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(54) Benævnelse: **Dekantercentrifuge med en energigenvindingsenhed**

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Description

Solid-bowl screw centrifuge having an energy recovery device

Background of the invention

The invention relates to a solid-bowl screw centrifuge with a centrifuge drum which can rotate about a longitudinal axis during operation, on the front side of which at least one discharge opening for discharging clarified product from the centrifuge drum is formed, being provided with a weir edge delimiting the discharge opening towards the outside radially, and an energy recovery device for recovering energy from the clarified discharged product is formed. Furthermore, the invention also relates to such an energy recovery device for mounting on a front side of a centrifuge drum.

It is known in general that a plurality of discharge openings may be provided on the front side of the centrifuge drum of a generic solid-bowl screw centrifuge, so that the clarified product can flow out through the opening by way of a respectively associated weir edge. The weir edge forms the radially inner edge of an associated weir plate, which is mounted on the front side of the centrifuge drum so that it is radially adjustable.

In order for the kinetic energy of the product discharged to be reusable for driving the rotational movement of the centrifuge drum, energy recovery devices are now provided on such weir edges. It is thus known that, among other things, deflecting devices may be provided on the front side of a centrifuge drum, so that the flow of clarified product can be diverted in a tangential direction. The product, which is then emerging from the centrifuge drum, not axially but instead tangentially opposite the direction of rotation of the centrifuge drum, transmits a momentum to the centrifuge drum in the direction of rotation, driving the centrifuge drum in the direction of rotation accordingly. Such deflecting devices are known from WO 2012 013624 A2, for example.

From US 7 022 061 B2 there is known a solid-bowl screw centrifuge with a centrifuge drum which can rotate about a longitudinal axis during operation, on the front side of which two discharge openings, a first discharge opening and a second discharge opening, for discharging clarified product from the centrifuge drum are provided. The first discharge opening has a weir edge delimiting the discharge opening towards the outside radially. An energy recovery device for recovering energy from the clarified discharged product is formed in front of the second discharge opening, being designed as a discharge pipe through which the clarified discharged product flows.

Object of the invention

The invention is based on the object of creating a solid-bowl screw centrifuge which has a particularly effective energy recovery device.

Solution according to the invention

This object is achieved according to the invention with a solid-bowl screw centrifuge according to claim 1. The object is furthermore also achieved with an energy recovery device which is adapted for direct mounting axially on the outside in front of an associated discharge opening and is designed as a discharge pipe through which clarified discharged product flows.

In the solid-bowl screw centrifuge according to the invention, the discharge opening in the front side of the centrifuge drum extends essentially transversely to the longitudinal axis of the centrifuge. The weir edge, which may be aligned at least slightly, advantageously obliquely to the longitudinal axis, is situated radially on the outside of the discharge opening. The energy recovery device according to the invention, which is designed as a pipe that is closed over essentially its entire circumference, is situated on the outside directly axially in front of the discharge opening, essentially at the height or the radius of the weir edge. Such a pipe thus forms a discharge conduit, which is closed over its entire circumference on the outside axially, in front of the discharge opening. On the outside radially with respect to the longitudinal axis, this discharge pipe acts like a discharge trough or a discharge channel and at the same time is closed on the inside radially with respect to the longitudinal axis.

The solution according to the invention is based on the finding that the energy recovery effect of energy recovery devices of the aforementioned type is based in particular on this energy recovery device being closed on its inside radially. With this design, the product discharged through the energy recovery device is protected from external aerodynamic influences within the energy recovery device. Otherwise the air on the outside of the centrifuge drum, which is rotating at a high speed, will have a substantial influence on the product discharged, so that it loses a portion of its energy content due to friction with this air. This energy loss is prevented with the solution according to the invention, so that more energy can be recovered from the product discharged. With the solution according to the invention, the product discharged can be deflected from the axial direction essentially into the tangential direction in a particularly homogeneous and targeted manner, contrary to hitherto known solutions. At the same time, energy losses occurring due to a diversion of the product discharged in the radial direction can be prevented. With the discharge pipe according to the invention, the product discharged is held largely at the radius of the associated weir edge during the deflection, the discharge pipe being arranged on the outside axially in front of the discharge opening, so that even minor changes in the radius of the flow path may be advantageous, as will be explained below.

