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- (74) Fuldmægtig i Danmark: **Plougmann Vingtoft A/S, Strandvejen 70, 2900 Hellerup, Danmark**
- (54) Benævnelse: **Flowmåler med forstærket polymerhus**
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DESCRIPTION

FIELD OF THE INVENTION

[0001] The invention relates to the field of ultrasonic flow meters. More specifically, the invention relates to an ultrasonic flow meter with a polymer house.

BACKGROUND OF THE INVENTION

[0002] An ultrasonic flow meter forming part of a consumption meter for measuring a consumed amount of water, heat or cooling is normally mounted in a water pipe system. In such water pipe system the flow meter can be exposed to rather high peak fluid pressure forces known as "water hammering". The water hammering on the flow meter can as large as 100 bar. In a design where an ultrasonic piezo-electric transducer front absorbs the water hammering, a pressure build up of 100 kg over the area of the transducer front (100 bar over an area of 25 mm²) can be seen.

[0003] This means that if the transducer is housed in a separate polymer house mounted on a pressure carrying flow tube, there is a high risk that the polymer house will break and thus cause permanent damage of the flow meter. Solutions to this problem in the prior art are to provide a monolithic polymeric unit of flow tube and housing, or to mount transducer capsules in the flow tube in a manner where they can withstand the water hammering, see for example WO 2011/072693 and EP 2 141 463. WO2011/127934 discloses an ultrasonic flow meter according to the preamble of claim 1.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to provide an ultrasonic flow meter with a separate polymer house capable of withstanding normally occurring water hammering without the risk of breaking.

[0005] In a first aspect, the invention provides an ultrasonic flow meter according to claim 1.

[0006] Such an ultrasonic flow meter is advantageous, since it provides a flow meter where transducers and control electronics can be provided in a separate enclosure to be mounted on the flow tube. By use of a monolithic polymeric house with only a single opening that can be sealed with a single sealing member, the cavity when closed, provides a high protection to water intrusion, i.e. it is water tight to a very high degree, but which is nevertheless simple to assemble and has a minimal amount of potential leak areas. Due to the mounting element, the

house is made robust to water hammering, and the remaining part of the house can be provided with the aim to ensure a sufficient robustness of the house wall, a sufficiently low degree of water penetration, and other aspects without considering the water hammering aspect.

[0007] The mounting element arranged to assist the polymer house in absorbing water hammering forces can in embodiments be provided as a separate element or as an element cast as a part of the house. In both situations, the provision of the mounting element can be integrated in the manufacturing process with no or only a few additional manufacturing steps.

[0008] In an important embodiment, the elastic modulus of the mounting element is higher than the elastic modulus of the polymer monolithic house element, preferably such as a factor of 2, 5, 10, 25 or even 50 or more.

[0009] In embodiments, the ultrasonic flow meter may be or may be part of a charging consumption meter, e.g. a water meter, gas meter, heat meter, or cooling meter, where the consumption meter is arranged for measuring consumption data of a supplied utility used as a basis for billing. The consumption meter may be used in connection with district heating or district cooling. The consumption meter may be a legal meter, i.e. a meter which is subdued to regulatory demands. Such regulatory demands may be demands to the precision of the measurements.

[0010] A second aspect of the invention provides a method of manufacturing an ultrasonic flow meter according to claim 14.

[0011] Preferably, the method comprises an intermediate step of mounting ultrasonic transducers and measurement circuit in the cavity of the house is performed prior to sealing the single opening in the house with sealing means. Hereby, the sub-assembly house component is a functioning component that can be tested separately prior to mounting on the flow tube.

[0012] It is appreciated that the same advantages and embodiments described for the first aspect apply as well for the second aspect. Further, it is appreciated that the described embodiments can be intermixed in any way between the two aspects.

BRIEF DESCRIPTION OF THE FIGURES

[0013] The invention will now be described in more detail with regard to the accompanying figures of which

Fig. 1 illustrates a sectional view of an embodiment with a plane mounting element,

Fig. 2 illustrates a house seen from the bottom with a mounting element in the form of two

bars,

Fig. 3 illustrates a house seen from the bottom with a mounting element in the form of a plane member with openings aligned with transducer areas of the house,

Fig. 4 illustrates an exploded view of a house with a plane mounting element with holes arranged for engagement with protrusions on the bottom of the house,

Figs. 5 and 6 illustrate the embodiment of Fig. 4 in an assembled state, in two different views,

Fig. 7 illustrates an exploded lower view of a house with a plane mounting element attached to its bottom, and a flow tube on which the house is to be mounted,

Fig. 8 illustrates the embodiment of Fig. 7 in an assembled state in an upper view,

Fig. 9 illustrates an exploded upper view of an embodiment with a house with through-going tracks for receiving two bar shaped mounting elements, and

Fig. 10 illustrates a flow meter house with the mounting element formed as an integral part of the bottom of the house.

