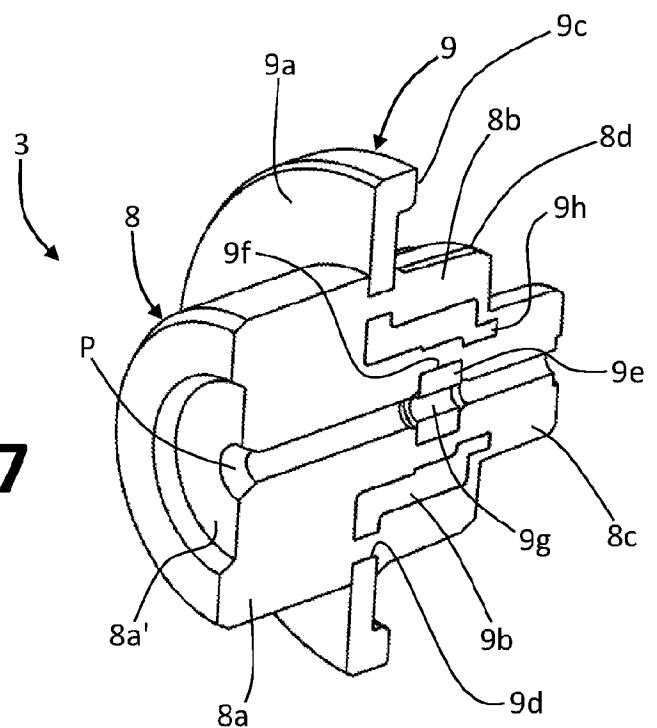


Fig. 7



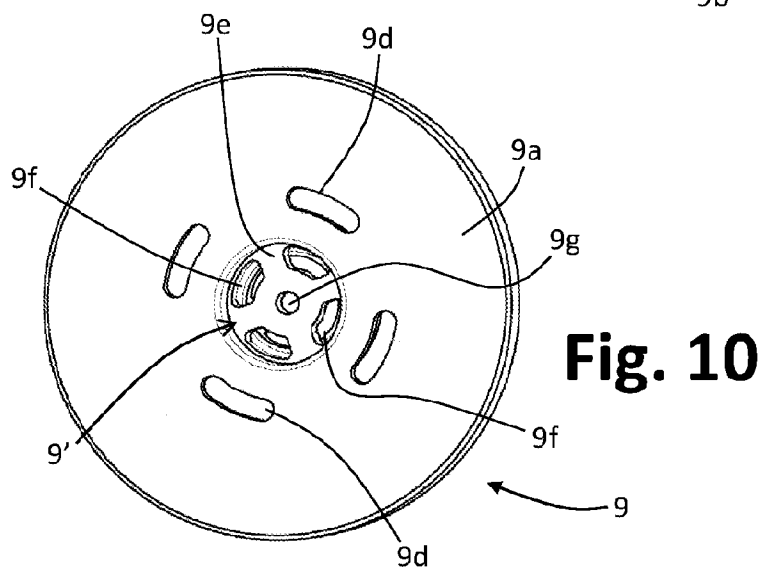
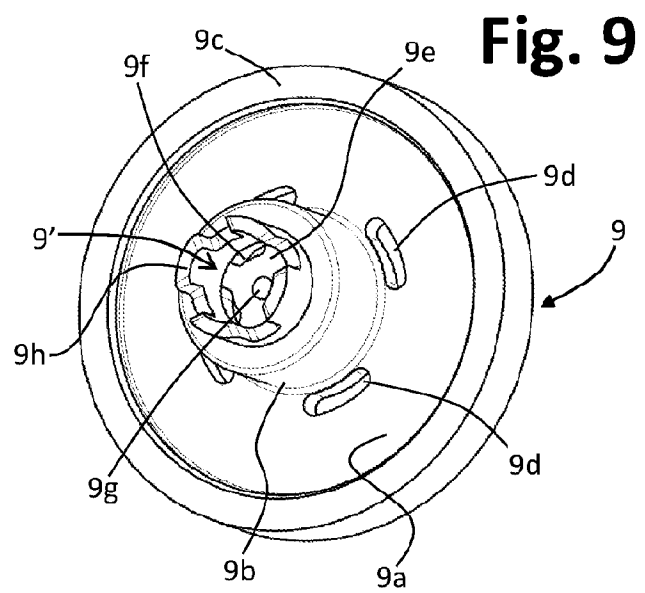
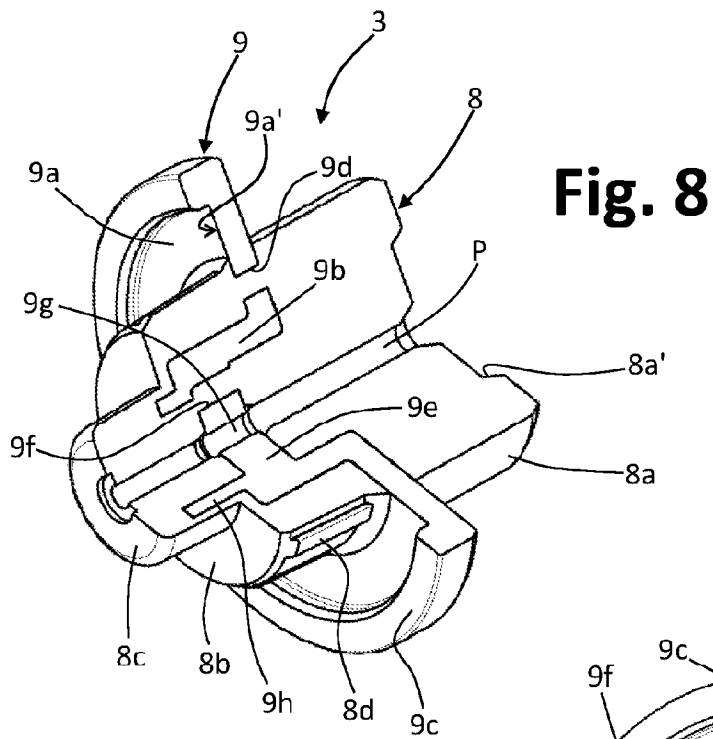


Fig. 11

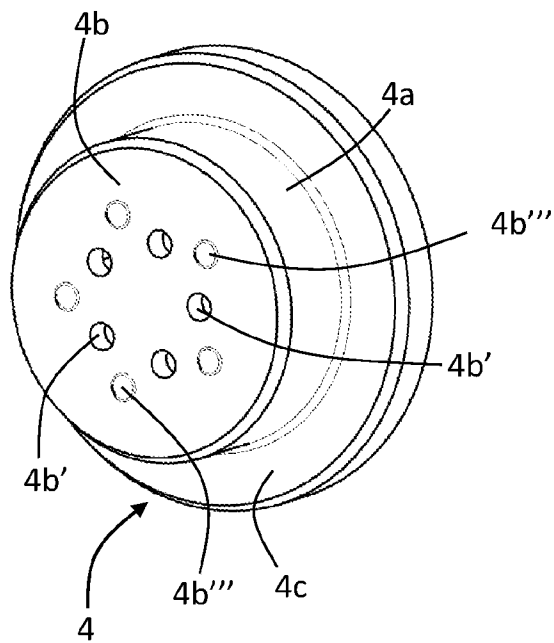


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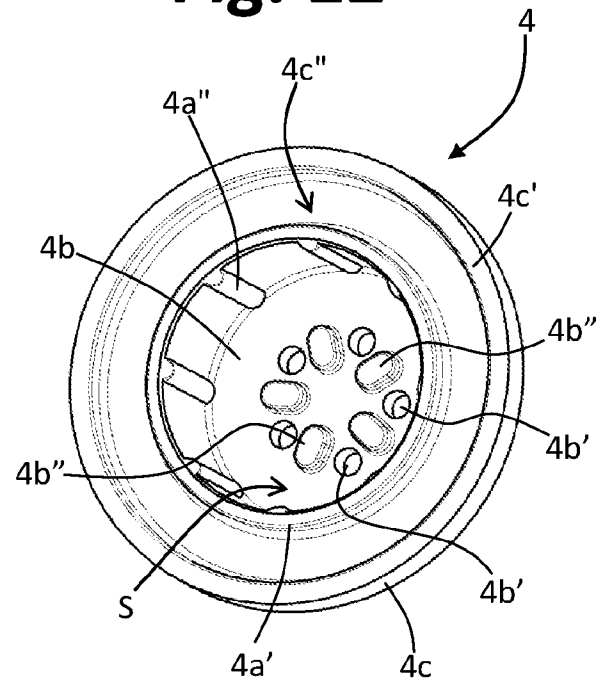


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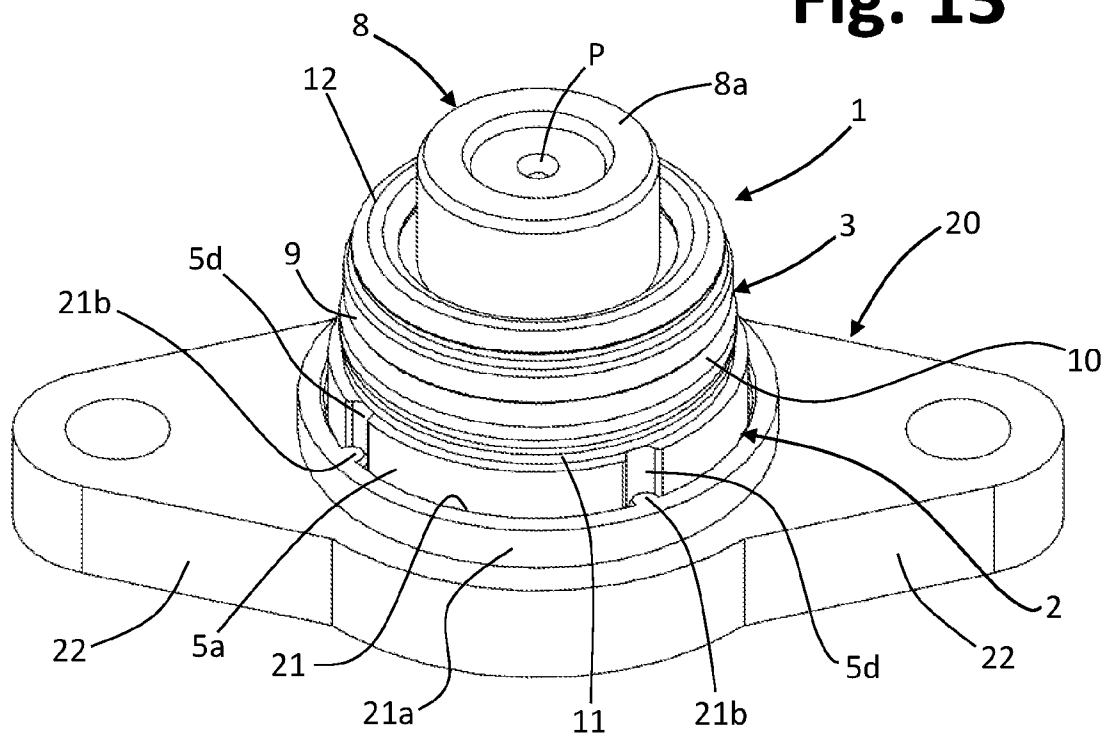


Fig. 14

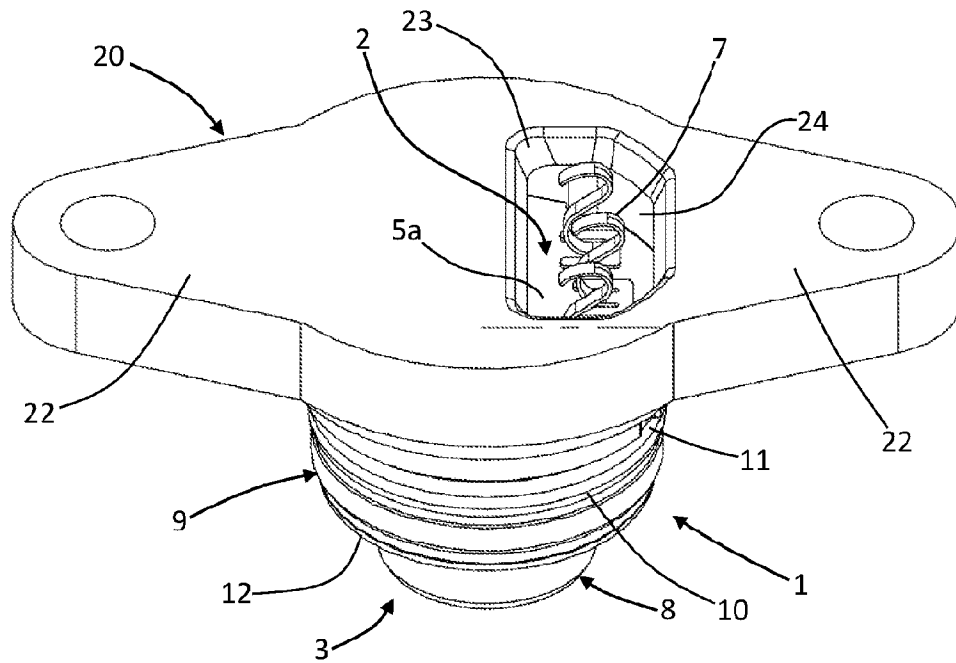


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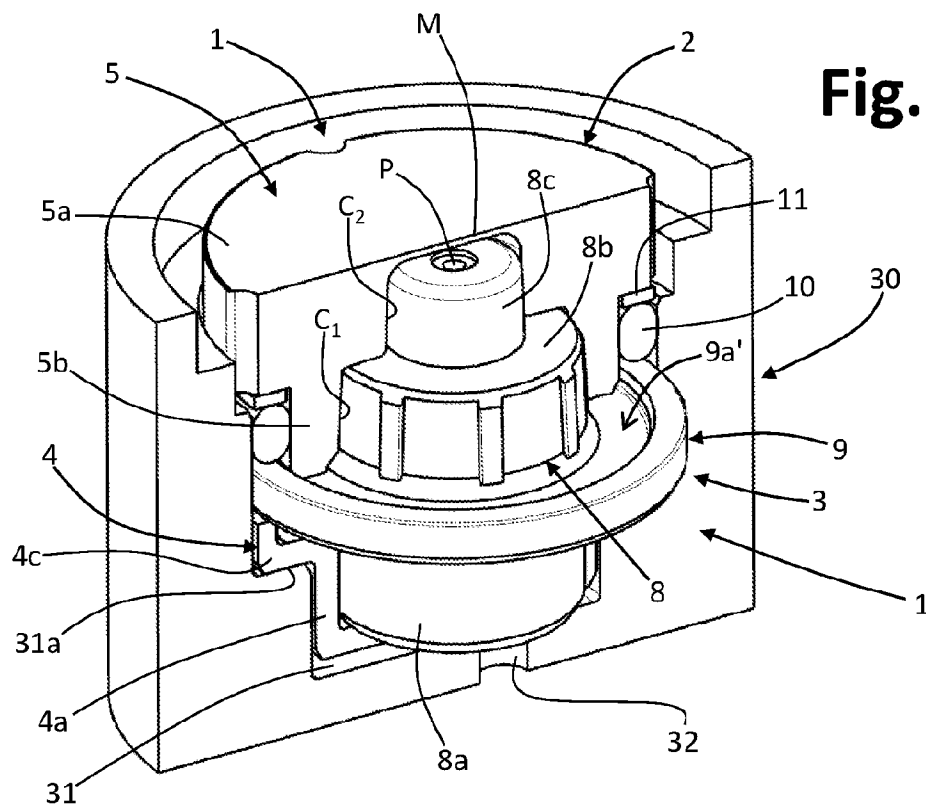