In the case of such a solid-bowl screw centrifuge, the centrifuge drum may advantageously be equipped so that it can rotate in two opposing directions. With the discharge pipe, the clarified discharged product is preferably deflected opposite a respective direction of rotation of the centrifuge drum. The energy recovery device according to the invention may also be designed with two active surfaces as discharge pipes, one active surface of which manifests an effect in a first direction of rotation and the second active surface manifests an effect in the second direction of rotation.

In the case of the solid-bowl screw centrifuge according to the invention, the discharge pipe is advantageously designed with at least one section having an essentially straight flow path, which is set at an inclination at an angle between 45° and 85°, preferably between 55° and 65°, to the longitudinal axis of the centrifuge drum. The discharge pipe according to the invention also preferably has at least one section having an essentially straight flow path which is set at an inclination by an angle of 4° to 28°, preferably 8°, radially inwards to the tangential direction at the discharge opening. The bottom surface of such a section is especially advantageously designed to be planar for at least a section or to be largely planar. Such a bottom surface can be produced especially favourably in terms of the manufacturing technology. In addition, the product discharged thereon experiences a uniform acceleration over a longer distance, so it is comparatively easy to reconstruct technically by modelling. The acceleration leads to an increased conversion of the centrifugal momentum into a kinetic momentum directed tangentially. As a particularly large component of the centrifugal energy, it is converted into a tangential drive energy. The planar section of the bottom surface is especially preferably inclined by an angle of 4° to 28°, preferably 8°, radially inwards to the tangential direction. Such an alignment of the deflected product stream causes deceleration of the outgoing flow, which is predefined in a targeted manner in comparison with a purely tangential flow, and this leads to a precisely predetermined stagnation effect. This stagnation leads to an increase in the potential energy of the product discharged and thus an improved subsequent conversion into tangential kinetic energy.

Furthermore, the discharge pipe according to the invention preferably has a discharge mouth with a flow path or a direction of flow which is set at an inclination at an angle between 70° and 90°, preferably between 77° and 83°, with respect to the longitudinal axis of the centrifuge drum. With such a direction of flow, the product discharged is deflected from axially at first to essentially tangentially, i.e., transversely thereto. Deflection to less than 90° with respect to the longitudinal axis entails the advantage that the product exiting the discharge mouth is not directed as sharply against the front side of the centrifuge drum and therefore the friction losses there are lower.

The solution according to the invention also advantageously provides a solid-bowl screw centrifuge in which the discharge pipe is designed with a flow cross section of a constant size in the direction of flow of the clarified discharged product. Alternatively, the discharge pipe is designed with a diminishing, in particular conically tapering, flow cross section in the direction of flow of the clarified discharged product. A non-tapering flow shape reduces the risk of blockage of the discharge pipe during operation of the associated solid-bowl screw centrifuge. A tapering pipe shape creates an additional stagnation effect, which results in improved energy recovery.

With the solid-bowl screw centrifuge according to the invention, the discharge pipe is also preferably designed with a round, in particular circular or elliptical, cross section. Alternatively, the discharge pipe is designed with a rectangular, in particular square, cross section. The two cross-sectional shapes mentioned lead to energy recovery devices that are particularly inexpensive to manufacture. Furthermore, these cross sections are especially suitable for allowing the product discharged to flow out in a predetermined manner. A rectangular cross section also has the advantage that the product discharged emerges at the associated discharge mouth at a predefined radius on a wide plane.