[0014] The figures illustrate specific ways of implementing the present invention and are not to be construed as being limiting to other possible embodiments falling within the scope of the attached claim set.

DESCRIPTION OF EMBODIMENTS

[0015] Fig. 1 illustrates a side section view of an ultrasonic flow meter with a separate house H formed by a cup shaped monolithic polymer element with a sidewall W and a generally plane bottom B with protrusions aligned with positions of ultrasonic transducers T1, T2. The sidewall W and bottom B are shaped so as to form a cavity C in which the ultrasonic transducers T1, T2 and measuring circuits MC are positioned. The protrusions on the bottom B of the house H are arranged in respective holes P1, P2 in a pressure carrying flow tube F, e.g. formed of metal. This allows ultrasonic signals to pass through the wall of the polymer protrusions of the bottom B and into a fluid, such as water, flowing in the through-going opening between inlet I and outlet O of the flow tube F. The flow tube comprises two openings P1, P2 and the outer surface of the house wall at the area of the transducers are directly exposed to the fluid flow. The gap between the house and the openings P1, P2 of the flow tube F can be sealed by means of a sealing member, e.g. an O-ring (not shown in Fig. 1, but shown as SR on Fig. 7). Due to the direct exposure of the house bottom in direct contact with the fluid, any water hammering will act at these areas. The forces that arise from a fluid pressure in connection with water hammering are indicated by the wide dashed arrows. To ensure that the house will not break from a large fluid pressure transient, the bottom of the house is reinforced by the presence of

the mounting element M.

[0016] An important feature of the present invention is the ability to provide an enclosure for the electronic components, which is sufficiently water tight to resist damaging humidity intrusion from the surrounding ambient. To ensure a sufficient watertight meter house, a sealing ring S between the house wall and the cover member CM is used to seal the cavity.

[0017] In an embodiment, the house H is shaped to provide the cavity C with sufficient space to house both the ultrasonic transducers T1, T2 and necessary measurement circuit and e.g. radio transmission module for wireless reading, display, etc., and still the house H has one single opening which can be sealed by means of a single sealing element and a single cover member.

[0018] In the illustrated embodiment of Fig. 1, the ultrasonic measurements of flow rate is performed by a measurement unit comprising measurement circuit MC in the form of a Printed Circuit Board (PCB) with circular shaped piezo-electric transducers T1, T2 mounted thereon. In general, the transducers T1, T2 may be electrically connected to the PCB by other means, such as wires, and thus the transducers T1, T2 may be positioned away from the PCB. The measurement circuit MC serves to control the transducers T1, T2 so as to allow measurement of a flow rate of the fluid flowing through the flow tube F. The transducers T1, T2 are preferably placed in the same plane in a manner so that the centre axis of the flow tube F, the plane of the mounting area, the transducers T1, T2, and the plane of the PCB of the measurement circuit MC are all parallel.

[0019] A set of reflectors R are shown in the flow tube aligned with the transducers T1, T2, and these reflectors serve to reflect ultrasonic signals so as to allow ultrasonic signals to travel between the transducers T1, T2 through a measurement distance in the fluid flow. The reflectors form part of a measuring insert MI also including an intermediate measurement tube forming the measurement distance between the two reflectors. The measuring insert MI is preferably arranged to be inserted into and fixed to the flow tube F.

[0020] The ultrasonic flow meter is a transit time flow meter arranged to measure a flow rate of a fluid flowing in the flow tube F by use of the known operation principle for transit time flow meters, where ultrasonic signals are emitted at one transducer and received at the other transducer, and where the difference in time-of-arrival between oppositely propagating signals is measured and converted into a flow rate. Further signal processing required to calculate the flow rate or parameters derived from the flow rate may be part of the measurement circuit MC, or may be part of a separate calculator circuit (not shown) communicatively connected to the flow meter, placed inside or outside the cavity C.