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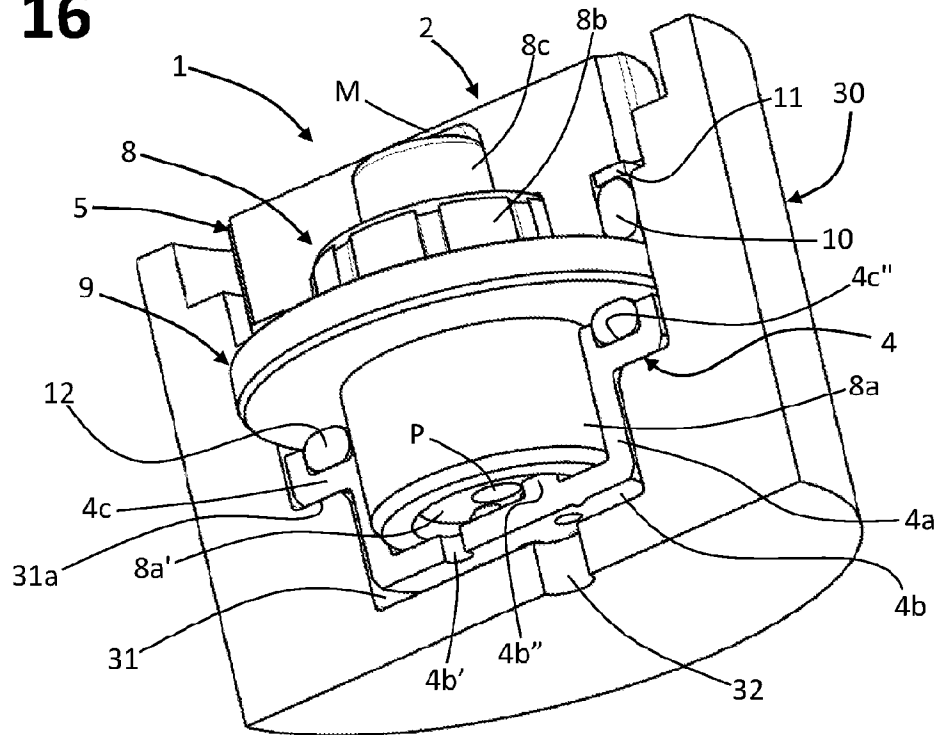


Fig. 17

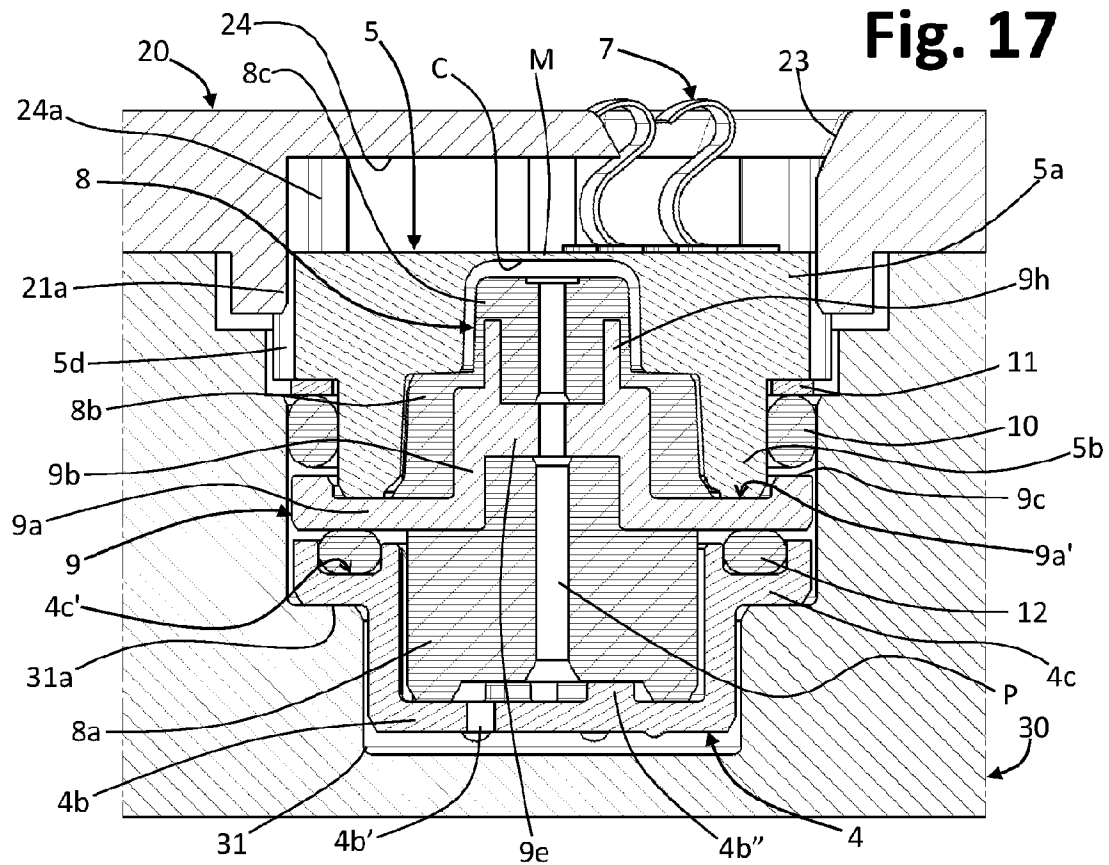


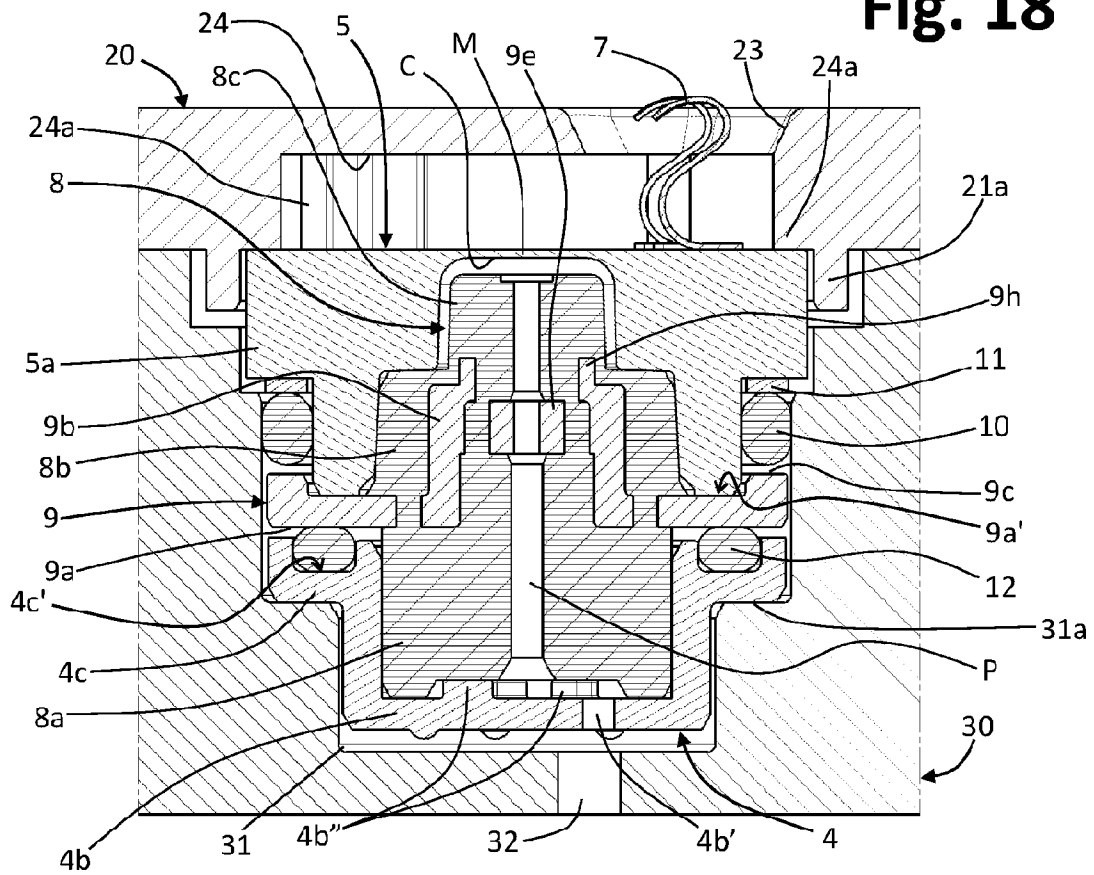
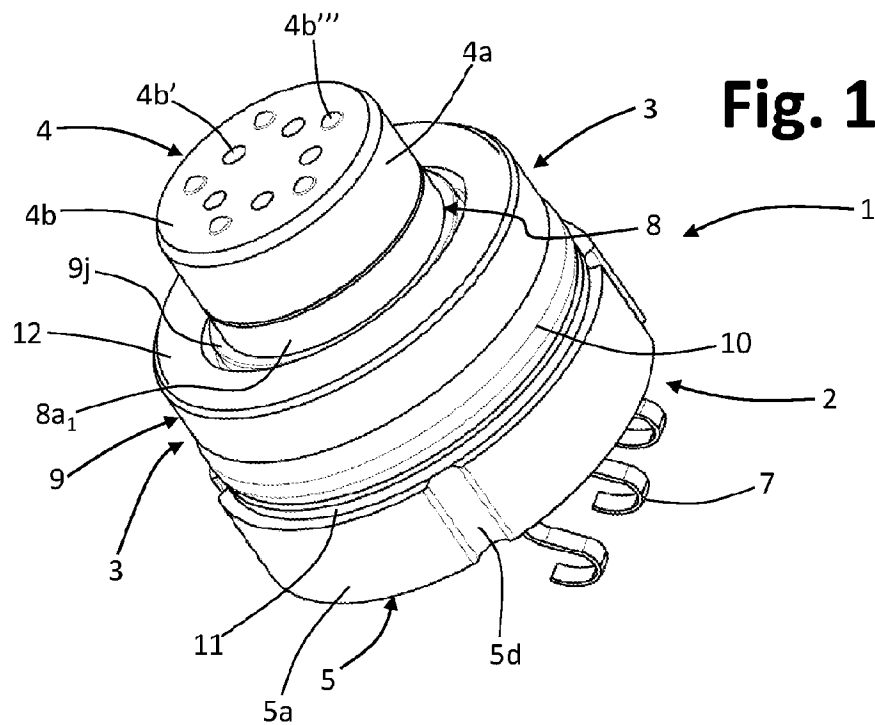
Fig. 18**Fig. 19**

Fig. 20

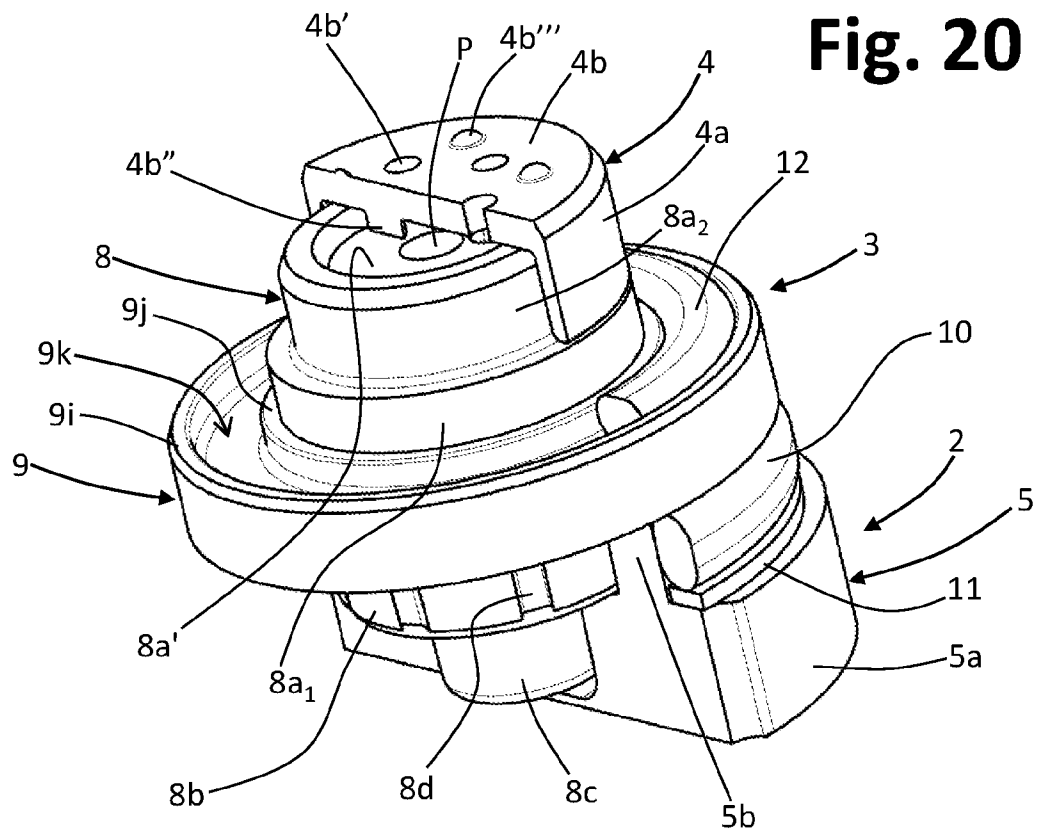
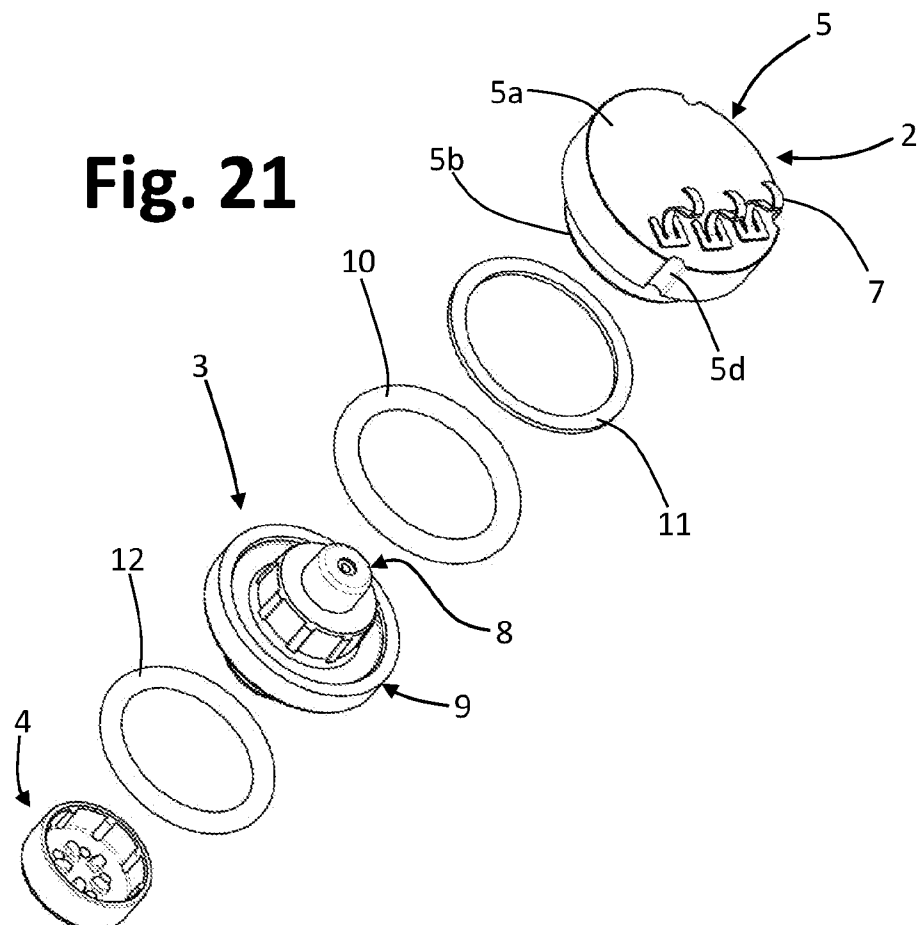