Finally, with the solid-bowl screw centrifuge according to the invention, the discharge pipe is preferably designed with an adapted aerodynamic exterior wall shape also on its exterior wall facing in the direction of rotation. The flow resistance of the energy recovery device and thus the associated energy loss can be reduced with this exterior wall shape. An aerodynamically adapted exterior wall shape is understood here to be a shape which offers the least possible flow resistance for oncoming air. Such a shape is rounded with no edges and is provided with a smooth surface with very little roughness.

Brief description of the drawings

An exemplary embodiment of the solution according to the invention is described in greater detail below on the basis of the accompanying schematic drawings, in which

Fig. 1 shows a longitudinal section through a centrifuge drum with a weir plate and an energy recovery device of a solid-bowl screw centrifuge according to the prior art,

Fig. 2 shows the longitudinal section II-II in Fig. 1.

Fig. 3 shows a side view of a centrifuge drum with a weir plate and an energy recovery device of a first exemplary embodiment of a solid-bowl screw centrifuge according to the invention,

Fig. 4 shows the longitudinal section IV-IV according to Fig. 3,

Fig. 5 shows the view V according to Fig. 4.

Fig. 6 shows a side view of a centrifuge drum with a weir plate and an energy recovery device of a second exemplary embodiment of a solid-bowl screw centrifuge according to the invention,

Fig. 7 shows the longitudinal section VII-VII according to Fig. 6,

Fig. 8 shows the view VIII according to Fig. 7,

Fig. 9 shows a side view of a centrifuge drum with a weir plate and an energy recovery device of a third exemplary embodiment of a solid-bowl screw centrifuge according to the invention,

Fig. 10 shows the longitudinal section X-X according to Fig. 9,

Fig. 11 shows the view XI according to Fig. 10,

Fig. 12 shows a side view of a centrifuge drum with a weir plate and an energy recovery device of a fourth exemplary embodiment of a solid-bowl screw centrifuge according to the invention,

Fig. 13 shows the longitudinal section XIII-XIII according to Fig. 12,

Fig. 14 shows the view XIV according to Fig. 13,

Fig. 15 shows a side view of a centrifuge drum with a weir plate and an energy recovery device of a fifth exemplary embodiment of a solid-bowl screw centrifuge according to the invention,

Fig. 16 shows the longitudinal section XVI-XVI according to Fig. 15,

Fig. 17 shows the view XVII according to Fig. 16,

Fig. 18 shows the longitudinal section XVIII-XVIII according to Fig. 19 of a centrifuge drum with a weir plate and an energy recovery device of a sixth exemplary embodiment of a solid-bowl screw centrifuge according to the invention,

Fig. 19 shows a side view of a centrifuge drum according to Fig. 18,

Fig. 20 shows the longitudinal section XX-XX according to Fig. 21 of a centrifuge drum with a weir plate and an energy recovery device of a seventh exemplary embodiment of a solid-bowl screw centrifuge according to the invention and

Fig. 21 shows a side view of a centrifuge drum according to Fig. 20.

Detailed description of the exemplary embodiments

Figs. 1 and 2 show the centrifuge drum 12 of a solid-bowl screw centrifuge 10 with its front side or front wall 14. On the front wall 14 can be seen one of several discharge openings 16 passing axially through the front wall 14 in the direction of a longitudinal axis 18 of the centrifuge drum 12. On the outside in front of the discharge opening 16, a weir plate 20 is stationarily mounted on the front wall 14, but is adjustable. The weir plate 20 protrudes to just in front of the discharge opening 16, so that it covers the latter on the outside on its radially outer region. The weir plate 20 has a weir edge 22 on its radially inward facing border. According to the prior art, such a weir edge 22 extends along the front wall 14 and thus transversely to the longitudinal axis 18. The weir edge 22 retains clarified product 24 in the centrifuge drum 12, so that during operation of the solid-bowl screw centrifuge 10, this clarified product 24 collects there with a pond depth 26 and then flows off over the weir edge 22 mostly continuously thereafter.