[0021] A mounting element M in the form of a rather thin, e.g. 1-2 mm thick, monolithic element of steel or reinforced polymer plate is arranged below the bottom B of the house H. The mounting element M may be attached to the bottom of the house H with various means, e.g. by glue, ultrasonic welding, rivets or by means of one or more spatially distributed screws

to as to allow a large area of the bottom B to be attached to the mounting element M in order to ensure that the bottom B and the mounting element M serve to effectively engage in order to cooperate in absorbing water hammering forces from the fluid flow. Alternatively, the mounting element M may be inserted into a slot formed in the bottom B of the house H. Hereby, the rather vulnerable polymer house H is significantly reinforced such that damage to the house H due to water hammering can be avoided. The mounting element M and bottom B of the house H can alternatively be attached to each other by means of glue, or by means of ultrasound welding. Further alternatives for attachment of the mounting element M and bottom B of the house H to ensure mutual engagement are described in the following.

[0022] According to the invention, the mounting element M has two or more holes arranged for attaching the mounting element M to the flow tube F by means of screws S1, S2. As seen, the mounting element M is shown to protrude outside the boundary of the house H, thus allowing space for holes, preferably at least one on each side of the house H, so as to fasten the mounting element M to the flow tube F, and thereby also attaching the house H to the flow tube F. Other means for fastening mounting element M and house H to the flow tube F, such as using a bracing element, clips or clamping, are not part of the invention. Screws or other fastening means cannot be placed inside the cavity, since they would penetrate the bottom of the cavity which would provide channels for humidity to enter into the cavity.

[0023] The house element is made in a polymeric material. Suitable materials may be selected from, but is not limited to, the group consisting of polyphenylene sulphide (PPS), polyether sulphone (PES) and Polyether Sulphone (PSU). It is noted that the properties of the polymeric materials can be customized by adding certain additives prior to the moulding process, affecting the material properties such as stiffness, density or the acoustic impedance. Examples of potential additives include reinforcement materials such as glass fibres, density increasing fillers such as chalk (calcium carbonate, CaCO_3) or powdery stainless steel raising the acoustic impedance of the material.

[0024] Fig. 2 shows a sketch of an embodiment serving to illustrate relation between bottom B of a polymer house, a flow tube F with two openings (dashed circles) for ultrasonic signals to penetrate, and one way of forming a mounting element, namely as two separate monolithic elements M1, M2, e.g. made of steel. These elements M1, M2 may be bars, and to engage with the house bottom B for supporting the house against water hammering, the two elements M1, M2 are arranged on opposite sides of the openings in the flow tube F. In each end of the elements M1, M2 the black circles indicate holes for attachment to the flow tube by means of screws.

[0025] In general, the mounting element can be formed by more than two separate elements, e.g. three or four separate monolithic bar shaped or plate shaped elements, in case another spatially distributed coupling between mounting element and house bottom is desired.

[0026] Fig. 3 shows a similar view as Fig. 2, however with a mounting element constituted by a single monolithic element M, e.g. a plane steel plate. The plate M has circular openings OP1,

OP2 aligned with the openings (dashed circles) and slightly larger in diameter. The plate structure of the mounting element M serves to provide a large area common with the house bottom B, and thus an effective engagement with the house structure can be obtained using one of the mentioned fastening means. As also shown in Fig. 1, the mounting element M protrudes from the house H boundary, and the mounting element M has through-going holes, here shown as two in each end of the mounting element M, to allow fastening by means of screws to the flow tube F.

[0027] Fig. 4 shows an exploded view of a polymer house with a bottom B, and a plate shaped monolithic mounting element M with circular openings OP1, OP2 arranged to match transducer protrusions PA1, PA2 on the house bottom B. Further, to efficiently engage the mounting element M and house bottom B, a plurality of spatially distributed circular protrusions PT1 are provided and arranged for engagement with corresponding openings H1 of the mounting element M. This arrangement is suited for casting the house and mounting element M together, e.g. in the process of casting the house, however it may be preferred to first cast the house, and subsequently cast the mounting element M onto the house. The mounting element M can be such as a steel plate or a reinforced polymer plate. Further, the mounting element M has four holes HS1, two in each end, and these holes HS1 serve to fasten the mounting element M, and thus also the house, to a flow tube by means of screws, as also shown in Fig. 1.