Fig. 21



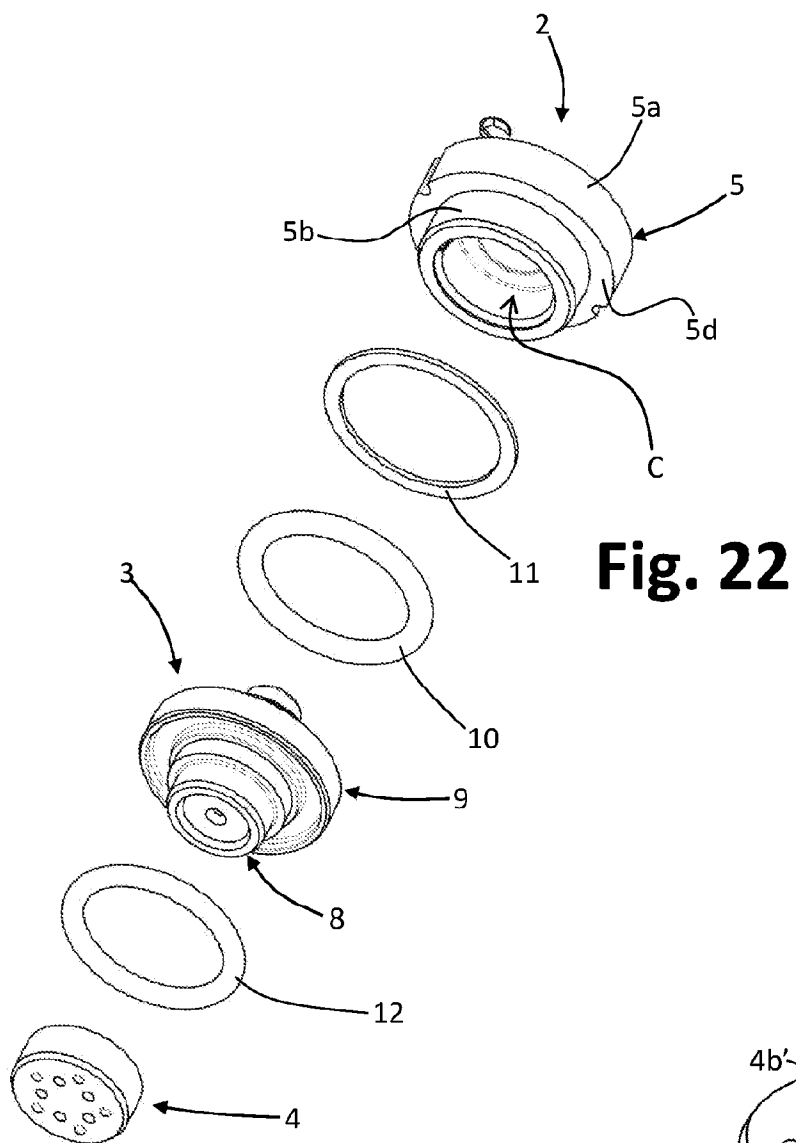
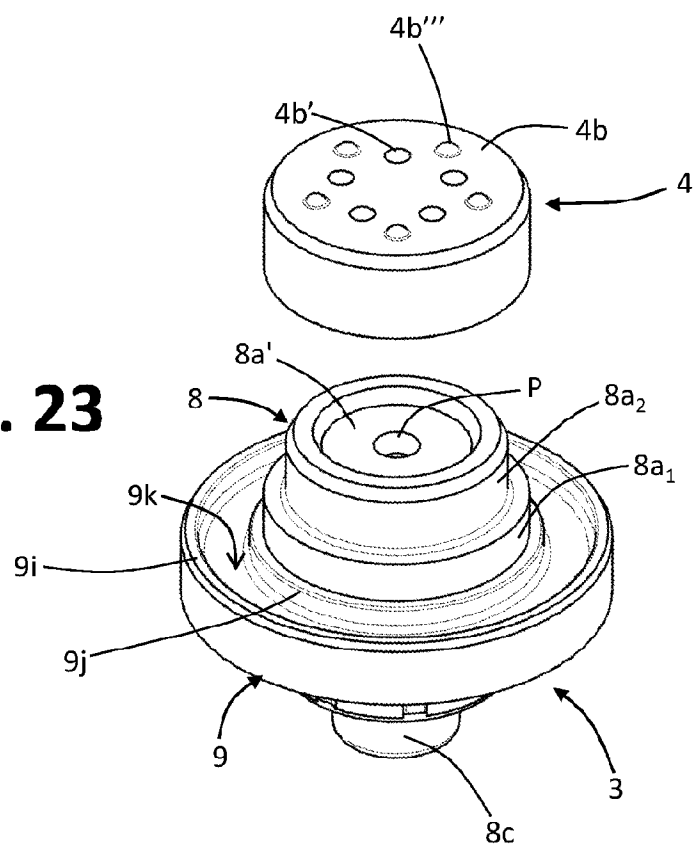


Fig. 23



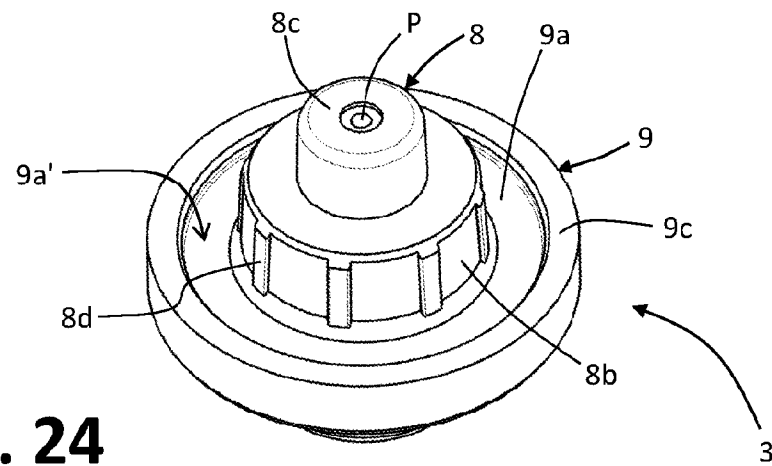


Fig. 24

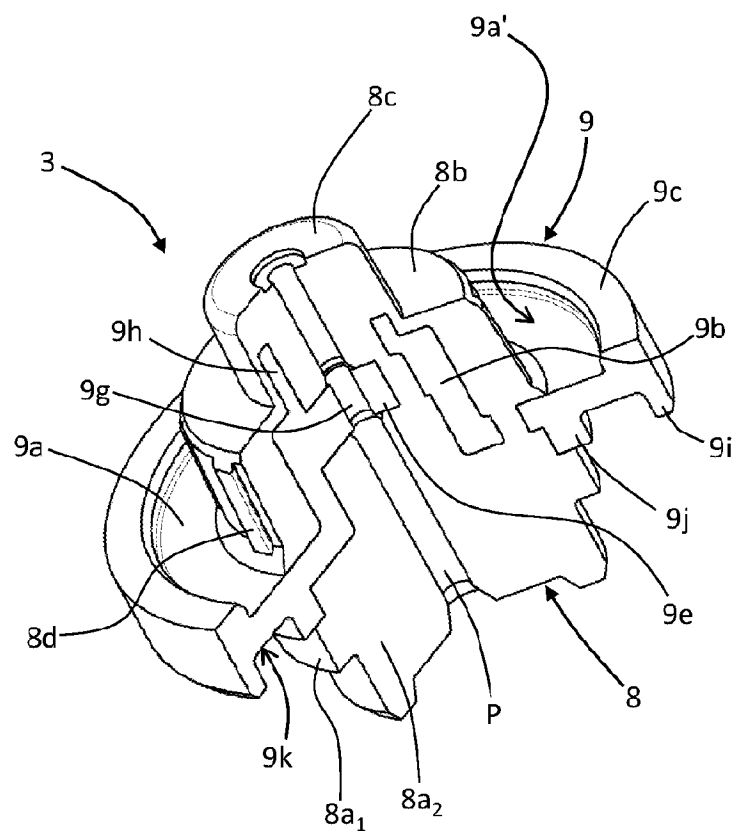
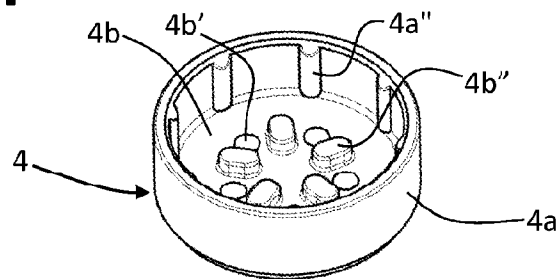


Fig. 25

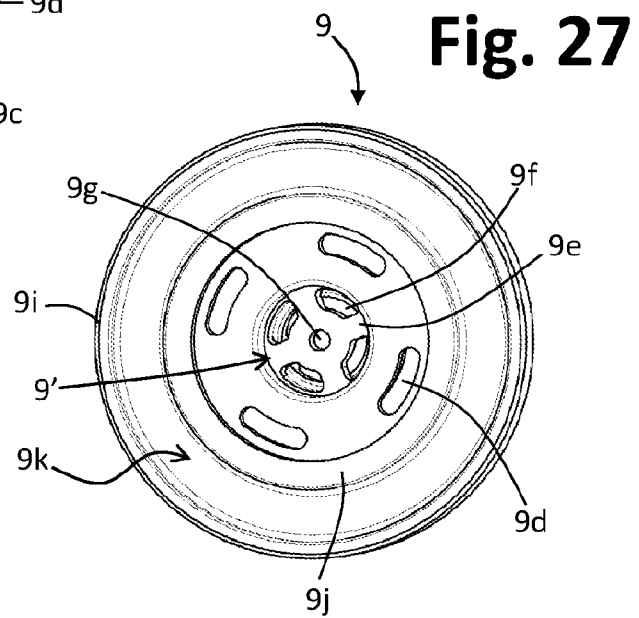
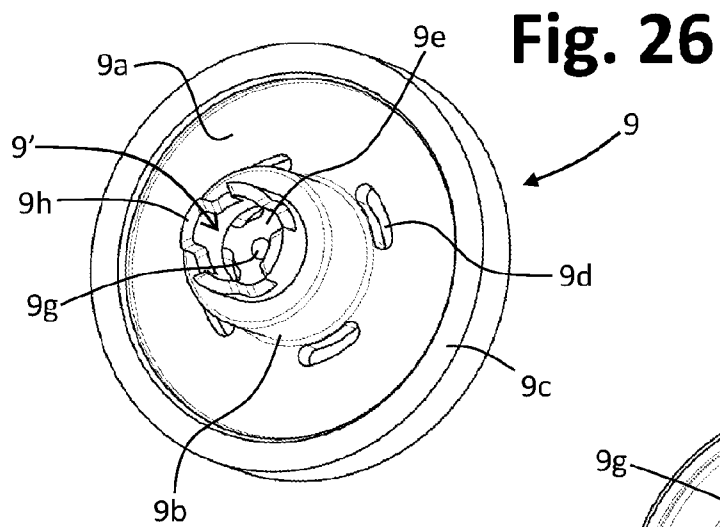


