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(54) Benævnelse: **VANDTÆT BEKLÆDNING TIL EN FLOWMÅLER**

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**WO-A-2008/129050**

# DESCRIPTION

## FIELD OF THE INVENTION

**[0001]** The invention relates to a water-tight casing for a flow meter and an ultrasound flow meter unit, such as for ultrasonic measurements of fluid flow as used e.g. in consumption meters.

## BACKGROUND OF THE INVENTION

**[0002]** Normally, ultrasound flow meters suited for measuring a fluid flow in connection with charging of a consumed quantity (e. g. heat, cooling, water or gas) will have a housing, which can be metallic or polymeric, with a cavity in the form of a through-going hole for receiving a fluid flow to be measured. Connection means to other fluid flow elements are present in each of the housing ends.

**[0003]** In the housing a number of ultrasound transducers are installed for measuring the velocity of the fluid flow. In most flow meters two ultrasound transducers are used for sending, respectively receiving, an ultrasound signal, but versions with one ultrasound transducer, as well as versions with more than two ultrasound transducers, are seen. Furthermore, an electronic circuit for operation of the ultrasound transducers typically mounted in a separate enclosure and fastened to the housing. Most often the electronic circuit is implemented on a Printed Circuit Board (PCB).

**[0004]** In typical metallic flow meter housings, through-going holes are present between the exterior of the housing and the measuring tube, enabling ultrasonic signals to penetrate from the exterior of the housing, through the holes, to the measuring tube. The through-going holes are necessary since the ultrasonic signals are poor at penetrating directly through metallic materials. In order to protect the ultrasound transducers from the effects of contact with the fluid flowing through the housing, a protection membrane is inserted between the fluid and the ultrasound transducer. More specifically, each of the ultrasound transducers is glued onto a thin, sheet metal membrane then put into an injection moulded polymeric part, which also contains the electrical connection to the ultrasound transducer. This subassembly is then placed in the flow meter housing.

**[0005]** However, one common problem with prior art ultrasound flow meters is that the level of complexity, and consequently high expenditures and large timeframes, involved with the manufacturing are too high.

**[0006]** A further problem is that the mentioned way of manufacturing an ultrasound flow meter necessitates that several parts are dedicated for used with one specific type of housing, and

thus a large number of specially designed parts must be manufactured for each flow meter version.

**[0007]** Still further, it is a problem that it is difficult to protect electronic parts of a flow meter against humidity such that these parts can have a long life-time, e.g. of 20 years, even if the meter is installed in a humid environment.

## SUMMARY OF THE INVENTION

**[0008]** In view of the above, it may be seen as an object of the present invention to provide an improved casing for an ultrasound flow meter for ultrasonic measurement of a fluid flow.

**[0009]** Accordingly, the invention provides, in a first aspect, a water-tight casing for an ultrasound flow meter unit comprising: a bottom part formed by a common protection membrane, and a top part connected to the bottom part, wherein the water-tight casing is adapted to receive first and a second ultrasound transducer and a circuit board with an electronic circuit arranged for operating the first and second ultrasound transducers, and wherein the common protection membrane comprises first and second recesses shaped so as to receive the first and second ultrasound transducers, respectively.

**[0010]** Such a water-tight casing is advantageous as it is adapted to enclose the transducers and electronic circuit serve to protect these parts against humidity, which improves the life-time of these components. Still, the common protection membrane is understood to allow penetration of ultrasound signals to and from the first and second ultrasound transducers, preferably the first and second ultrasound transducer are arranged such within the water-tight casing, that they transmit and receive ultrasound signals through the common protection membrane in a direction substantially parallel with each other, and wherein this direction is preferably perpendicular to a plane extended by the common protection membrane.

**[0011]** By 'water-tight casing' is understood a casing which at least serves to protect the components inside with respect to humidity. Such humidity may otherwise be generated on these components in case it is used as a cooling meter, i.e. where the components have a low temperature and wherein the humidity in the surroundings is rather high. Thus, at least the water-tight casing should be able to protect against such humidity, and in terms of Ingress Protection (IP) classes, the water-tight casing is understood to comply with class IP67 (Protection against effects of immersion from 15 cm to 1 m) or even class IP68 (Protection against complete, continuous submersion in water from 15 m or 50 feet.

**[0012]** For versions where the common protection membrane is arranged to protect the transducers against direct contact with the fluid to be measured, this common protection membrane should of course be able to seal the transducers from the fluid in question, i.e. including possible particles in the fluid that will cause mechanical wear on the common protection membrane.

**[0013]** Further, such unit provides a high versatility, since it can be used in a large number of different applications, i.e. mounted on different types of housing and measuring tube arrangements, whether forming part of a consumption meter or forming part of another type of application where a measurement of fluid flow is required. The unit is highly suited for different applications and can thus be manufactured as a low cost component, since one single version can fit many applications, thus enabling large scale manufacturing using a highly automated production line. Still further, the manufacturing is facilitated by the rather low number of single element required thus also reducing the necessary number of single manufacturing steps, especially in versions where the transducers are soldered directly onto the surface of the circuit board using automated Surface Mounting Technology.