[0028] In Fig. 4, the openings H1, OP1, OP2 of the mounting element M are not simple circular holes, but these openings H1, OP1, OP2 have varying diameter across the thickness of the plate. Hereby, a tight structural coupling between the house bottom B and the mounting element M can be obtained when cast together as mentioned, since the protrusions PA1, PA2, PT1 are shaped to match the mentioned varying diameter. In another embodiment, the protrusions PA1, PA2, PT1 may be initially cast formed with one diameter in their entire extension so as to allow penetration through the openings H1, OP1, OP2, and then subsequently, the protrusions PA1, PA2, PT1 can be melted into their final shape and thereby serving to effectively lock the mounting element to the house bottom B.

[0029] Fig. 5 and 6 show different views of the embodiment of Fig. 4 with the mounting element attached to the house. Fig. 5 shows a sectional view, whereas Fig. 6 shows a 3D view of the cup shaped house.

[0030] Fig. 7 shows an exploded view of the same house H and mounting element M embodiment as shown in Figs. 4-6, but illustrated together with a matching flow tube F, possibly formed of metal. Inlet and outlet in the ends of the flow tube F have flanges arranged for mounting the flow tube F to a pipe system. Sealing rings SR serve to seal the gap between transducer protrusions and the matching openings in the flow tube F. The flow tube may in embodiments be made of a metal or a metal alloy such as brass, red brass, stainless steel, or other suitable casting alloys, as well as of a suitable polymer material.

[0031] Fig. 8 shows another view of the embodiment of Fig. 7 but in an assembled state. The

flow tube F has portions arranged for receiving the house H and mounting element M assembly so as to allow fastening of this assembly to the flow tube F by means of screws through the holes in the protruding part of the mounting element M.

[0032] Fig. 9 illustrates one way of engaging the two bar shaped mounting elements M1, M2 shown in Fig. 2 with the structure of the house H. As seen, the house H has in its bottom part a through-going passage, here shown as two separate tracks TR1, TR2 shaped to fit the shape of the respective mounting element bars M1, M2, such that the bars can enter tracks, and preferably the mounting element bars M1, M2 are longer than the tracks, such that the ends of the mounting element bars M1, M2 can protrude from the house H. Inside the tracks TR1, TR2, the mounting element bars M1, M2 can be attached to the house structure in various ways as already mentioned. The house H and mounting elements M1, M2 are fastened to the flow tube F with screws through holes in the protruding ends of the mounting element bars M1, M2.

[0033] Fig. 10 illustrates a further embodiment of a flow meter house H. In the illustrated embodiment, the mounting element is provided as an integral part of the bottom of the house, cast monolithically with the house. The bottom part is in the area to be positioned on the flow tube, reinforced by providing a thicker wall TW. In the illustrated embodiment the mounting element is provided by a massive wall thickness along a part of the bottom periphery, however the bottom part may also be reinforced by one or more ribs formed integrally with the mounting element. That is, instead of a massive wall thickness, part of the material may be removed to form ribs.

[0034] Although the present invention has been described in connection with the specified embodiments, it should not be construed as being in any way limited to the presented examples. The scope of the present invention is to be interpreted in the light of the accompanying claim set. In the context of the claims, the terms "including" or "includes" do not exclude other possible elements or steps. Also, the mentioning of references such as "a" or "an" etc. should not be construed as excluding a plurality. The use of reference signs in the claims with respect to elements indicated in the figures shall also not be construed as limiting the scope of the invention. Furthermore, individual features mentioned in different dependent claims, may possibly be advantageously combined, and the mentioning of these features in different dependent claims does not exclude that a combination of features is not possible and advantageous.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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- [WO2011127934A \[0003\]](#)