Fig. 28

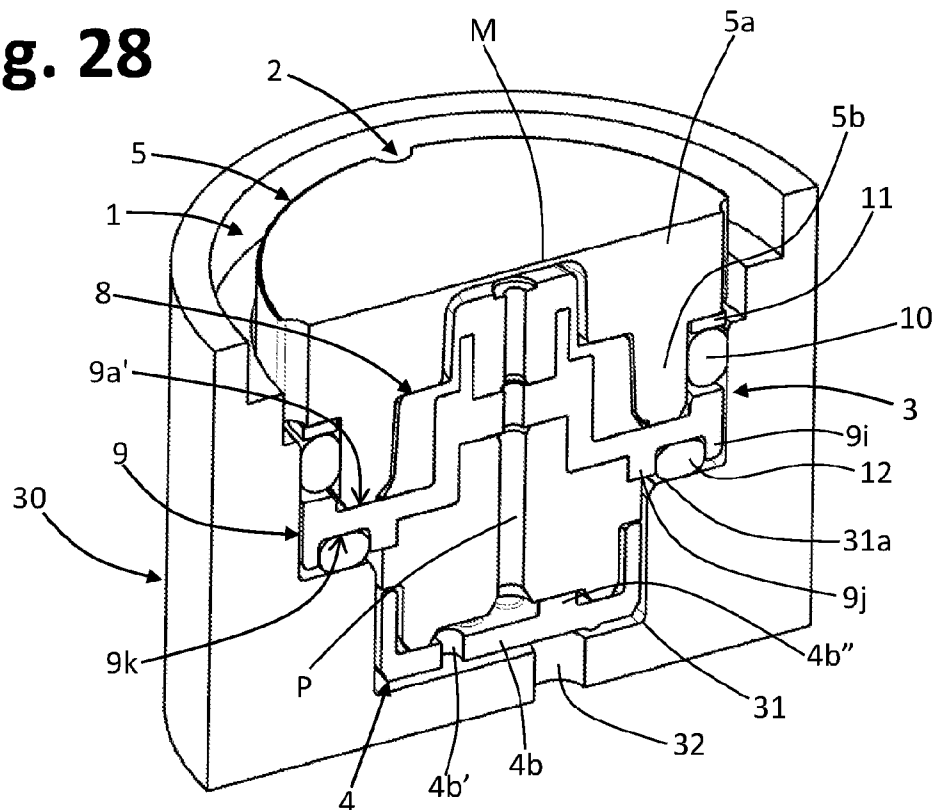
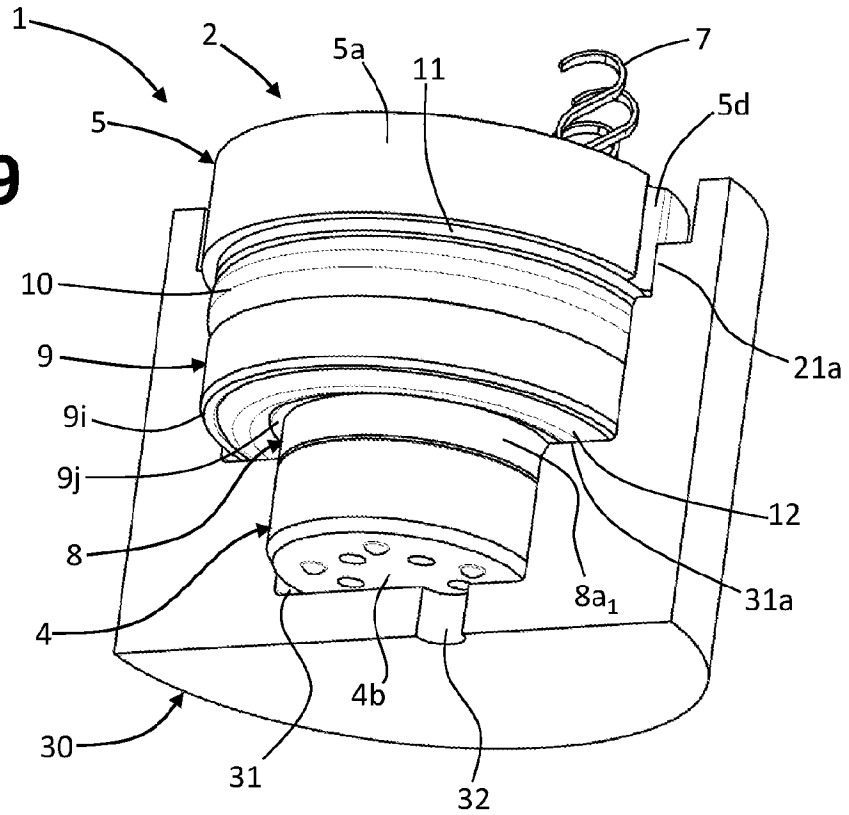
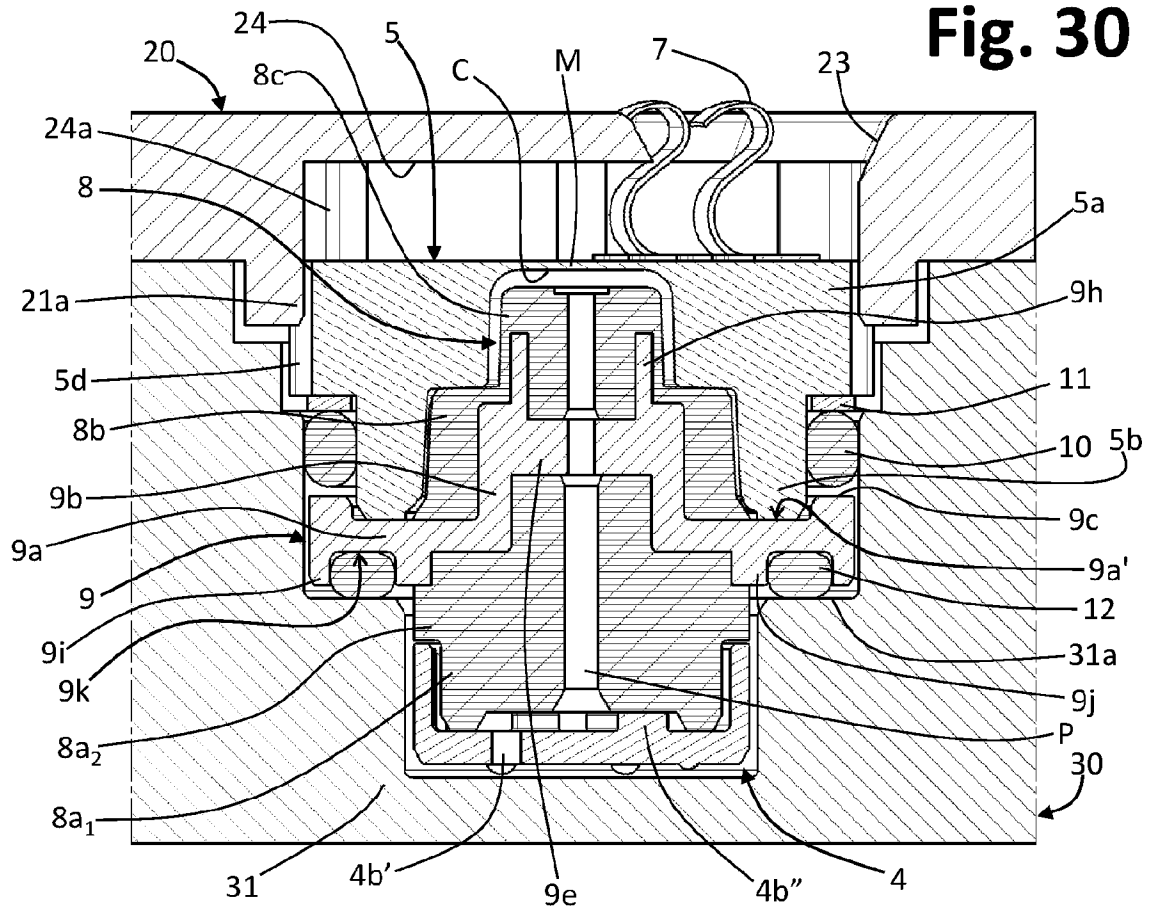
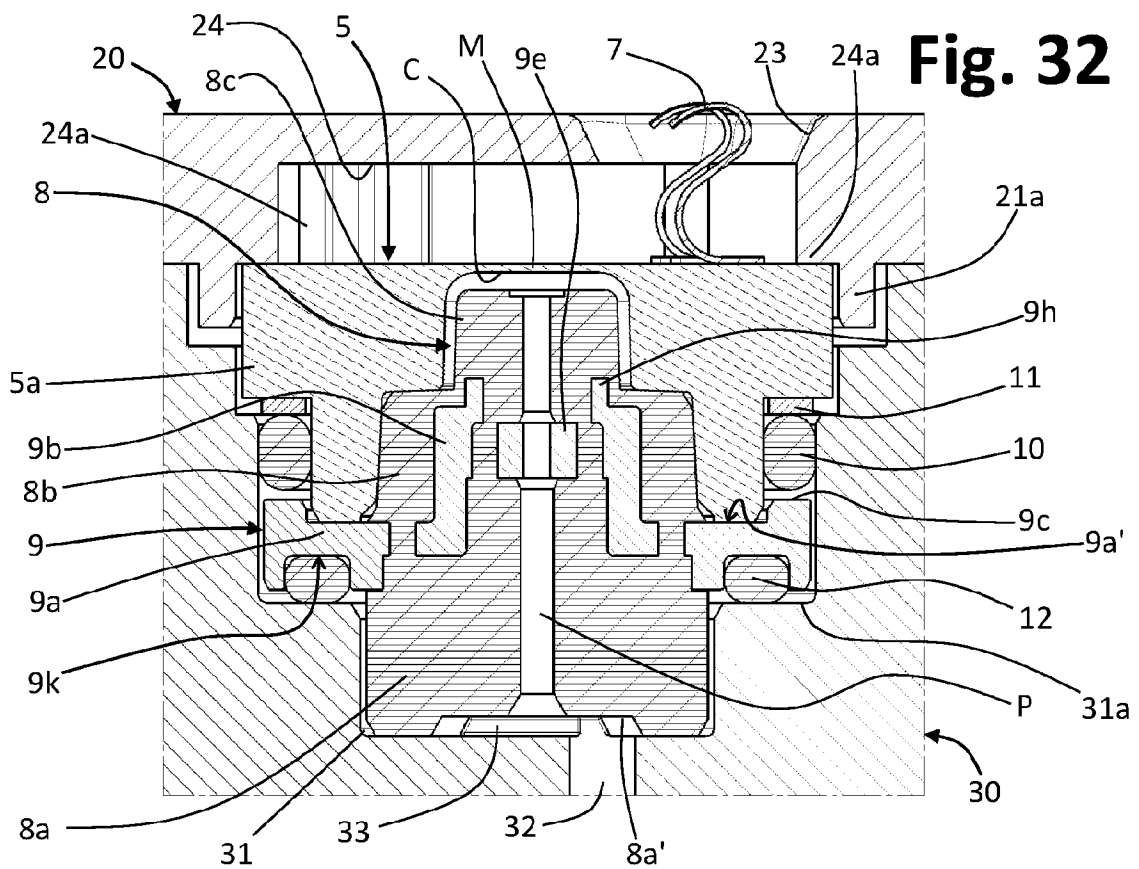
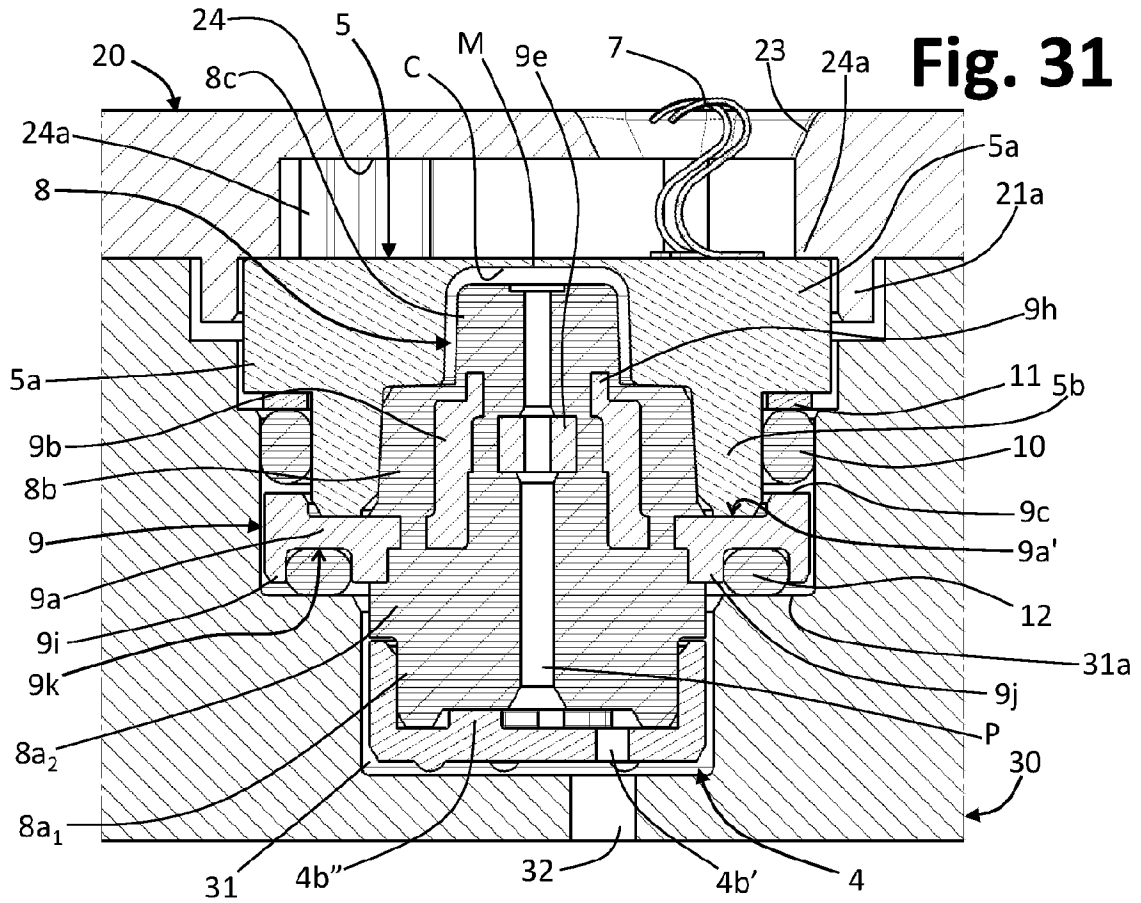
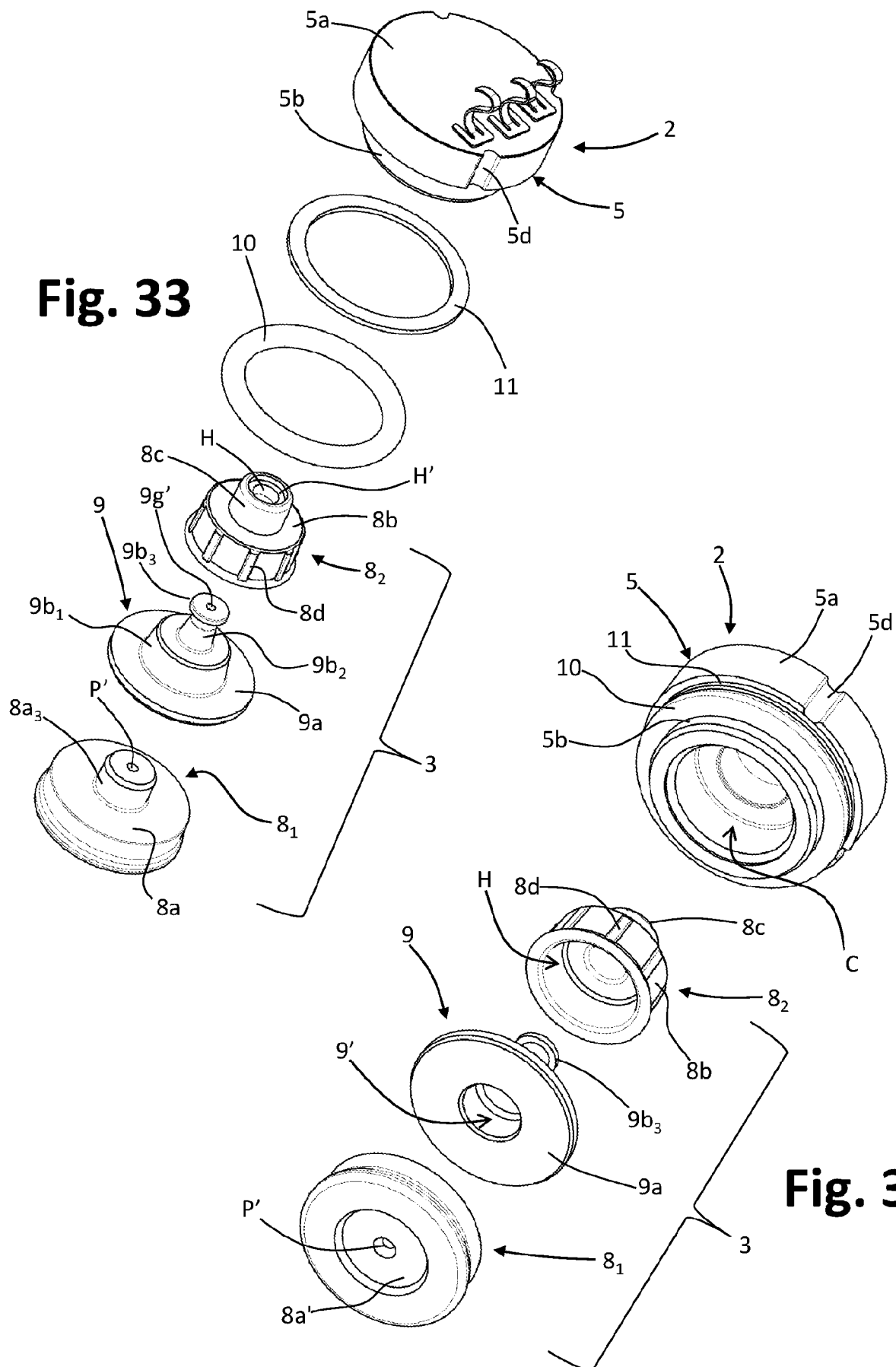