**[0014]** Furthermore, the common protection membrane may be formed by a polymeric material. Additionally, a battery may be provided within the water-tight casing, thus allowing a completely self-contained flow meter unit.

**[0015]** Further, the range of applications is extended due to the rather compact size of the unit, especially in versions where the electronic circuit is refined to allow a high measurement accuracy with a limited distance between the first and second ultrasound transducers, e.g. as described in European patent application EP 09180619.0 (filed 23 December 2009). This means that the unit can be used in applications where only a limited space is available for the flow rate sensor. Examples of relevant applications are: consumption meters for charging purposes, measurement of blood flow in medical examination or surveillance, ingredient flow within the food industry, flow of water, air or fuel in a machinery (e.g. a vehicle), flow provided to single sources or groups of heating/cooling elements (or the related heating/cooling power based on measurement of the flow) as feedback to heating/cooling control systems.

**[0016]** The common protection membrane forms a bottom part of the water-tight casing, and wherein a top part of the water-tight casing is connected to the bottom part, such as connected by a warm-forming process in the form of soldering or welding. Different types of welding can be used, such as laser welding or ultrasound welding. Thus, in such embodiment the water-tight casing is made of two monolithic parts, either two parts of the same material of two parts of different materials.

**[0017]** Furthermore, the common protection membrane is formed by a polymeric material, such as PPS.

**[0018]** The common protection membrane has First and second recesses shaped so as to receive the first and second ultrasound transducers, respectively. This facilitates the mounting of the ultrasound transducers with respect to the common protection membrane.

**[0019]** Preferably, the first and second ultrasound transducers form a mechanically separate unit together with the circuit board, preferably using Surface Mounting Technology for mounting the two ultrasound transducers on the circuit board. This is essential for effective

production, since the mechanically separate unit including transducers and circuit board forms already a functioning unit before this separate unit is mounted in the water-tight casing. Thus, before the final assembly steps of mounting this separate unit in the water-tight casing, it can be tested in a test setup and thus rejected at an early state prior to providing the final flow meter unit. Hereby, the production cost can be lowered since failing species are revealed at an early state, and in addition the rather complex handling of wires and connecting of wires between transducers and circuit board in automated manufacturing has been eliminated. Also, a more reliable flow meter can be achieved due to fewer parts and connections. Moreover, this can also lead to an increase in lifetime of the ultrasound flow meter. In addition, higher precision is possible as a result of reduced tolerances.

**[0020]** In a preferred embodiment the first and second ultrasound transducers are kept in position relative to the circuit board by one or more fixing members, especially such fixing members may include solderings and/or clips, especially electrically conductive clips. Most preferably, at least one electrical terminal for each of the two transducers is soldered directly to a conductive path on a surface of the circuit board so as to both electrically connect the transducers to the electronic circuit and to mechanically fix the transducers to the circuit board. As mentioned, the other electrical terminals of the transducers are then in electrical connection with the common protection membrane being formed by metal.

**[0021]** In a fourth aspect, the invention provides a flow meter arranged to measure a flow rate of a fluid flowing through a measuring tube, wherein the flow meter comprises: a housing with the measuring tube arranged inside, and a water-tight casing as described above arranged in relation to the housing so as to allow first and a second ultrasound transducer arranged inside the casing to transmit ultrasound signals through the fluid in the measuring tube.

**[0022]** In a fifth aspect, the invention provides a consumption meter comprising a flow meter according to the fourth aspect, and especially, the consumption meter may be a heat meter, a cooling meter, a water meter, or a gas meter.

**[0023]** WO 2008/129050, EP 0945712 and WO 2008/053193 disclose casings for ultrasonic flow meter units.

**[0024]** The invention is defined by the scope of the claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0025]** Embodiments of the invention will be described, by way of example only, with reference to the drawings, in which

Fig. 1 illustrates an ultrasound flow meter with a common protection membrane,

Fig. 2 illustrates an exploded view of an ultrasound flow meter with a common protection

membrane,

Fig. 3 illustrates a water-tight casing in Fig. 3A, and a cutaway illustration of a water-tight casing in Fig. 3B, and

Fig. 4 illustrates an ultrasound flow meter of the prior art with separate metal protection membranes for the two ultrasound transducers.

## DESCRIPTION OF EMBODIMENTS

**[0026]** Fig. 1 shows a perspective view of an ultrasound flow meter with a metallic flow meter housing 120, with a measuring tube 114 adapted for fluid flow inside. Attached to the flow meter housing 120 is a water-tight casing enclosing two ultrasound transducers and a circuit board with an electronic circuit for controlling the ultrasound transducers. The water-tight casing comprises a top-part 134 and a common protection membrane 132. The common protection membrane 132 is metallic in the shown embodiments, but other embodiments where the common protection membrane 132 is made of other materials, such as polymeric materials, are possible. The two parts 132, 134 forming the water-tight casing may be assembled in different ways, e.g. using a welding process in case both parts 132, 134 are of metal, however the two parts 132, 134 are preferably shaped to match together and the assembly process is selected so as to form a robust water-tight sealing between the two parts, e.g. using the principles known from manufacturing metal containers such as tins or cans.