An energy recovery device 28 according to the prior art is situated on the outside axially on the weir plate 20 behind or downstream from the weir edge 22 in the direction of flow of the clarified product 24. This energy recovery device 28 is designed as a discharge trough or a discharge channel 30, which has a planar bottom surface 32 extending tangentially at the height of the weir edge 22. A deflecting surface 34, which, as part of the discharge channel 30 perpendicular to the bottom surface 32, extends in an arc shape in front of the region of the discharge opening 16 that is open as seen in the longitudinal direction according to the prior art.

The deflecting surface 34 deflects the clarified product 24 that flows down axially through the discharge opening 16 on the inside radially below the weir edge 22 in a direction of inflow 38 is deflected in a direction tangential to a discharge direction 40. Meanwhile the centrifuge drum 12 rotates in one direction of rotation 36, while the clarified product 24 is deflected by the deflecting surface 34, so that it emerges tangentially from the energy recovery device 28 in the opposite direction from this direction of rotation 36. On its exit, the clarified product 24 “is repelled by” the centrifuge drum 12, thereby transferring a portion of its momentum to the centrifuge drum and contributes towards energy recovery on the centrifuge drum 12. This “repulsion” is mitigated by the internal fluid friction in the clarified product 24 and by the fact that the centrifuge drum 12 continues to rotate in the direction of rotation 36. The centrifuge drum 12 therefore partially evades the repulsion.

Figs. 3 to 5 show a first exemplary embodiment of a solid-bowl screw centrifuge 10 with its centrifuge drum 12, on which an energy recovery device 42 according to the invention is arranged. The energy recovery device 42 also has a weir plate 20 of the traditional type in front of the associated discharge opening 16. On the outside axially there is a discharge pipe 44 on the weir plate 20, through which discharge pipe flows the clarified product discharged through the discharge opening 16.

With regard to its cross section, the discharge pipe 44 is situated directly in front of the region of the otherwise open discharge opening 16, so that the opening is completely covered by the discharge pipe 44 on the outside. Therefore, no air flow can act from the outside during the passage of the clarified product past the discharge opening 16 and therefore this yields a particularly uniform flow, in particular a strictly laminar flow, with the corresponding purity of the clarified product discharged. The discharge pipe 44 is situated at the height or radius of the weir edge 20, so that the product thereby being discharged undergoes practically no change in position in the radial direction and there are no energy losses accordingly.

On its circumference, the discharge pipe 44 is completely closed and forms a tubular conduit with an inflow mouth 46 in front of the discharge opening 16 and a discharge mouth 48 on its other, exterior end. The outer part of this pipe on the outside radially with respect to the longitudinal axis acts like a discharge trough or discharge channel, and at the same time is closed on the inside radially with respect to the longitudinal axis of the centrifuge drum 12. Therefore, the product discharged through the energy recovery device 42 is also protected against external aerodynamic influences on the inside of the discharge pipe 44. The product is deflected out of the axial direction homogeneously, without turbulence and in a targeted manner, i.e., the incoming flow direction 38 essentially into the tangential direction or discharge direction 40.

With the discharge pipe 44, the product discharged is largely held at the radius of the weir edge 22 during the deflection process, wherein the discharge pipe 44 has a straight flow path 50, as seen in a side view (Fig. 3), which is set at an inclination radially towards the inside by an angle 54 of 6° to 8° to the tangential direction 52 on the discharge opening 16. An associated bottom surface 56 of the discharge pipe 44 is designed to be planar or largely planar and also set at an angle 54 of 6° to 8° at an inclination to the tangential direction 52. At the same time, the discharge pipe 44 according to Figs. 3 to 5 has a rectangular flow cross section 56, which is designed to taper starting from the inflow mouth 46 and going continuously to the discharge mouth 48. With such a taper, the product discharged is subject to additional stagnation and is bundled into a stream.