Fig. 29**Fig. 30**





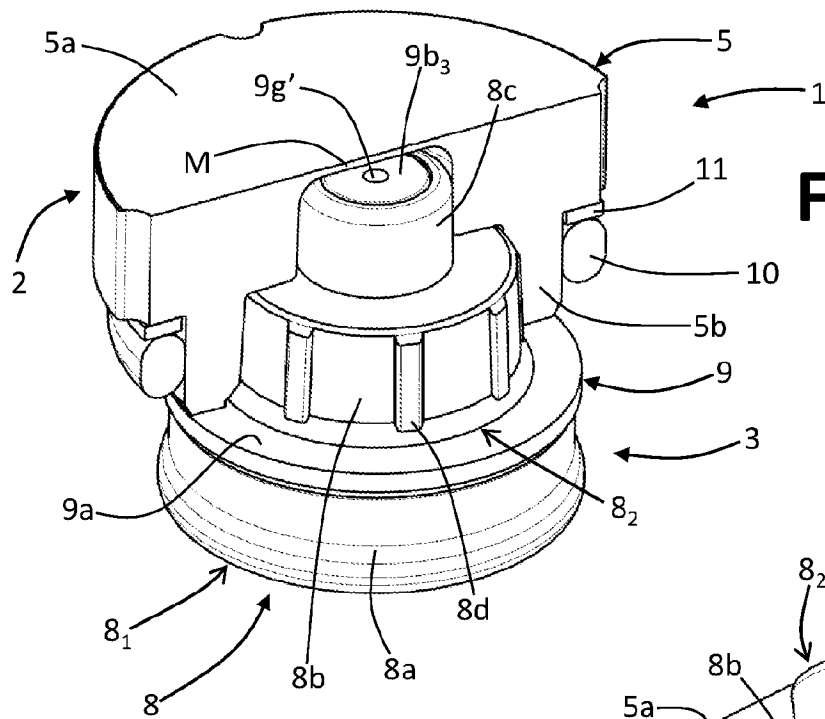


Fig. 35

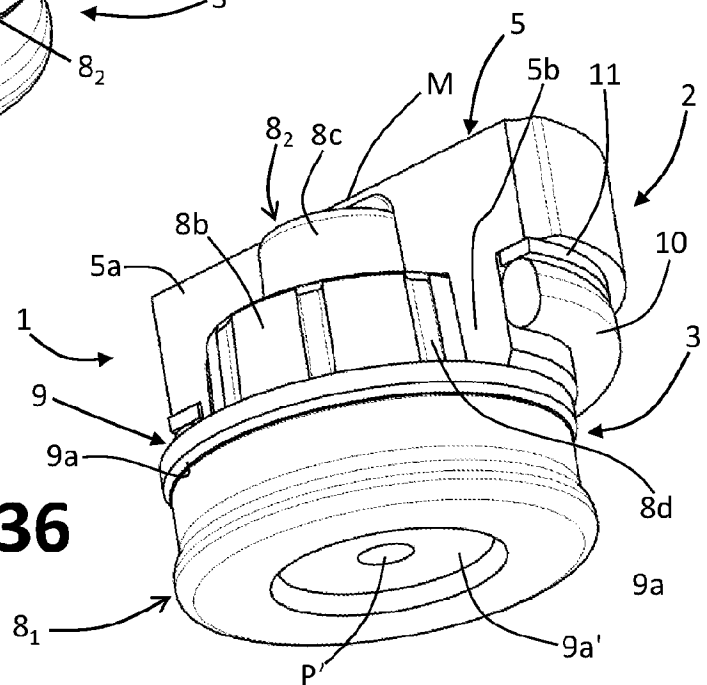


Fig. 36

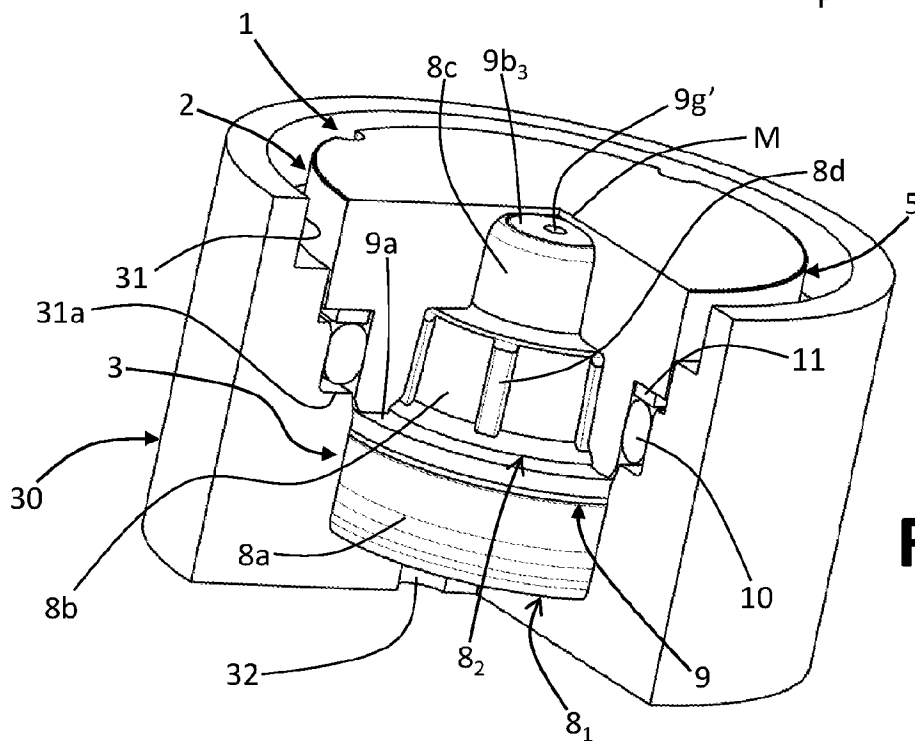
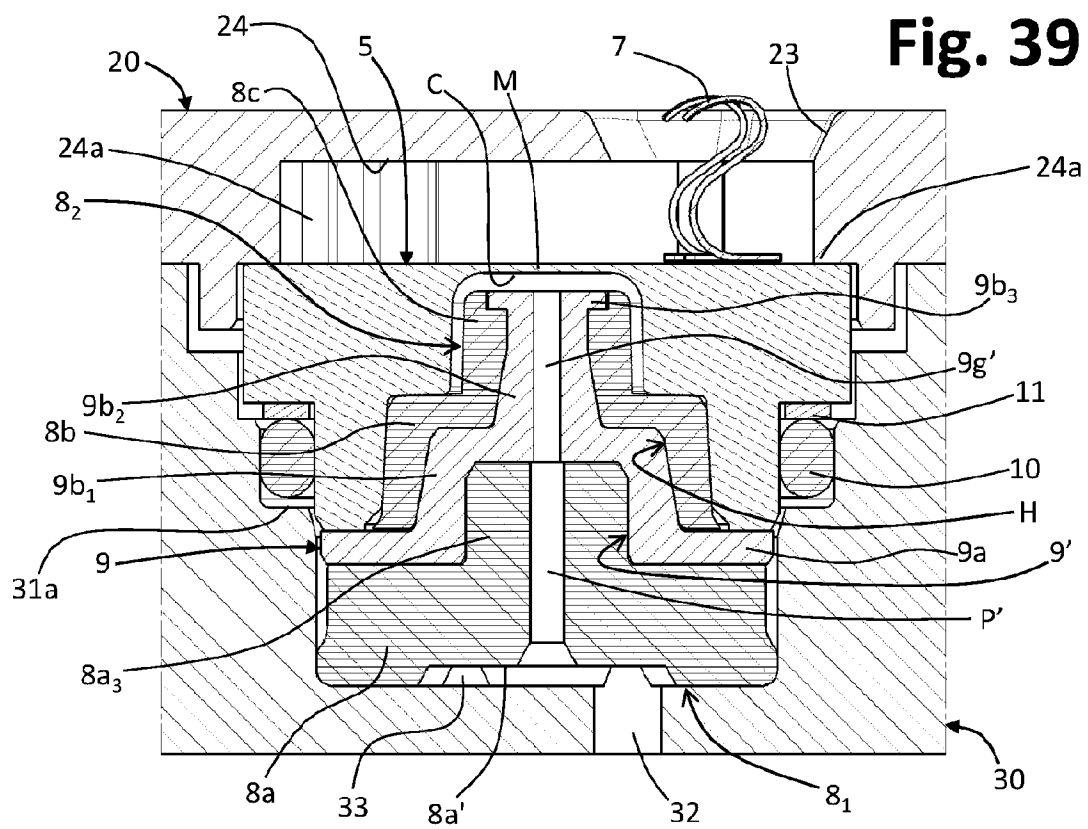
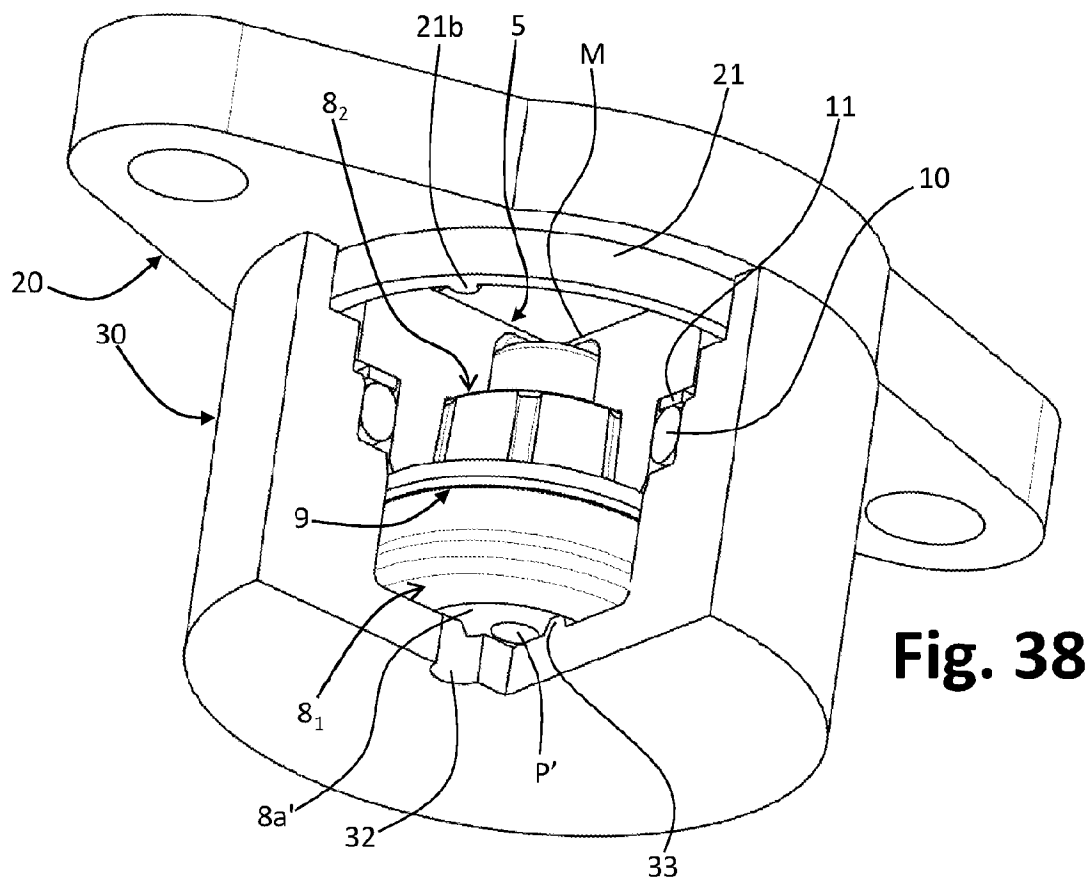


Fig. 37



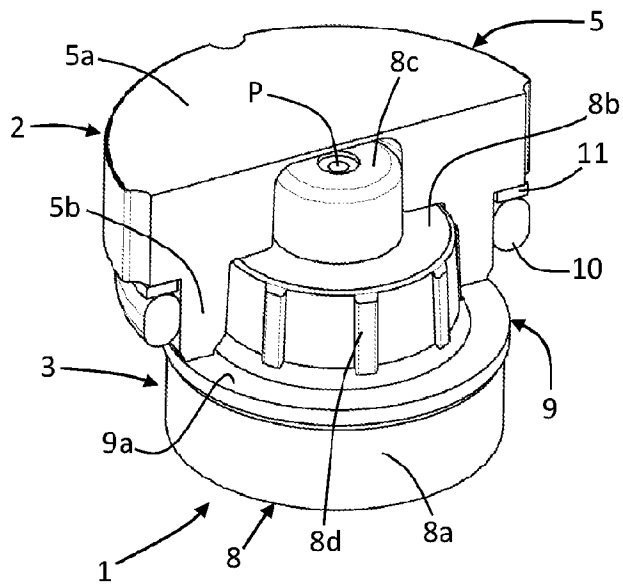


Fig. 40

Fig. 41

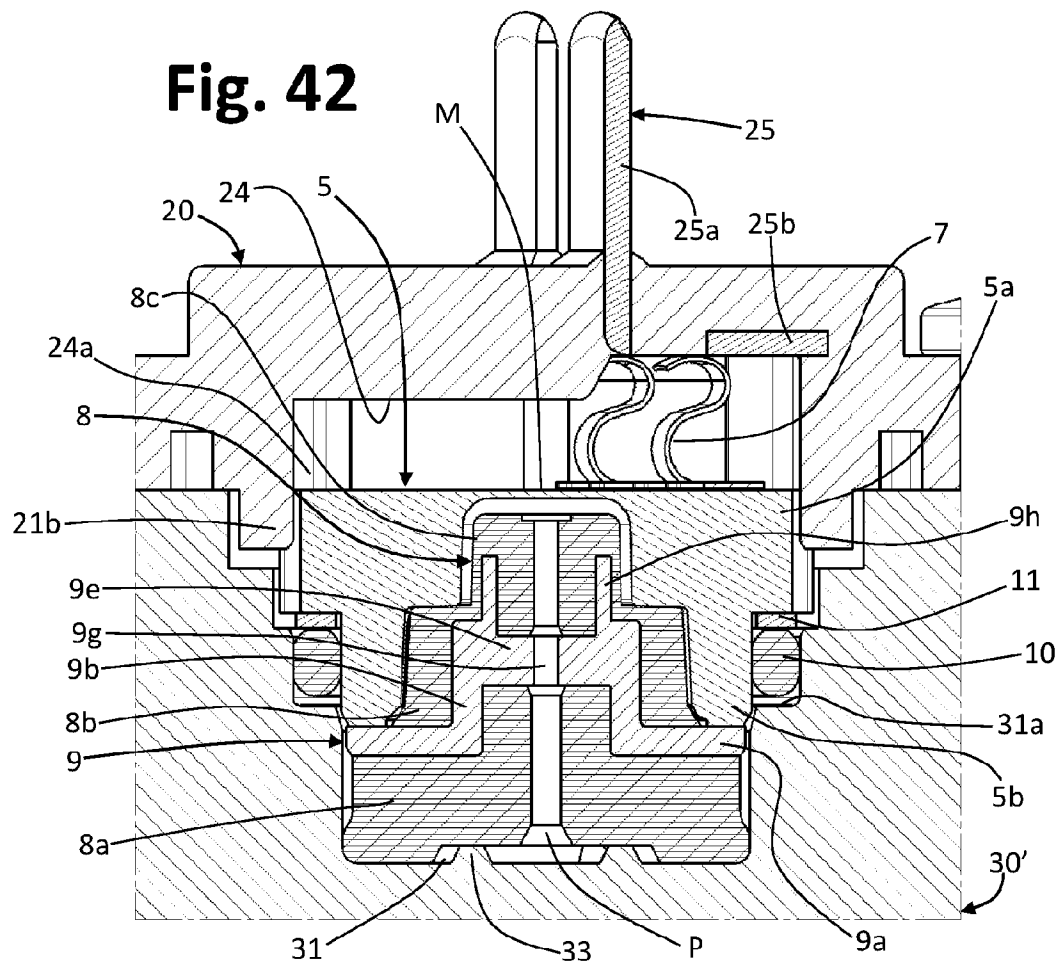
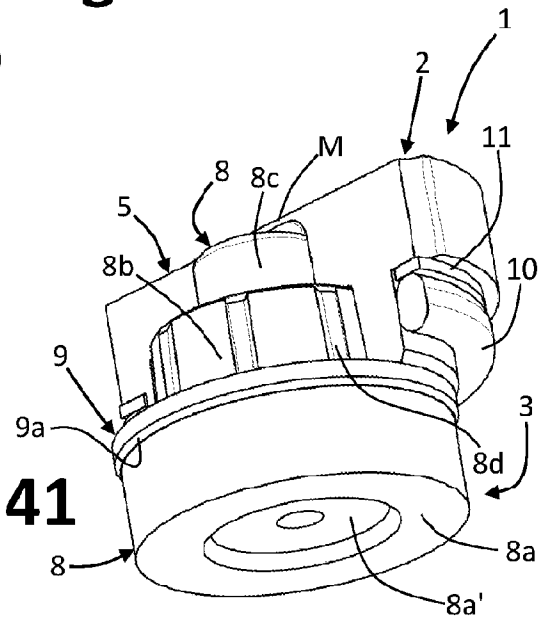