Patentkrav

1. Ultralydsflowmåler indrettet til at måle en flowhastighed af en væske, hvilken flowmåler omfatter:

- 5 - et flowrør (F) med en gennemgående flowpassage til passage af en væske mellem et indløb (I) og et udløb (O), og to gennemgående åbninger (P1, P2) anbragt i en væg af flowrøret (F), som hver især tilvejebringer en åbning ind i flowpassagen;
- 10 - et hus (H) adskilt fra flowrøret, dannet af et monolitisk polymerhus-element med en bunddel (B) og en sidedel (W) til at danne et hulrum (C) med en enkelt åbning, hvor bunddelen (B) har to områder indrettet til transmission af ultralydssignaler, nævnte områder er forsynet med fremspring (PA1, PA2) indrettet til at trænge ind i de to gennemgående åbninger (P1, P2) i væggen af flowrøret (F), og hvor huset (H) er indrettet til at blive monteret på flowrøret (F), således at fremspringene er anbragt i 15 åbningerne (P1, P2) ind i flowpassagen;
- to eller flere ultralydstransducere (T1, T2) anbragt i hulrummet (C) på linje med nævnte fremspring (PA1, PA2) og indrettet til udsendelse og modtagelse af ultralydssignaler gennem områderne af bunddelen (B) af huset (H); og
- 20 - et monteringselement (M) som rager frem fra hus- (H) grænsen, hvor nævnte monteringselement (M) er indrettet til at forstærke bunddelen af huset, hvor monteringselementet er anbragt i gensidigt indgreb med bunddelen af huset, og hvor bunddelen (B) af huset (H) og monterings-elementet samlet absorberer kræfter fra et væsketryk i flowrøret, når huset 25 er monteret på flowrøret,

kendetegnet ved, at monteringselementet (M) er fladt og har gennemgående huller (HS1) for at muliggøre fastgørelse til flowrøret (F) ved hjælp af skruer.

2. Ultralydsflowmåler ifølge krav 1, hvor monteringselementet (M) har et 30 elasticitetsmodul, som er højere end elasticitetsmodulet af det monolitiske polymerhuselement.

3. Ultralydsflowmåler ifølge et hvilket som helst af de foregående krav, hvor monteringselementet (M) er et separat element, støbt ind i bunddelen (B) af det

monolitiske huselement.

4. Ultralydsflowmåler ifølge et hvilket som helst af de foregående krav, hvor monteringsselementet (M) er fremstillet af et metal eller et kompositmateriale.

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5. Ultralydsflowmåler ifølge et hvilket som helst af de foregående krav, hvor monteringsselementet udgøres af et enkelt monolitisk element (M).

6. Ultralydsflowmåler ifølge krav 5, hvor bunddelen (B) har et flertal af rumligt fordelte cirkelformede fremspring (PT1) til indgreb med tilsvarende åbninger (H1) i monteringsselementet (M).

7. Ultralydsflowmåler ifølge et hvilket som helst af kravene 1-4, hvor monteringsselementet omfatter to eller flere monolitiske elementer (M1, M2).

15

8. Ultralydsflowmåler ifølge et hvilket som helst af de foregående krav, hvor et eller flere af områderne af bunddelen (B) indrettet til transmission af ultralydssignaler har mindst et fremspring (PA1, PA2) indrettet til at trænge ind i den mindst ene gennemgående åbning (P1, P2) i væggen af flowrøret (F).

20

9. Ultralydsflowmåler ifølge et hvilket som helst af de foregående krav, hvor bunddelen (B) omfatter en eller flere skinner (TR1, TR2) anbragt til at gå i indgreb med monteringsselementet (M1, M2).

25 **10.** Ultralydsflowmåler ifølge et hvilket som helst af de foregående krav, hvor monteringsselement (M) er fastgjort til bunddelen af det monolitiske huselement ved hjælp af mindst en af: skruer (S1, S2), lim, nitter og en eller flere ultralydssvejsninger.

30 **11.** Ultralydsflowmåler ifølge et hvilket som helst af kravene 1, 2 eller 8, hvor monteringsselementet er en integreret del af bunden af huset, støbt monolitisk med huset.

12. Ultralydsflowmåler ifølge krav 11, hvor bunddelen er forstærket ved at have en tykkere vægtykkelse af monteringsselementet, end af sidedelen.

13. Ultralydsflowmåler ifølge et hvilket som helst af de foregående krav, hvor det monolitiske huselement er formet således, at det giver plads i hulrummet (C) til de to eller flere ultralydstransducere (T1, T2) og et tilknyttet målekredsløb (MC).

14. Fremgangsmåde til fremstilling af en ultralydsflowmåler, hvilken fremgangsmåde omfatter

- 10 - at tilvejebringe et monolitisk polymerhuselement (H) med en bunddel og en sidedel til at danne et hulrum med en enkelt åbning, og hvor bunddelen har to områder indrettet til transmission af ultralydssignaler,
- at tilvejebringe et monteringsselement (M) dannet af et materiale med et elasticitetsmodul, som er højere end elasticitetsmodulet af det monolitiske polymerhuselement,
- 15 - at forbinde monteringsselementet (M) på bunddelen af huselementet for at danne et delmontagehus, således at bunddelen af huselementet og monteringsselementet er indrettet til samlet at absorbere kræfter fra et væsketryk,
- 20 - at fastgøre delmontagehuset på et flowrør med en gennemgående flowpassage til passage af en væske mellem et indløb og et udløb, og to gennemgående åbninger anbragt i en væg af flowrøret, som hver især tilvejebringer en åbning ind i flowpassagen,
- hvor monteringsselementet (M) er fladt og rager frem fra hus- (H) grænsen og har gennemgående huller (HS1) til fastgørelse ved hjælp af
- 25 skruer (S1, S2) på flowrøret (F).