**[0027]** Electrical connection to the electronic circuit from the exterior of the water-tight casing is provided through pins 130, which are led through a glass seal 128 forming a glass-sealed feed-through. In a preferred embodiment, the mounting flange of the glass sealed feed-through is laser welded to the casing top-part ensuring an impervious assembly. The shown embodiment has three pins, however, other numbers of pins are possible in other embodiments, e.g. down to one pin, as already described. The bracing 116 assists in fixing the water-tight casing. The glass sealed feed-through is merely shown as an example of feed-through implementations, and other implementations may be used as well.

**[0028]** In special embodiments of the measurement unit (circuit board with measurement circuit and ultrasound transducers), e.g. in the form of a water-tightly sealed measurement unit, more pins 130 can be provided in order to enable different angular engagements to a corresponding connector attached to a second unit, a calculator unit, including a calculator circuit and a display element arranged to display a measured quantity. Hereby, a consumption meter can be provided with the possibility of turning the display relative to the measurement unit which is normally fixed in relation to a housing, even though the calculator unit is integrated with the measurement unit, such as within one common casing, e.g. one common casing formed integrally with the housing. Such consumption meter is advantageous since it is easy to adapt for comfortable reading of the display in any given piping installation, irrespective

of the actual orientation of the consumption meter housing. During installation, the installing person can connect the calculator unit with the measurement unit at an appropriate angle which fits for comfortable reading of the display in the given installation.

**[0029]** Fig. 2 shows an exploded view of an ultrasound flow meter similar to the ultrasound flow meter shown in Fig. 1. In Fig. 2, the components of the ultrasound flow meter unit are illustrated, including top-part 134 of the water-tight casing, pins 130, glass seal 128, first and second ultrasound transducers 206, the circuit board 202, through-going holes 208 in the circuit board, electronic circuit 204, the common protection membrane 132, flow meter housing 120 with a measuring tube 114 inside. The ultrasound transducers 206 in the shown embodiment are ceramic, piezoelectric elements. Preferably, the transducers 206 are at least partly electrically connected to and mechanically attached to the circuit board 202 by means of Surface Mounting Technology. The common protection membrane 132 of the shown embodiment has first and second recesses 236 shaped so as to receive the first and second ultrasound transducers 206, respectively. In the shown embodiment, the distance between the first and second recesses 236 matches a distance between a first and second ultrasound transducer 206 arranged in connection with the circuit board 202. Furthermore, this distance matches a distance between a first and second transducer receiving position of the housing 120.

**[0030]** A hole in the top-part 134 is included for the protrusion of a glass sealed feed-through. In a preferred embodiment of the invention the common protection membrane 132 is formed by deep drawing. In another preferred embodiment of the invention the common protection membrane 132 can be formed by deep drawing or die punching. Similarly, the top-part 134 could be formed by either deep drawing or die punching. In an advantageous embodiment, the material thickness of the top-part 134 is larger than a corresponding material thickness of the common protection membrane 132.

**[0031]** The shape and dimensions of the common protection membrane 132 and the top-part 134 is preferably arranged so that the ultrasound transducer 206 can be fixed in position in relation to the housing 120, e.g. by means of an intermediate element 207 as shown serving to fix the transducer between the common protection membrane 132 and the top-part 134. The bracing 116 is provided in order to fix the position of the transducer 206 to the housing. The bracing 116 in the shown embodiment is provided with mounting means in the form of holes for screwed connections for the mounting of the bracing onto the flow meter housing 120. Hereby, the bracing 116 serves to press the common protection membrane 132 against the housing 120 and thus serves to provide a water-tight sealing to the housing 120 by means of the intermediate flexible O-ring 209 being pressed between the common protection membrane 132 and the housing 120.

**[0032]** In a favoured embodiment, the top-part 134 and the bracing 116 are integrated, possibly monolithically, e.g. the mounting means of the bracing 116 could be in the form of flanges. The through-going holes 208 together with one or more fixing members are suited for fixing the ultrasound transducers 206 to the circuit board 202 in order to provide a

mechanically separate unit comprising circuit board 202 and ultrasound transducers 206. Alternative embodiments have non-through-going cavities or planar surfaces instead of through-going holes.

**[0033]** Fig. 3A shows a perspective view of a water-tight casing 338 in which a mechanically separate unit consisting of a circuit board and ultrasound transducers is placed, enclosed by the water-tight casing which is formed as an enclosure comprising a top-part 134, a common protection membrane 132, and a glass seal 128. Electrical connection to the electronic circuit is provided through pins 130, which are led through a glass seal 128, forming a glass-sealed feed-through. The shown embodiment is capable of being submerged in liquid without the intrusion of liquid or moisture, and without the occurrence of any harmful effects due to the submersion in liquid. The shown embodiment is classified as IP68 according to the standard IEC 60529, however, other embodiments with other classifications are possible provided that the casing is water-tight, such as already described.