Fig. 43

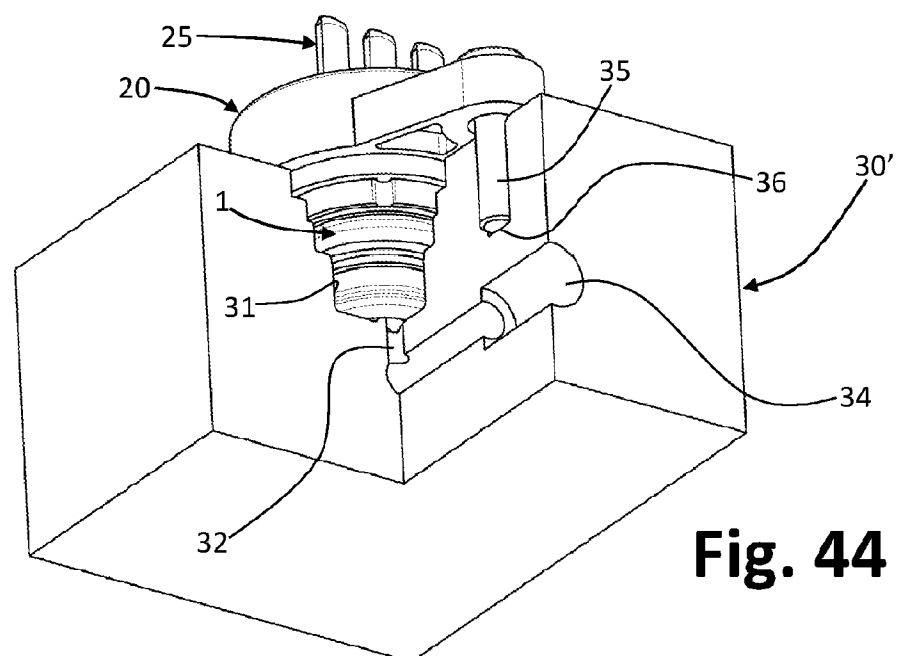
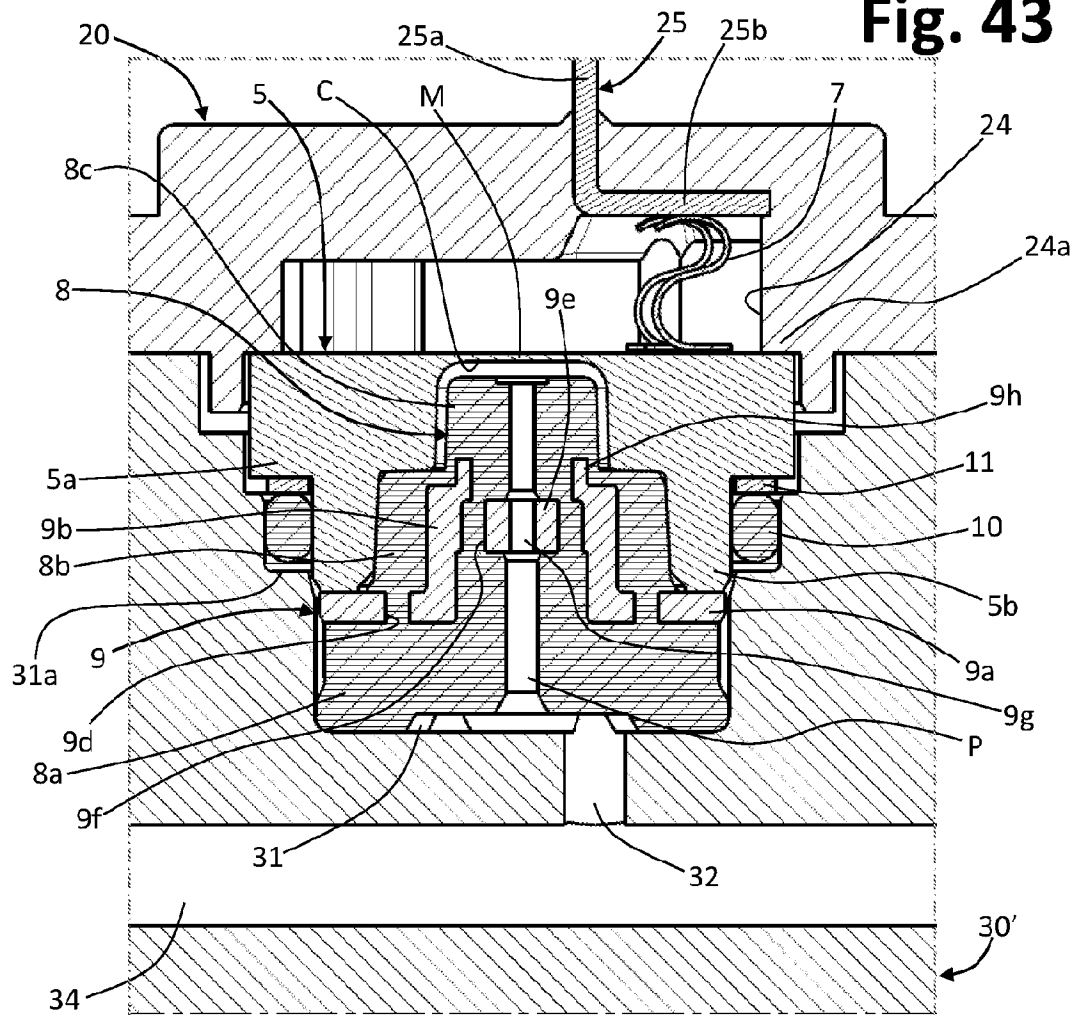