In the exemplary embodiment of an energy recovery device 42 according to Figs. 6 to 8, the discharge pipe 44 there is designed with an oval flow cross section 56. Such a flow cross section 56 also tapers over the flow path of the product discharged through the discharge pipe 44. The discharge pipe 44 has a section with an essentially straight flow path 58, as seen in the longitudinal section (Fig. 7) downstream from the inflow mouth 46, set at an angle 60 between 55° and 65° to the longitudinal axis 18 of the centrifuge drum. On the whole, this design yields a drop shape (see Fig. 6) for the discharge pipe 44, which is particularly advantageous aerodynamically.

Figs. 9 to 11 show an exemplary embodiment of an energy recovery device 42, in which the discharge pipe 44 is designed with an essentially circular flow cross section 56. At the same time, the flow path 58, which is essentially straight in the longitudinal section, extends over the total length of the discharge pipe 44, so that the pipe is designed as a straight cylindrical pipe on the whole. Such a solution can be manufactured very inexpensively.

Figs. 12 to 14 show an exemplary embodiment of an energy recovery device 42, in which the associated discharge pipe 44 is designed as a conical pipe set at an inclination upstream from the discharge opening 16. The pipe is set at an inclination to the longitudinal axis 18 at an angle 60 of 60° and is conical over its entire length and is designed to be rectangular in the flow cross section 56. The height of the flow cross section 56 is kept constant over the length of the discharge pipe 44.

The energy recovery device 42 shown in Figs. 15 to 17 is designed with a bent discharge pipe 44, which has after a first section with an angle 60 of 30° to the longitudinal axis 18 a second section with an angle 64 of 75° to the longitudinal axis 18. This second section forms one direction of flow 62 at the associated discharge mouth 48, so that the flow path or direction of flow 62 there, is also set at an inclination at an angle 64 of 75° with respect to the longitudinal axis 18 of the centrifuge drum 12. With such a direction of flow 62, the product discharged is deflected fundamentally transversely to the longitudinal axis 18, but at the same time, is not deflected towards the front wall 14 so sharply that it results in energy losses there due to fluid friction during the discharge.

Finally, with the exemplary embodiments according to Figs. 15 to 21, the discharge pipe 44 there is designed on its exterior wall 66 facing the direction of rotation 36 with an adapted aerodynamic exterior wall shape 68. The exterior wall shape 68 here is such that the wall thickness, starting from the inflow mouth 46, decreases continuously in the direction of flow of the product discharged, as far as the discharge mouth 48. The outside of the exterior wall 66 is thus flatter with respect to the incoming air there in rotation of the centrifuge drum 12 and therefore is designed to be smaller with respect to the flow resistance. At the same time, this form of the wall thickness is advantageous with respect to a great rigidity of the discharge pipe 44 in relation to its weight.

In the exemplary embodiment according to Figs. 18 and 19, this design of a discharge pipe 44 is combined with a continuously tapering inner flow cross section 56 and a continuous arc shape like that in Figs. 3 to 5. The exemplary embodiment according to Figs. 20 and 21 also shows a continuous arc shape of the discharge pipe 44, wherein its flow cross section 56 is kept the same size over the entire flow length. With such a flow cross section profile, blockage of the discharge pipe 44 with product being discharged is additionally prevented.

List of reference numerals

10	solid-bowl screw centrifuge
12	centrifuge drum
14	front wall
16	discharge opening
18	longitudinal axis of the centrifuge drum
20	weir plate
22	weir edge
24	clarified product
26	pond depth
28	energy recovery device according to the prior art
30	discharge channel according to the prior art
32	bottom surface according to the prior art
34	deflecting surface according to the prior art
36	direction of rotation
38	inflow direction of the clarified product (axially)
40	discharge direction of the clarified product (tangentially)
42	energy recovery device according to the invention
44	discharge pipe
46	inflow mouth
48	discharge mouth
50	straight flow path in a side view
52	tangential direction
54	angle between tangential direction and flat flow path in a side view
56	flow cross section
58	straight flow path in a longitudinal section
60	angle between longitudinal axis and flat flow path in a longitudinal section
62	direction of flow at the discharge mouth