15. Fremgangsmåde ifølge krav 14, omfattende montering af ultralydstransducere og målekredsløb i hulrummet af huselementet forud for tætning af den enkelt
30 åbning i huset med tætningsmiddel.

DRAWINGS

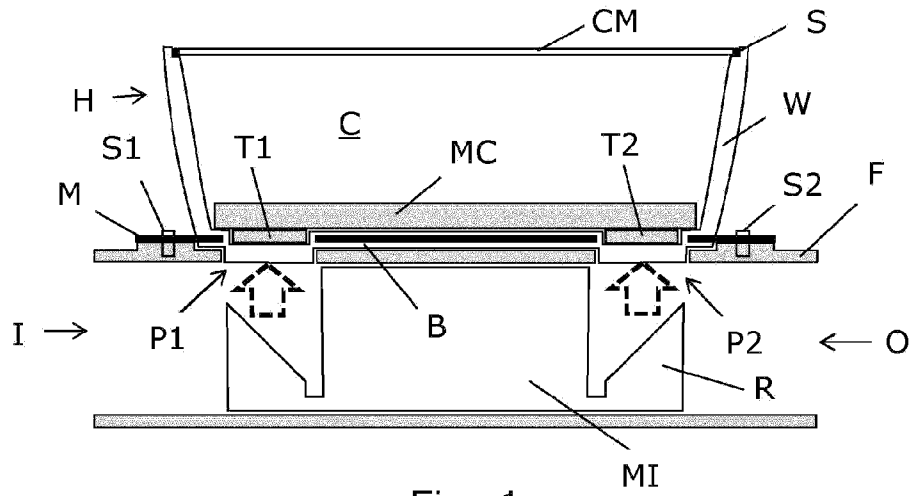