Fig. 44

Fig. 45

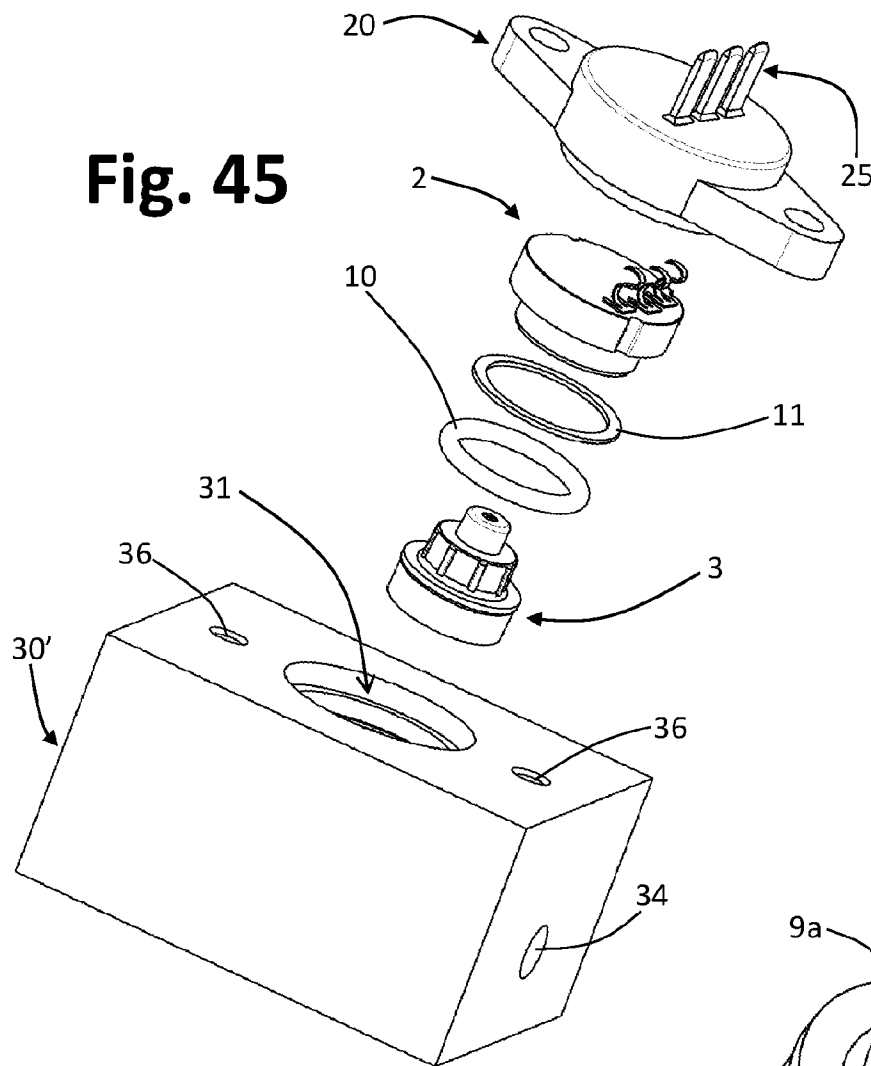


Fig. 46

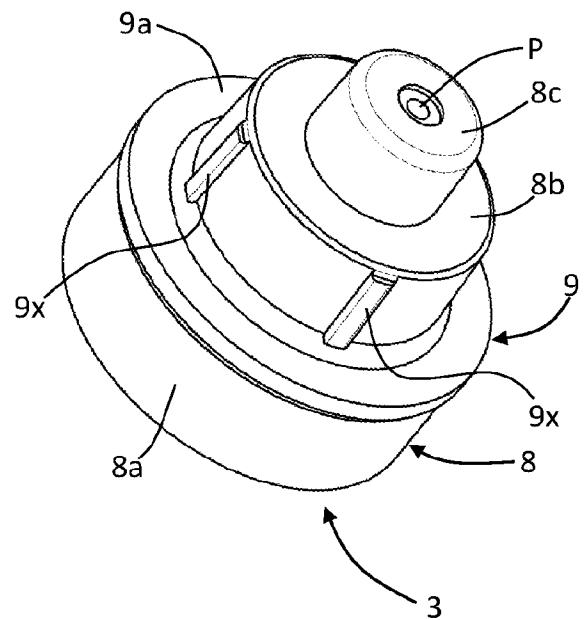


Fig. 47

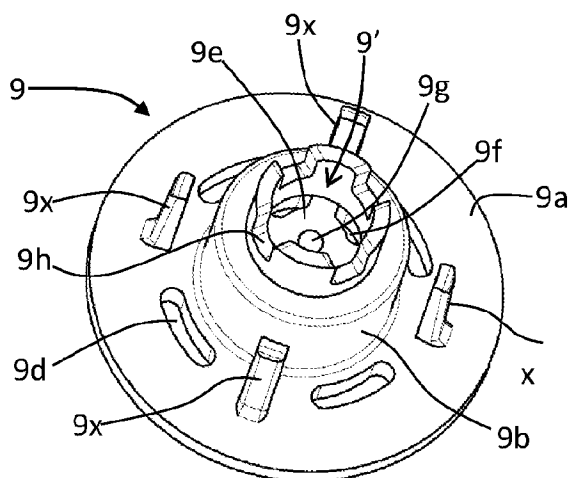


Fig. 48

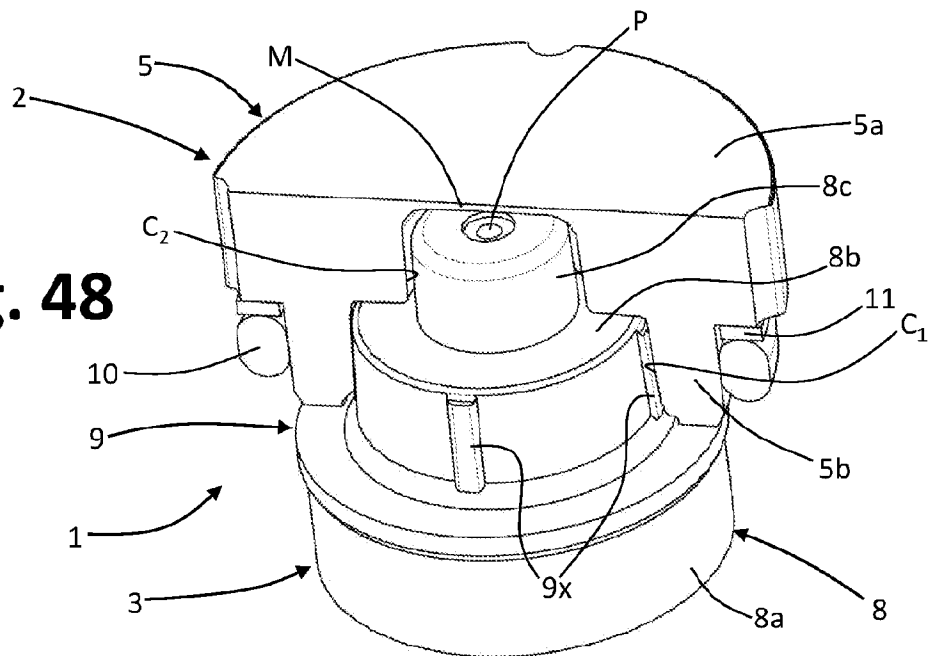


Fig. 49

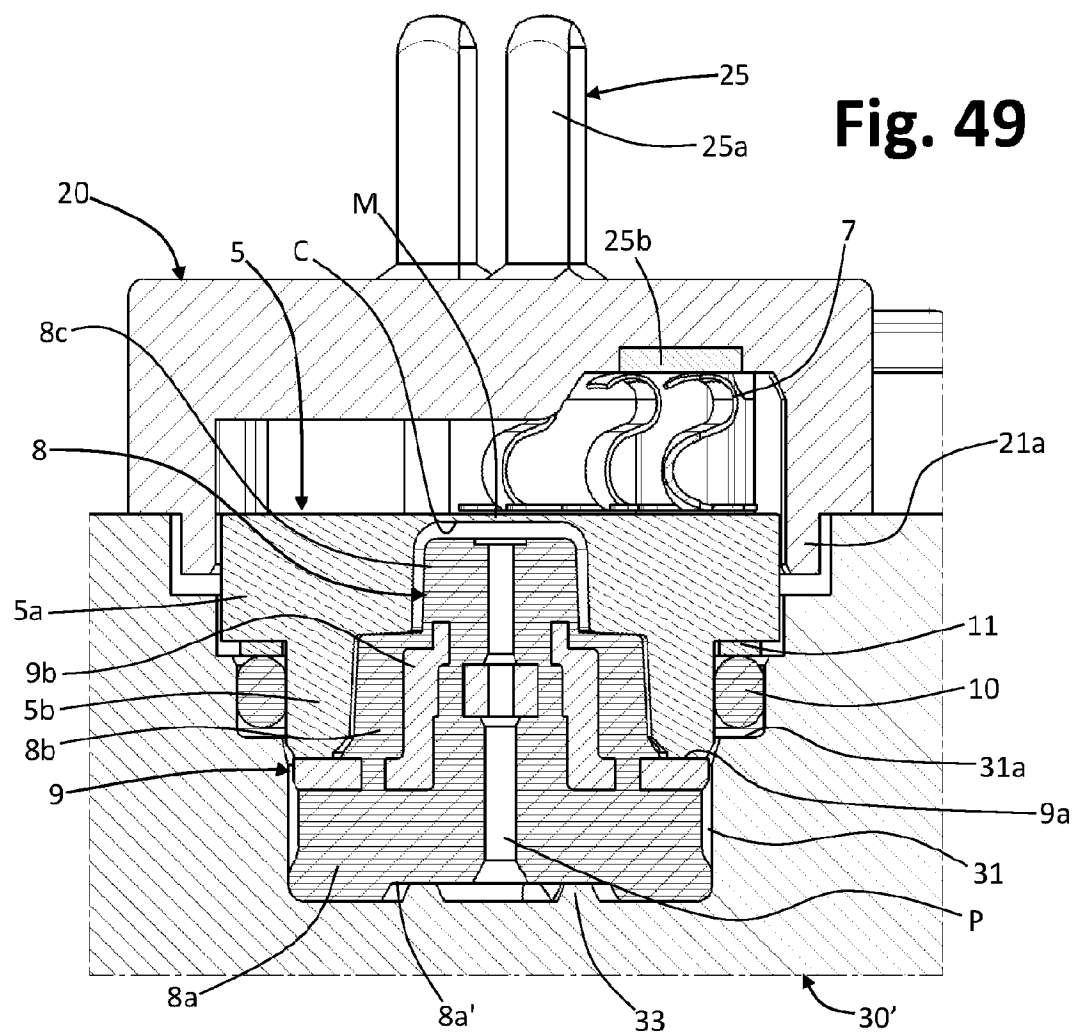


Fig. 50

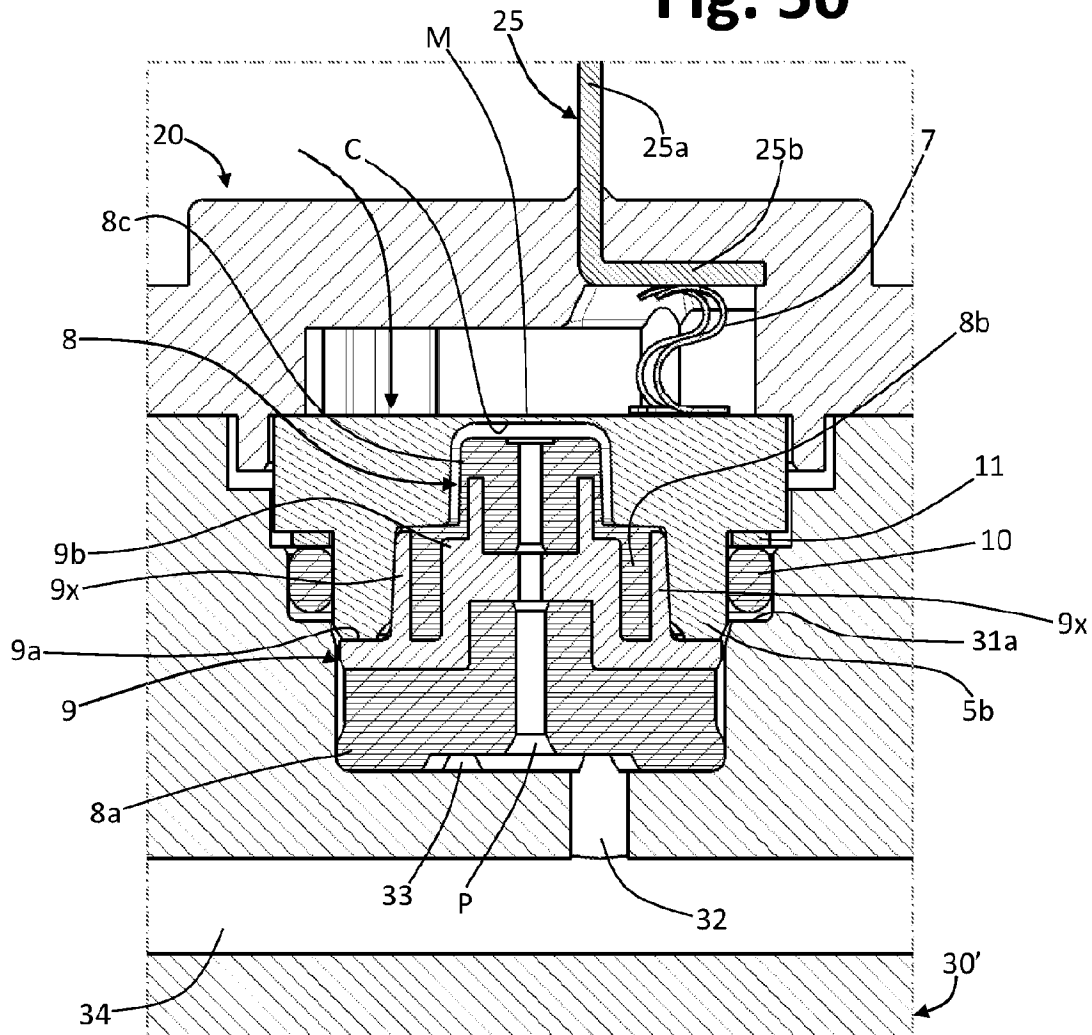


Fig. 51

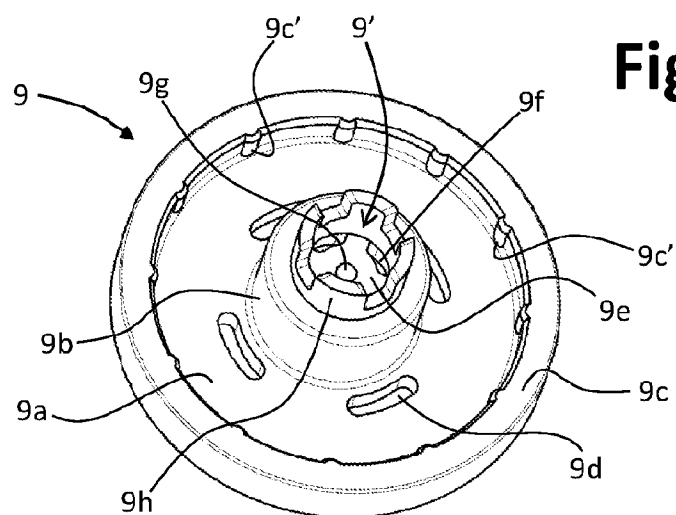


Fig. 52

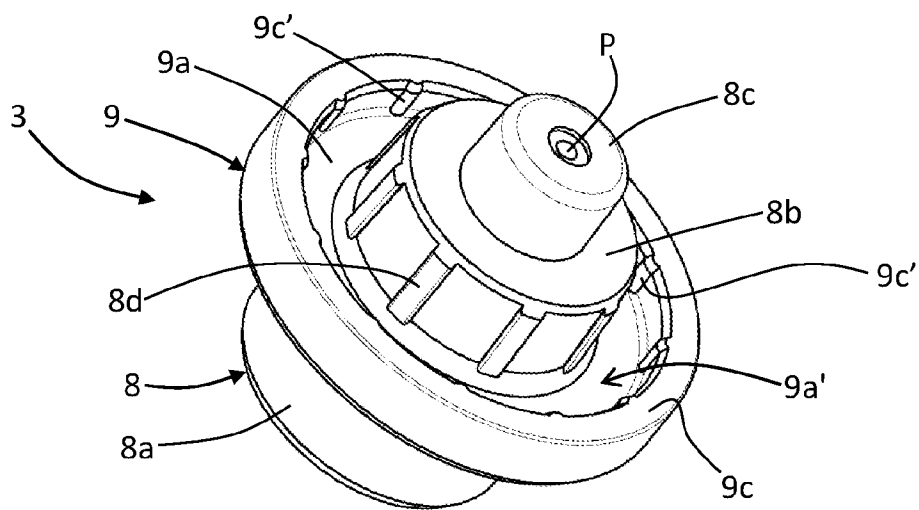


Fig. 53

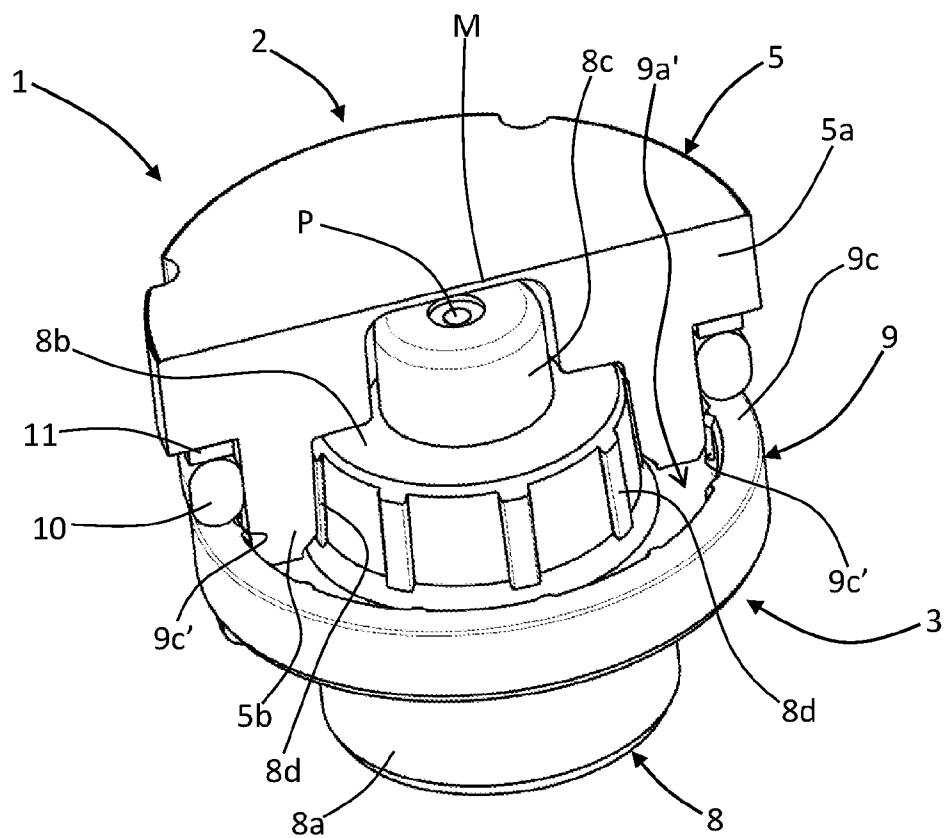


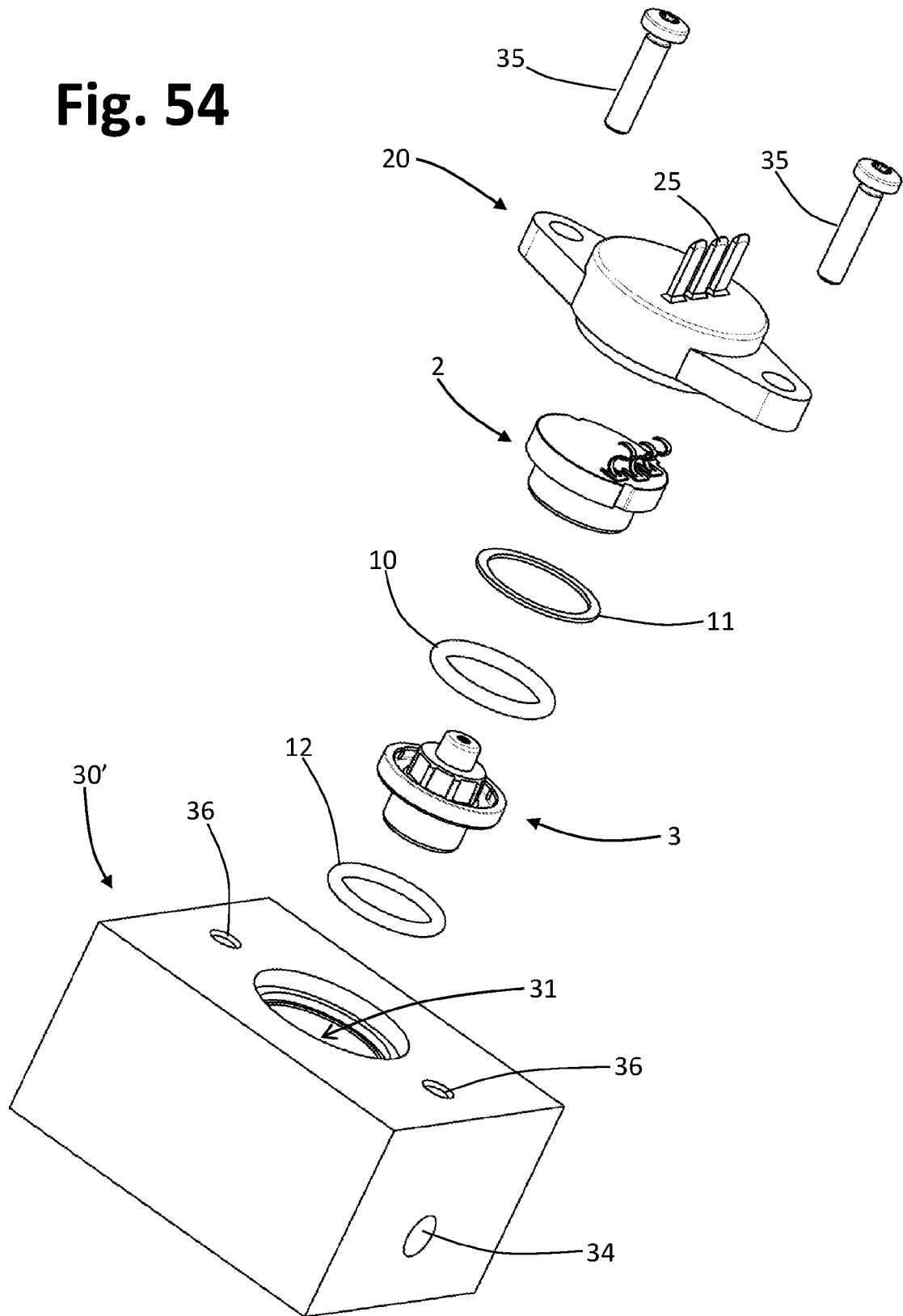
Fig. 54

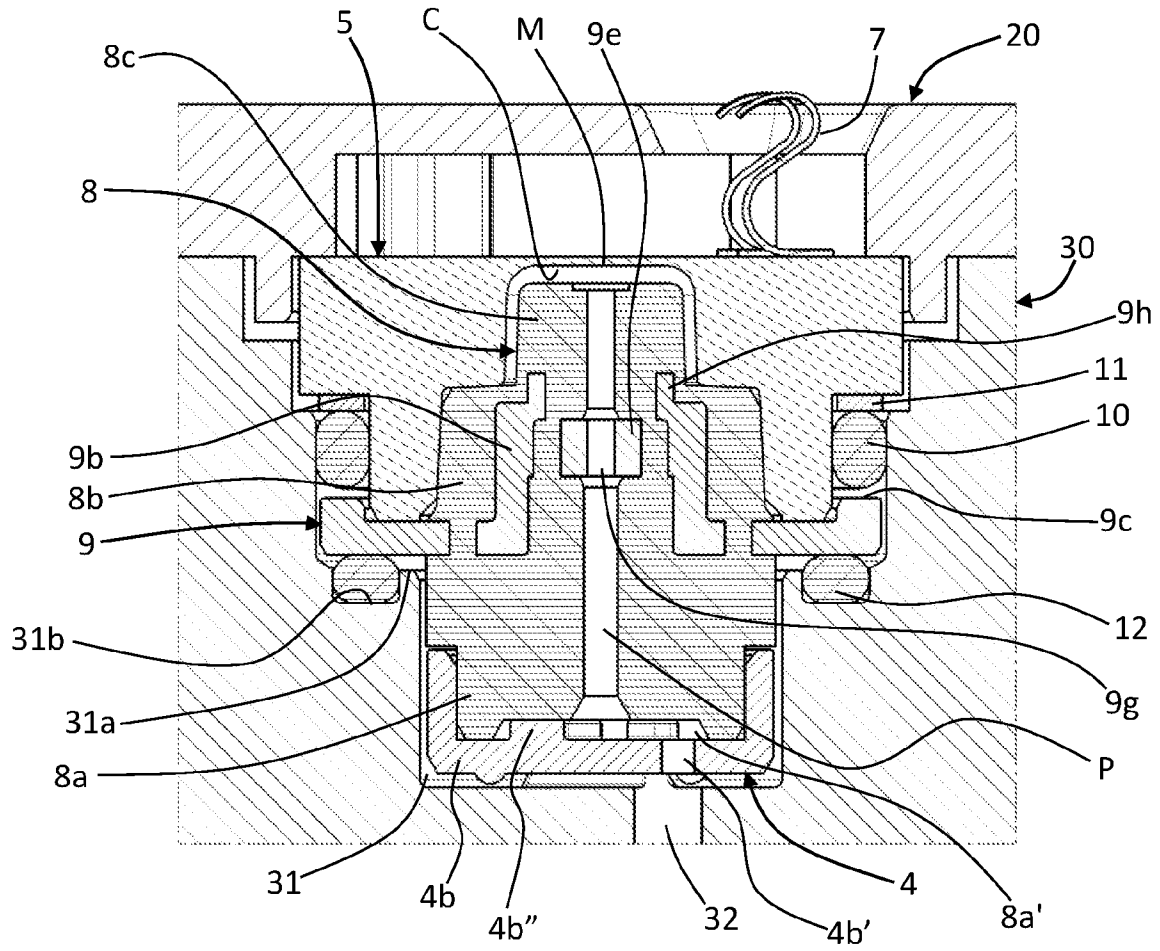
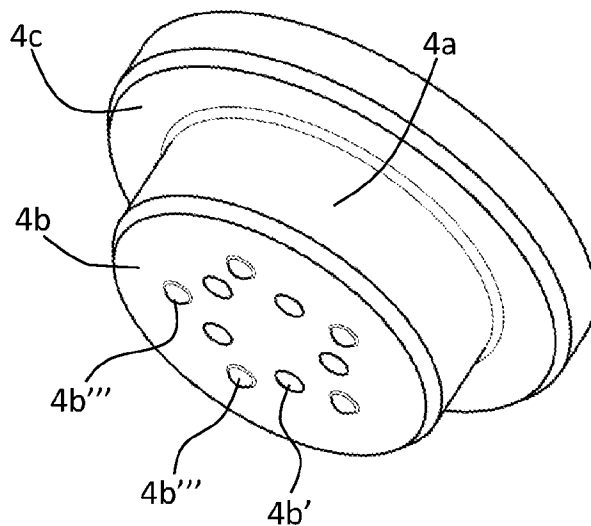
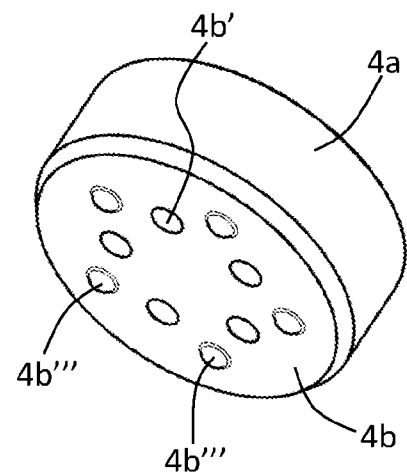
Fig. 56**Fig. 57****Fig. 58**

Fig. 59

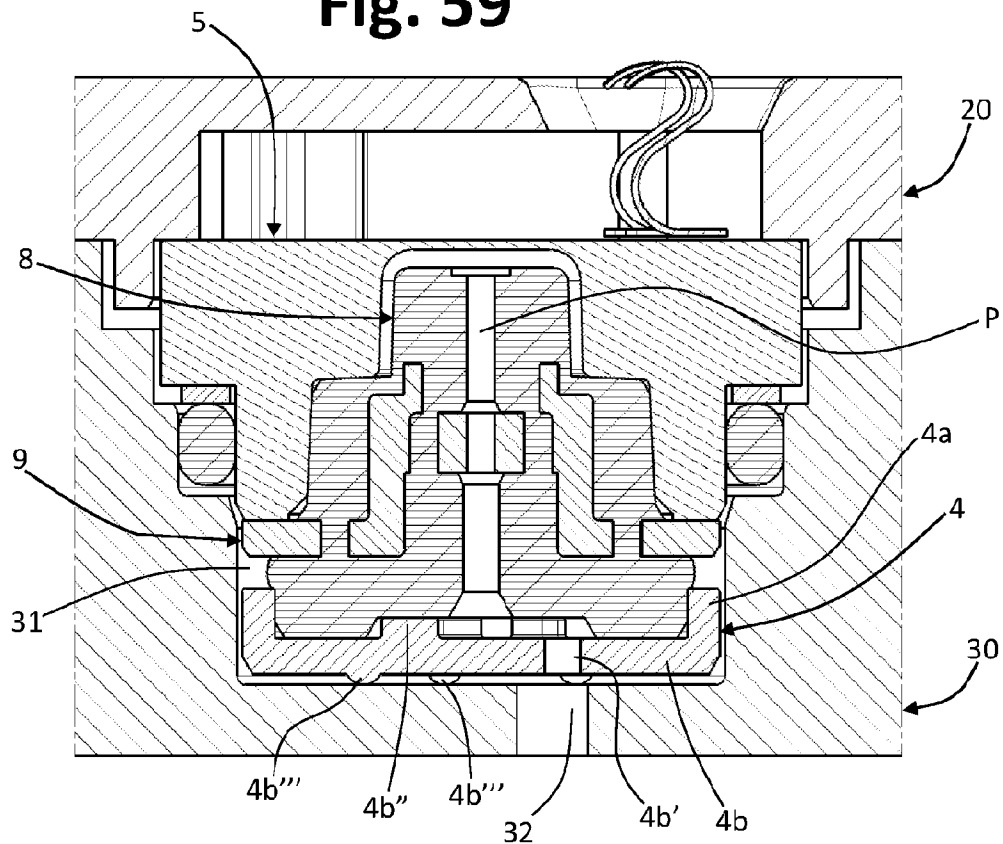


Fig. 60

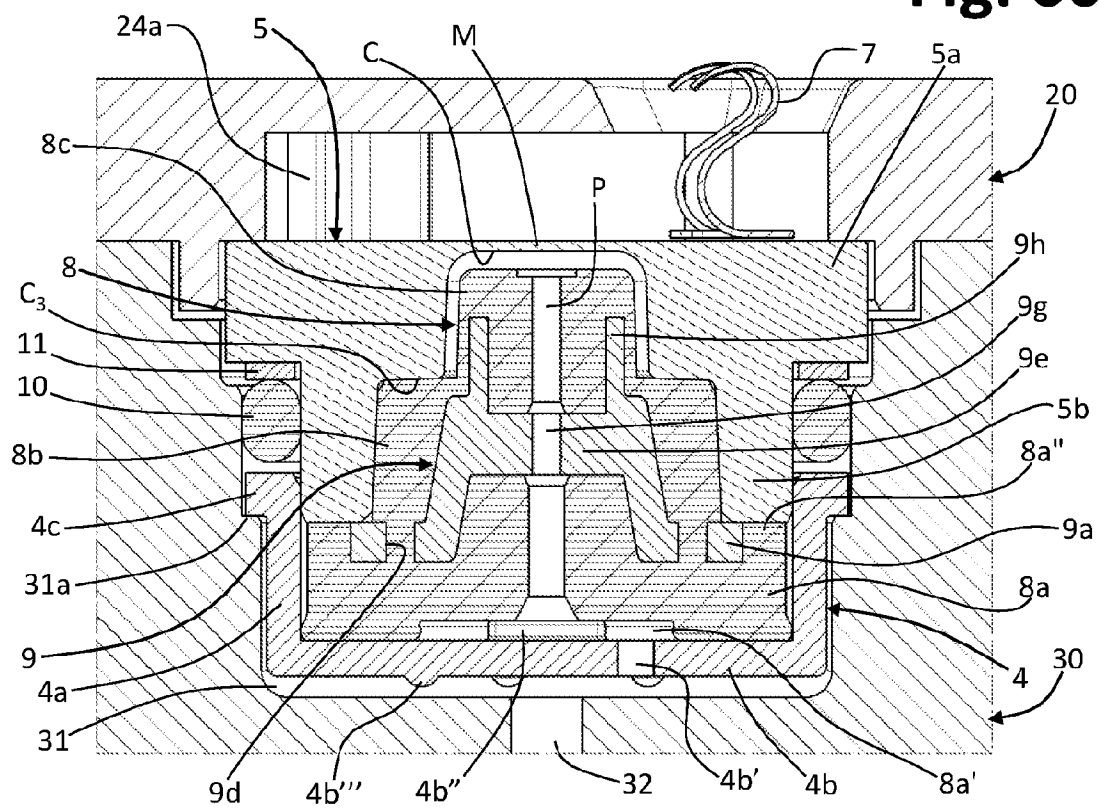


Fig. 61

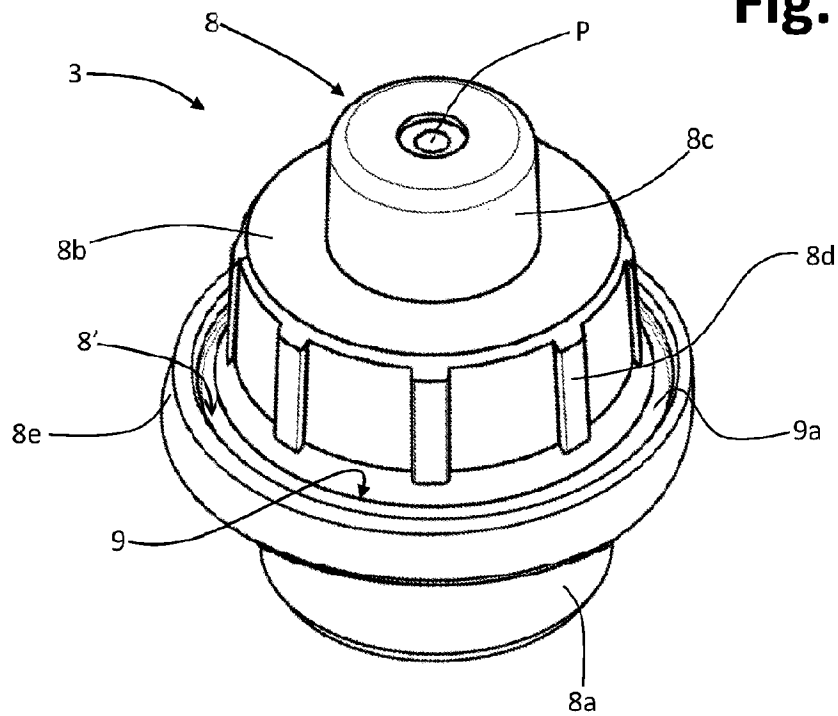
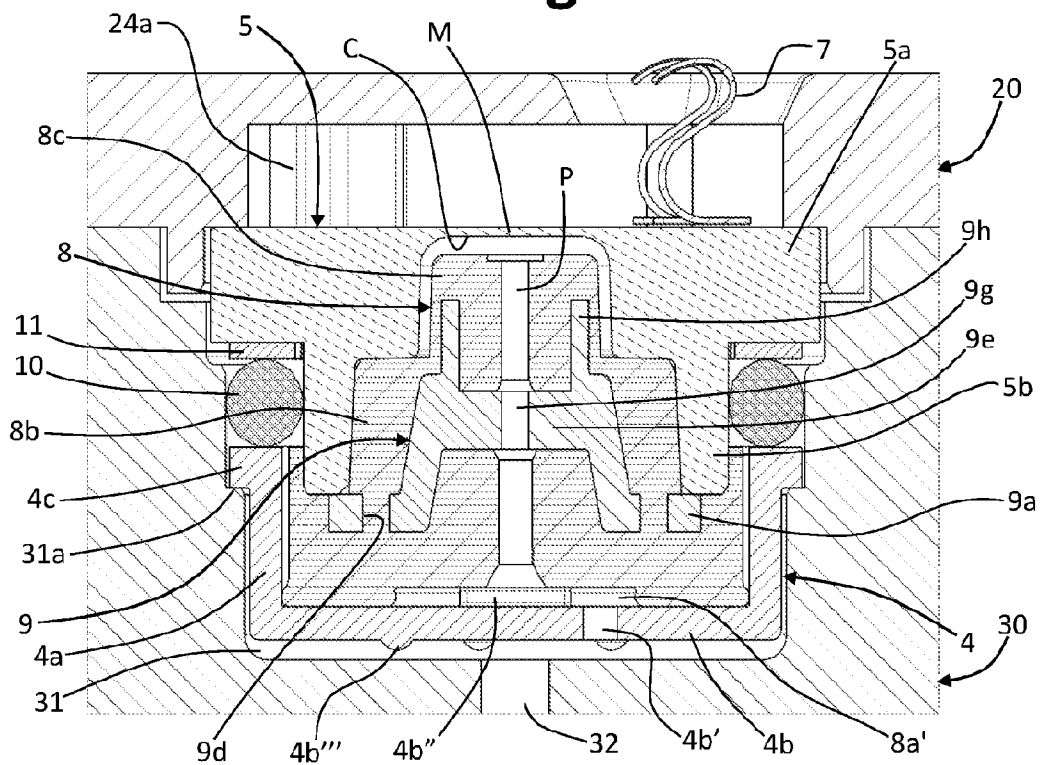


Fig. 62



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2021/052046

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01L19/06 G01L19/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP S61 246642 A (NIPPON DENSO CO) 1 November 1986 (1986-11-01)	1,2,8, 11,12, 15-17
A	abstract; figure 1	3-7,9, 10,13
X	----- JP H07 294354 A (NIPPON DENSO CO) 10 November 1995 (1995-11-10) abstract; figure 1	1
X	----- WO 98/31997 A1 (HONEYWELL INC [US]) 23 July 1998 (1998-07-23) abstract; figures 9,11 page 9, line 28 - page 10, line 16	1,3,14
A	----- WO 2017/077448 A1 (ELTEK SPA [IT]) 11 May 2017 (2017-05-11) cited in the application the whole document -----	1-17

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

7 June 2021

Date of mailing of the international search report

15/06/2021

Name and mailing address of the ISA/

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Authorized officer

Stavrourlis, Stefanos

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2021/052046

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP S61246642	A	01-11-1986	NONE	
JP H07294354	A	10-11-1995	NONE	
WO 9831997	A1	23-07-1998	US 5792958 A WO 9831997 A1	11-08-1998 23-07-1998
WO 2017077448	A1	11-05-2017	CN 108368764 A EP 3371426 A1 US 2018319271 A1 WO 2017077448 A1	03-08-2018 12-09-2018 08-11-2018 11-05-2017