**[0034]** Fig. 3B shows a cutaway drawing of the embodiment of Fig. 3A, where approximately half of the common protection membrane 132 and half of the top-part 134 are not shown. This enables the presentation of the interior of the water-tight casing comprising a circuit board 202 with electronic circuit 204 and ultrasound transducers fixed to it. Electrical connection to the electronic circuit from the exterior of the water-tight casing is provided through pins 130, which are led through glass seal 128, forming a glass-sealed feed-through. Furthermore, in the present embodiment, the electrically conducting common protection membrane is connected to electrical ground as well as to both of the ultrasound transducers, thus serving to connect both of the ultrasound transducers to electrical ground. The components of the electronic circuit 204 in the shown embodiment comprise Surface Mounted Device (SMD) components, i.e. components adapted to Surface Mounting Technology, preferably in the same process in which the transducers are mounted on the circuit board 202.

**[0035]** In the present embodiment the top-part 134 and common protection membrane 132 are connected to each other by soldering. However, in alternative embodiments connection might be done by laser welding. Laser welding is advantageous, since it enables local heating of materials which makes it possible to weld with only small heat deflections. In a further alternative embodiment the connection is made by sealing by elastic forces, such as snap fittings. In still further alternative embodiments, the casing is sealed with glue or the sealing is done by applying counteracting forces onto adjacent surfaces facing each other, the forces being applied in order to press the surfaces together, wherein one of more sealing materials between the surfaces may be present. Even further, the top-part 134 and the common protection membrane 132 can be connected together by means of screws.

**[0036]** Fig. 4 shows a perspective view of a prior art ultrasound flow meter with a metallic flow meter housing 420, with a measuring tube 414 adapted for fluid flow inside. Attached to the flow meter housing are a first protection membrane 432a and a second protection membrane 432b for shielding the ultrasound transducers 406 from direct contact with the fluid flowing inside the housing during operation. Also shown are pins 430 for electrical connection between

the ultrasound transducers 406 and an electronic circuit for operating the transducers 406. A bracing 416 serves to press the transducers 406 against the housing 420.

**[0037]** In such prior art embodiment, the ultrasound transducers and the electronic circuit for operating the transducers (not shown) are not protected against humidity, and thus such flow meter is not suited for use in a cooling meter, since transducers and electronics would then be damaged due to humidity caused by condensing due to the low temperature of the cooling fluid, and furthermore a complete assembly of the transducers 406, the electronic circuit and the housing 420 is required before the function of the meter can be tested. These disadvantages are remedied by the flow meter unit according to the invention. To sum up, the invention provides an ultrasound flow meter unit, e.g. a unit forming part of a flow meter for ultrasonic measurement of a fluid flow. The unit comprises two ultrasound transducers 206, a circuit board 202 with an electronic circuit 204 arranged for operating the ultrasound transducers 206, and a common protection membrane 132 for protecting the transducers 206. The common protection membrane 132 forms part of a water-tight casing, such as an IP68 class casing. The two ultrasound transducers 206 and the circuit board 202 with the electronic circuit 204 are positioned within the water-tight casing and are thus protected against damaging humidity. Such flow meter unit is highly versatile within many applications since it provides a compact and robust unit. The unit can be used with or integrated in many types of devices, e.g. flow meters, such as used in consumption meters for charging purposes or in many other industrial or home applications.

# REFERENCES CITED IN THE DESCRIPTION

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**Patent documents cited in the description**


- EP09180619 **[0015]**
- WO2008129050A **[0023]**
- EP0945712A **[0023]**
- WO2008053193A **[0023]**

## Patentkrav

**1.** Vandtæt beklædning til en ultralydsflowmålerenhed (338), indrettet til at fastgøres til et flowmålerhus (120) og tilpasset til at modtage en første og en anden ultralydstransducer (206) og en printplade (202) med et elektronisk kredsløb (204) indrettet til at drive de første og anden ultralydstransducere (206), hvilken vandtæt beklædning omfatter:

- en nedre del (132), og
- en øvre del (134) forbundet med den nedre del (132),

hvor den nedre del er dannet af en fælles beskyttelsesmembran (132) indrettet til at beskytte de første og anden transducere mod direkte kontakt med et fluid, som skal måles, og
hvor den vandtætte beklædning er tilpasset til at omslutte transducerne og det elektroniske kredsløb for at beskytte disse dele mod fugt, og
hvor den fælles beskyttelsesmembran (132) omfatter første og anden recesser (236) udformet til at modtage henholdsvis de første og anden ultralydstransducere (206), og en afstand mellem de første og anden recesser svarer til en afstand mellem de første og anden ultralyds-transducere indrettet i forbindelse med printpladen, og en afstand mellem de første og anden recesser (236) svarer til en afstand mellem en første og anden transducermodtagelsesposition af huset (120).

**2.** Vandtæt beklædning ifølge krav 1, hvor den fælles beskyttelsesmembran (132) er dannet af et polymermateriale.

**3.** Vandtæt beklædning ifølge et hvilket som helst af de foregående krav, hvor de første og anden ultralydstransducere (206) holdes i position i forhold til printpladen (202) af et eller flere fastgørelseselementer, såsom at mindst en elektrisk terminal af de første og anden ultralydstransducere (206) er loddet direkte på printpladen (202).