Fig. 1

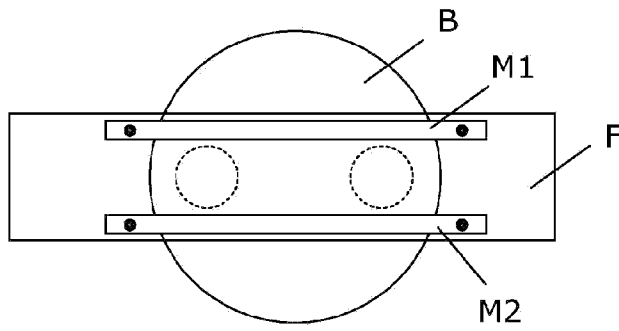


Fig. 2

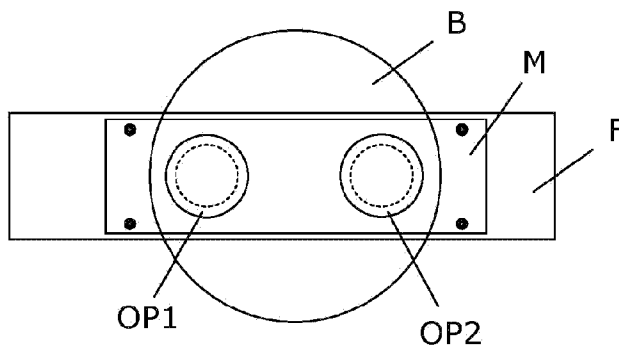


Fig. 3

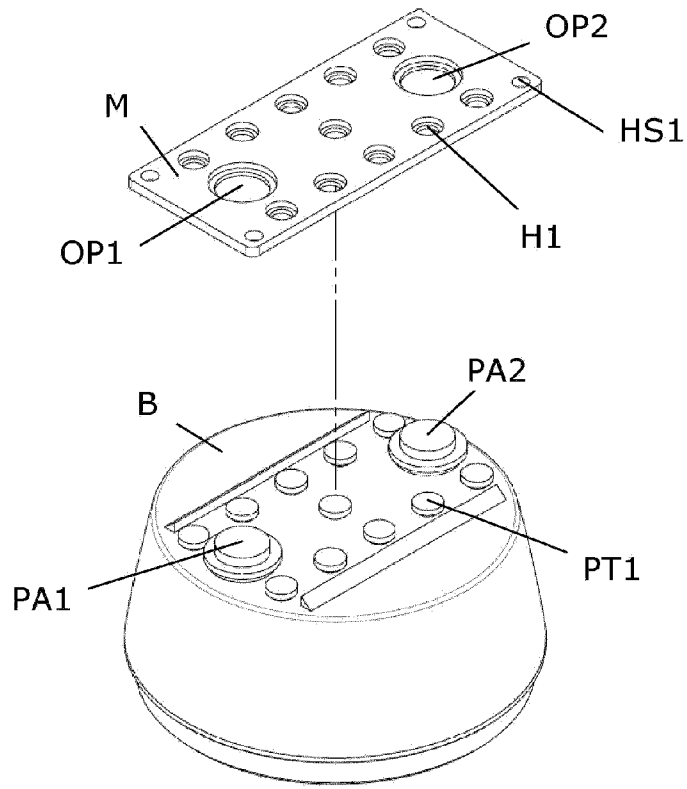


Fig. 4

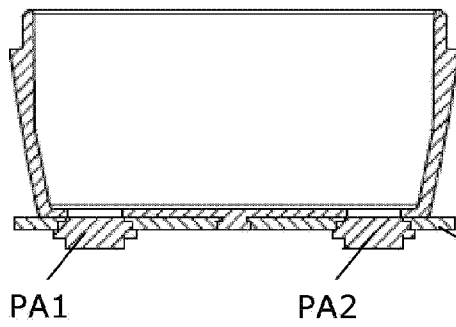


Fig. 5