64	angle between the longitudinal axis and the direction of flow at the discharge mouth
66	exterior wall of the discharge pipe facing in the direction of rotation
68	aerodynamic exterior wall shape

Dekantercentrifuge med en energigenvindingsenhed

Patentkrav

1. Dekantercentrifuge (10) med en centrifugetromle (12) som i drift kan rotere om en længdeakse (18), og på hvis endeflade (14) der er mindst en udløbsåbning (16) til udstrømning af dekanteret materiale (24) fra centrifugetromlen (12), hvilken udstrømningsåbning er forsynet med en stemmekant (22), som begrænser udstrømningsåbningen (16) radialt udadtil, og en energigenvindingsindretning (28; 42) til genvinding af energi fra det udstrømmende dekanterede materiale (24), hvilken indretning er udformet som et udløbsrør (44), der gennemstrømmes af udstrømmende dekanteret materiale (24),
er kendetegnet ved at energigenvindingsindretningen (42), der er udformet som udløbsrør (44), der gennemstrømmes af udstrømmende dekanteret materiale (24), er arrangeret ude foran udstrømningsåbningen (16) med stemmekanten (22).

2. Dekantercentrifuge ifølge krav 1, hvor det udstrømmende dekanterede materiale (24) er omledet med udløbsrøret (44) imod en respektiv omdrejningsretning (36) af centrifugetromlen (12).

3. Dekantercentrifuge ifølge krav 1 eller 2, hvor udløbsrøret (44) har mindst en del med i det væsentlige lige strømningsvej (50), der i forhold til den tangentielle retning (52) ved udløbsåbningen (16) er skrå med en vinkel (54) fra 4 ° til 28 °, fortrinsvis 8 ° radialt indadtil.

4. Dekantercentrifuge ifølge et af kravene 1 til 3, hvor udløbsrøret (44) har mindst en del med i det væsentlige lige strømningsvej (58), der i forhold til centrifugetromlens (12) længdeakse (18) er skrå med en vinkel (60) mellem 45 ° og 85 °, fortrinsvis mellem 55 ° og 65 °.

5. Dekantercentrifuge ifølge et af kravene 1 til 4, hvor udløbsrøret (44) har en udløbsåbning (48) med en strømningsretning (62), som i forhold til

centrifugetromlens (12) længdeakse (18) er skrå med en vinkel (64) mellem 70 ° og 90 °, fortrinsvis mellem 77 ° og 83 °.

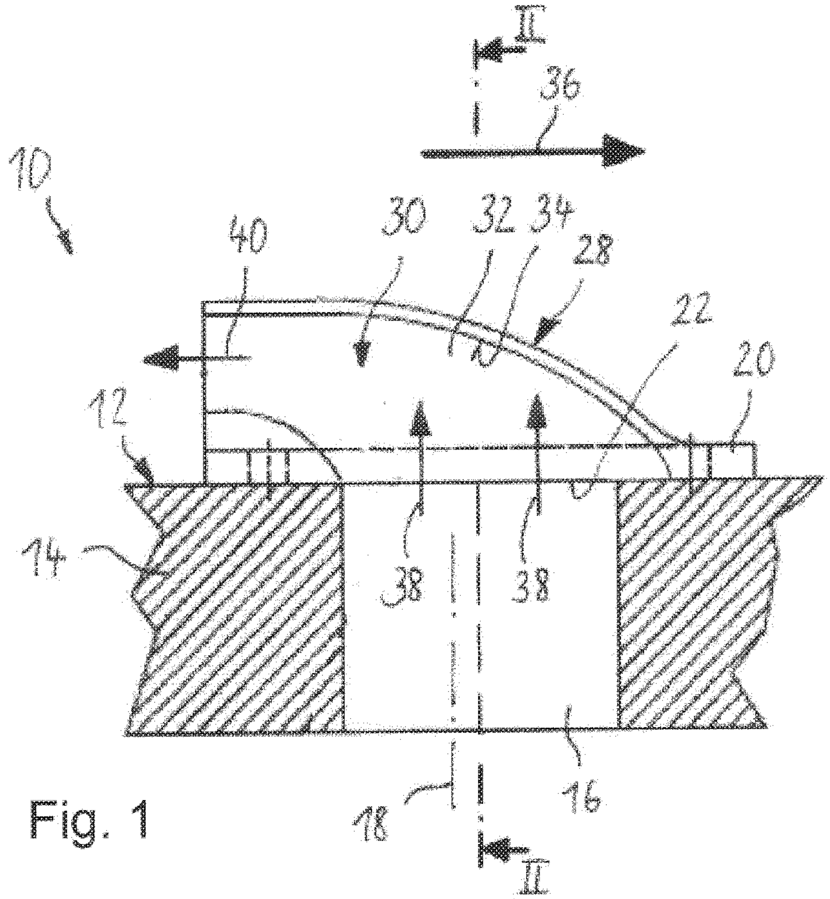
6. Dekantercentrifuge ifølge et af kravene 1 til 5, hvor udløbsrøret (44) i det udstrømmende dekanterede materiales (24) strømningsretning er udformet med konstant stort strømningstværsnit (56).