**4.** Flowmåler indrettet til at måle en flowhastighed af et fluid, som strømmer gennem et målerør, hvor flowmåleren omfatter:

- et hus (120) med målerøret indrettet deri, og

- en vandtæt beklædning ifølge et hvilket som helst af kravene 1-3 indrettet i forhold til huset (120) for at lade en første og en anden ultralydstransducer anbragt inde i beklædningen sende ultralydssignaler gennem fluidet i målerøret.

**5.** Forbrugsmåler omfattende en flowmåler ifølge krav 4, hvor forbrugsmåleren er en af: en varmemåler, en kuldemåler, en vandmåler og en gasmåler.

# DRAWINGS

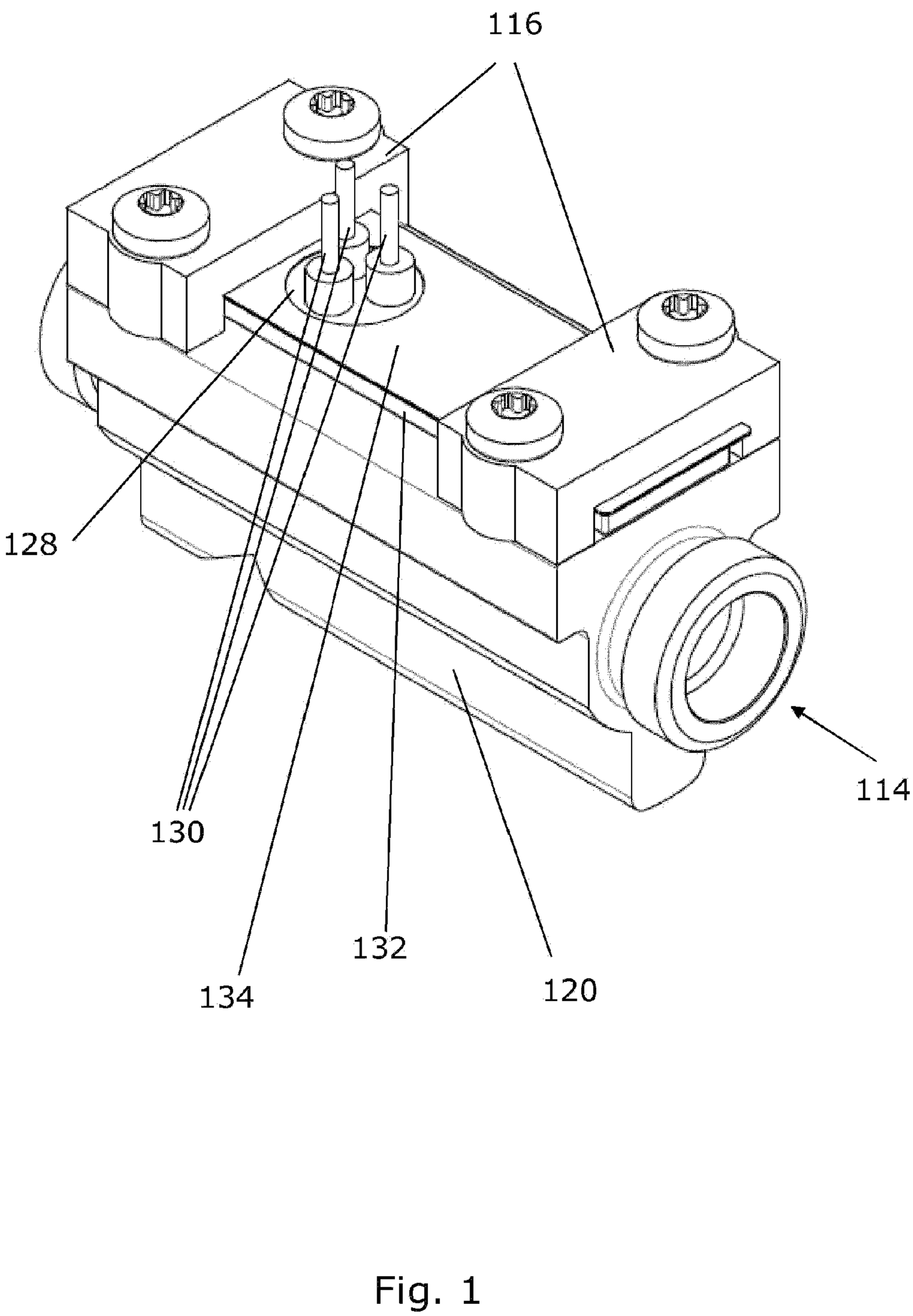


Fig. 1