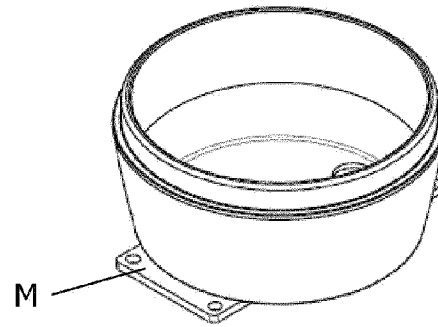


Fig. 6

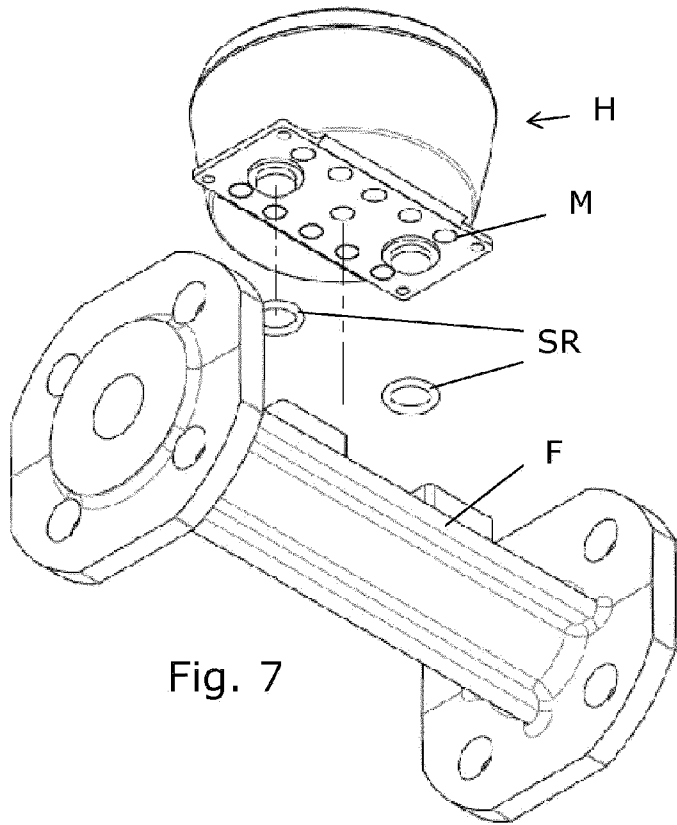


Fig. 7

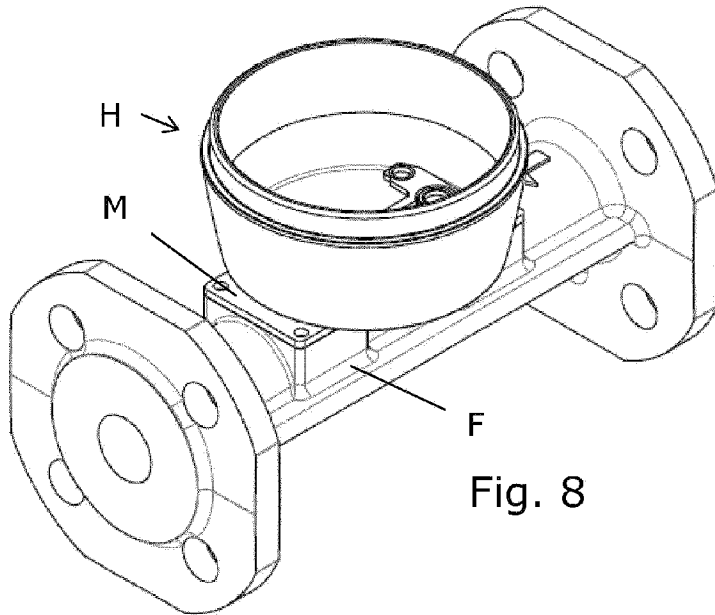


Fig. 8

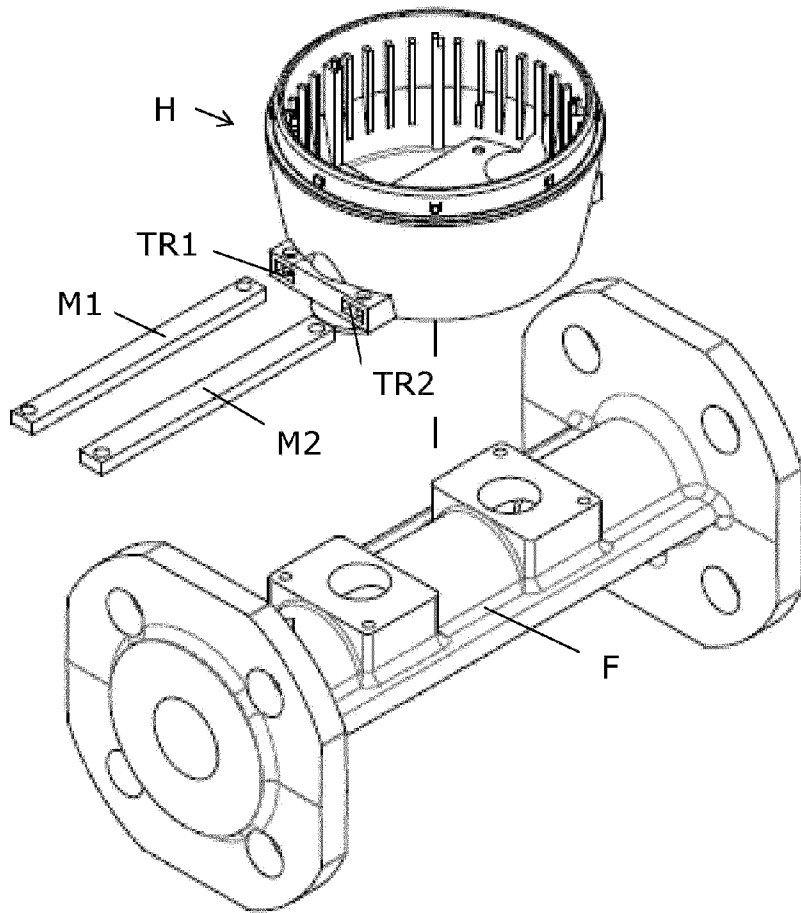


Fig. 9

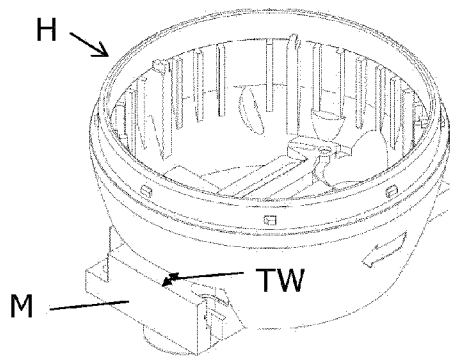


Fig. 10