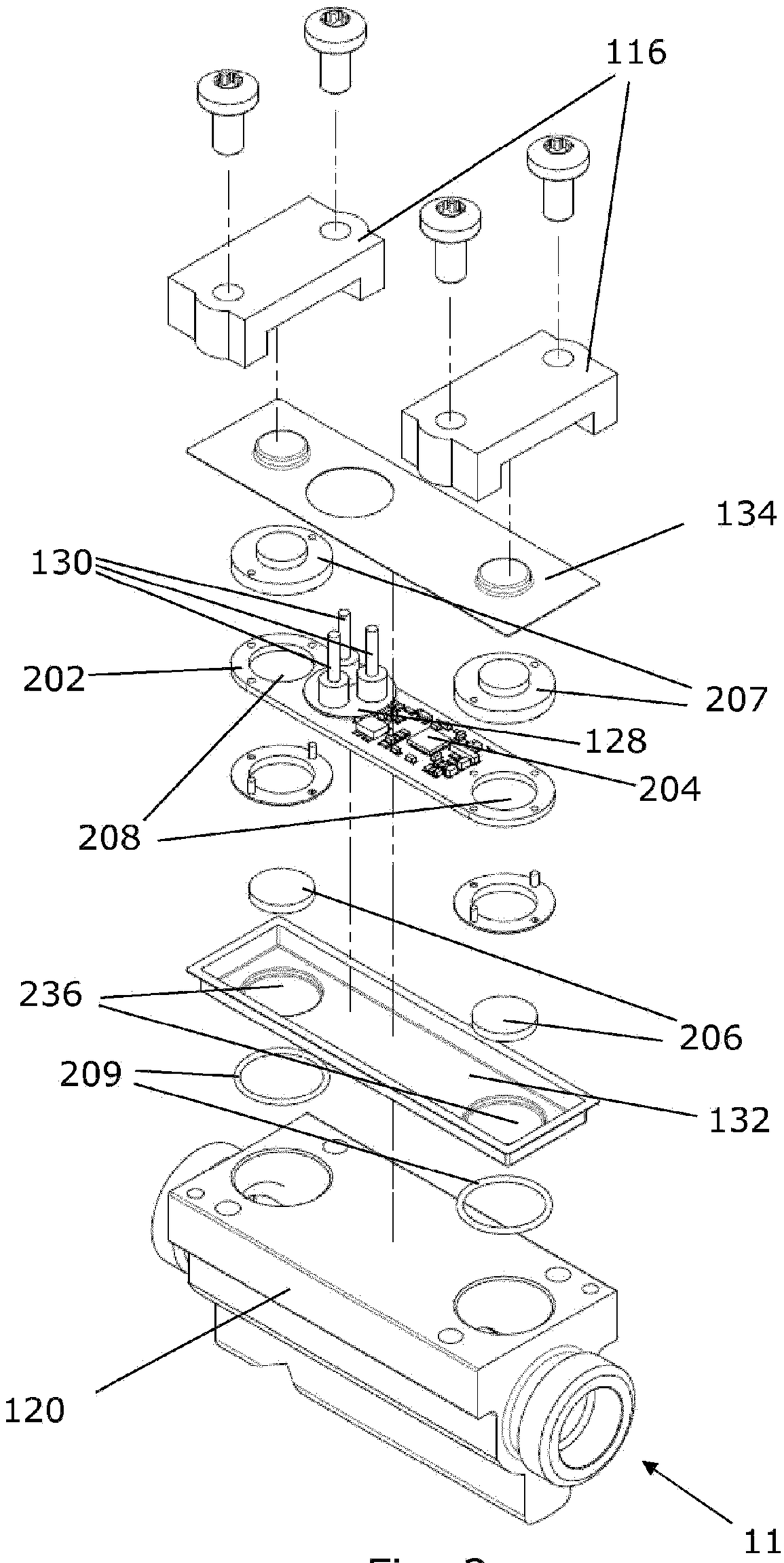


Fig. 2

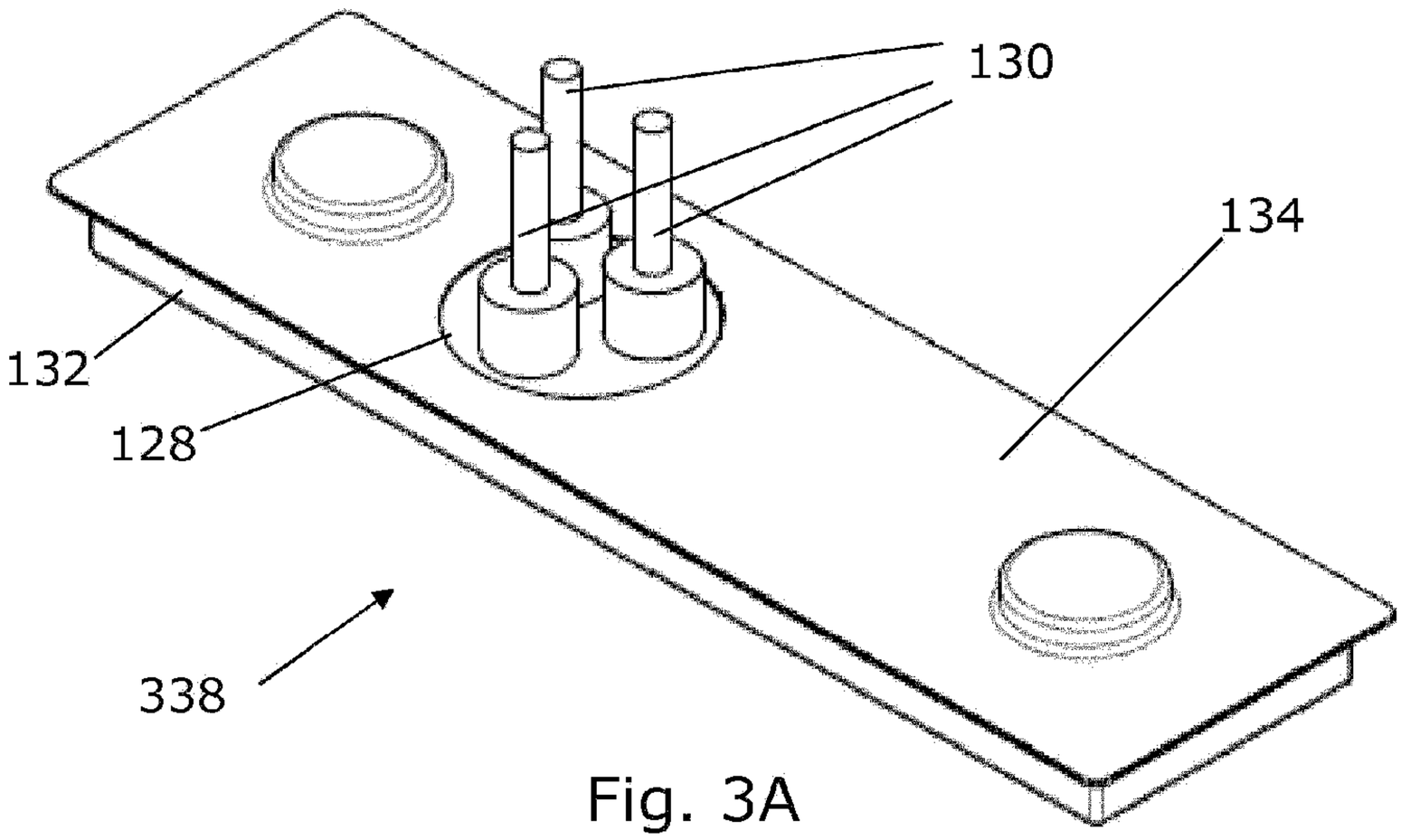


Fig. 3A

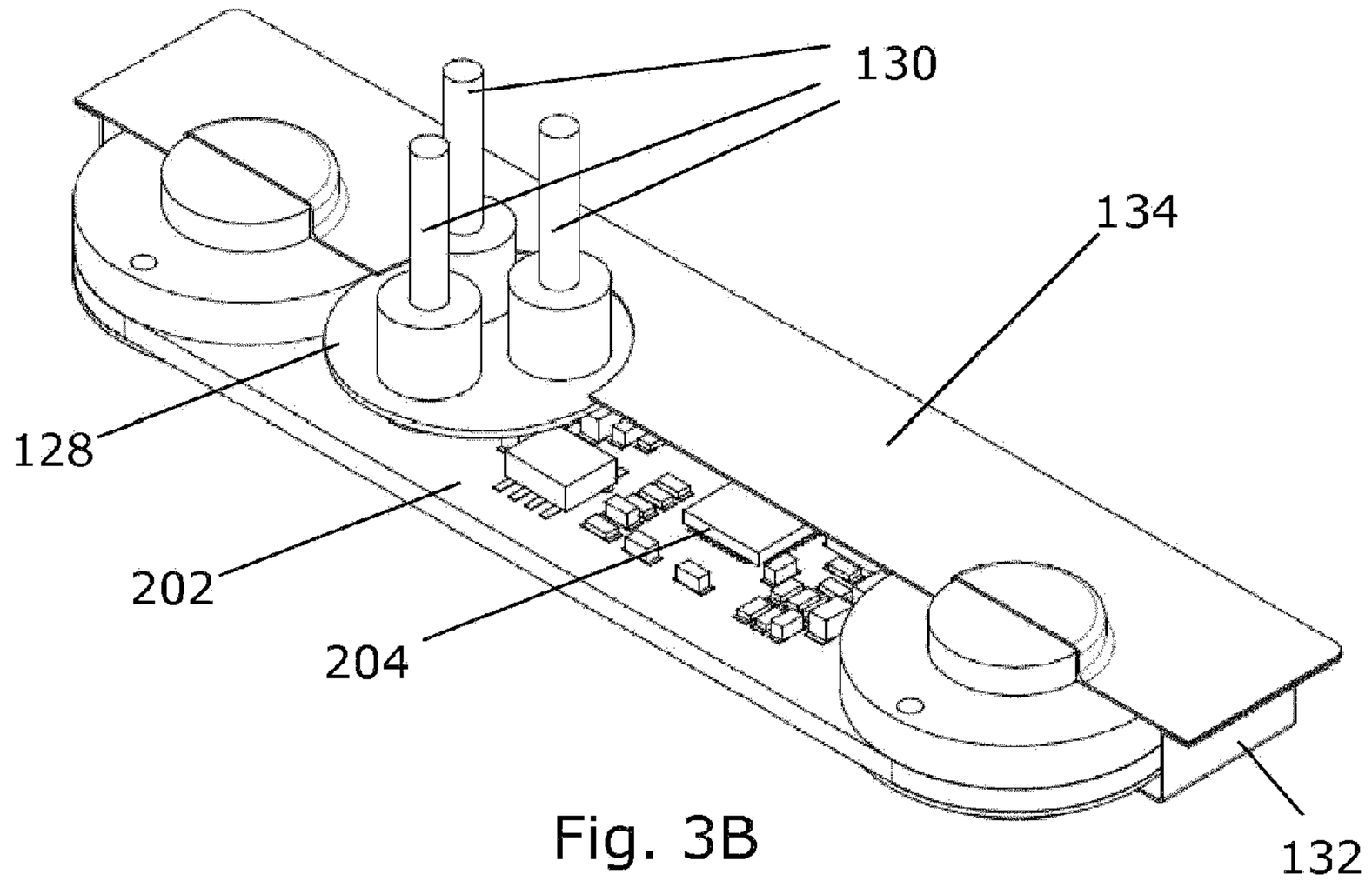


Fig. 3B

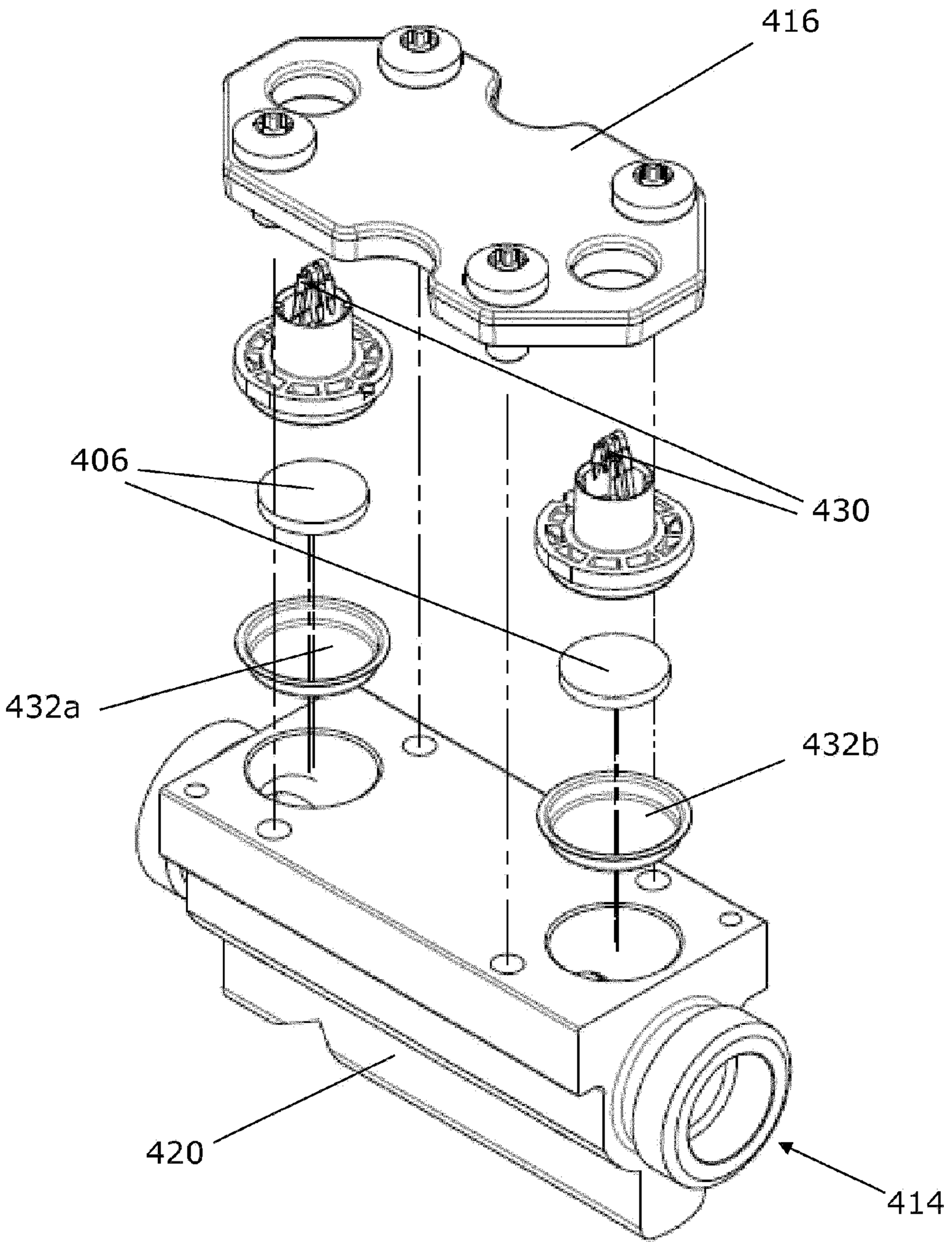


Fig. 4
PRIOR ART