7. Dekantercentrifuge ifølge et af kravene 1 til 5, udløbsrøret (44) i det udstrømmende dekanterede materiales (24) strømningsretning er udformet med aftagende, især konisk tilspidsende strømningstværsnit (56).

8. Dekantercentrifuge ifølge et af kravene 1 til 7, hvor udløbsrøret (44) er udformet med et rundt, især cirkulært eller elliptisk strømningstværsnit (56).

9. Dekantercentrifuge ifølge et af kravene 1 til 7, hvor udløbsrøret (44) er udformet med et rektangulært, især kvadratisk strømningstværsnit (56).

10. Dekantercentrifuge ifølge et af kravene 1 til 9, hvor udløbsrøret (44) ved sin ydervæg (66), som vender i rotationsretningen (36), har en tilpasset aerodynamisk ydervægform (68).



II
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Fig. 1

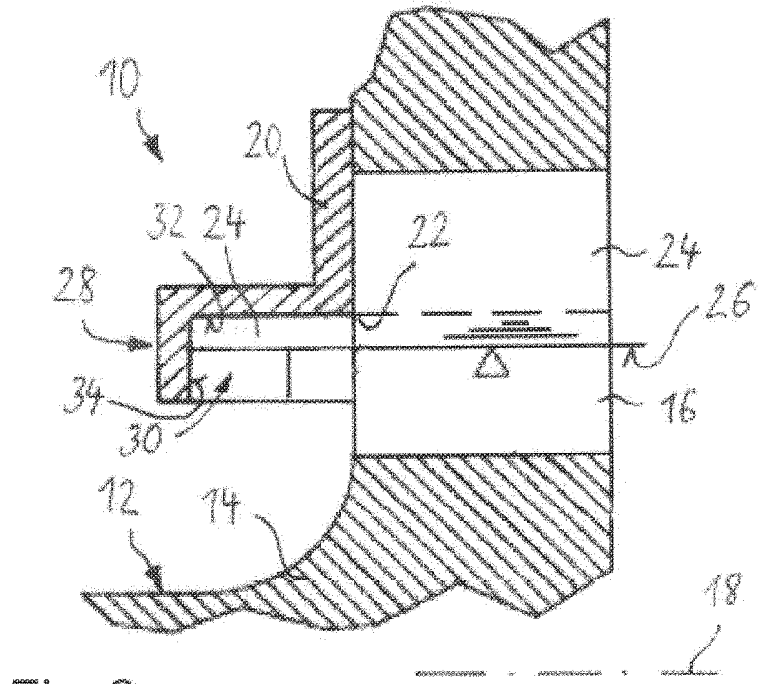

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Fig. 2

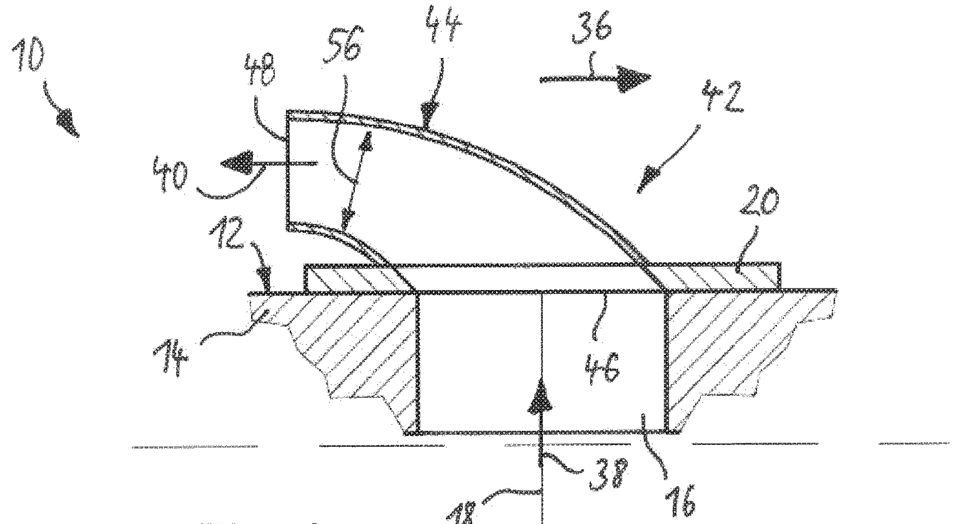
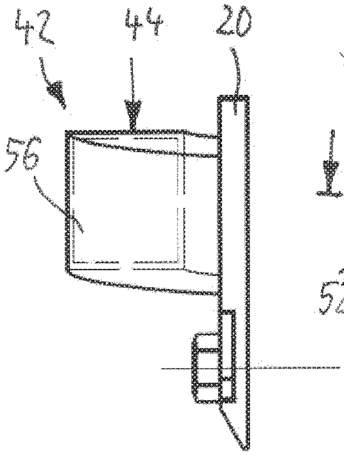


Fig. 4



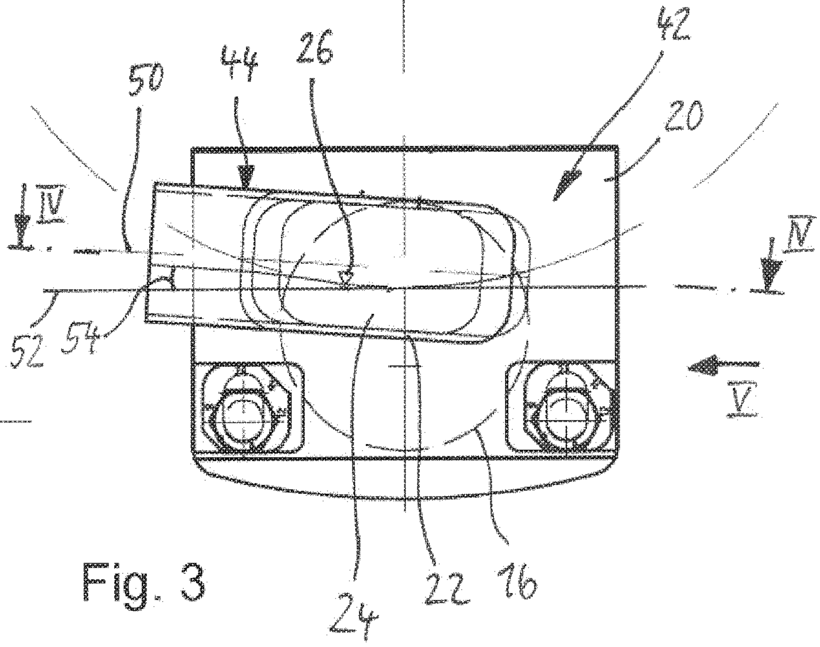


Fig. 5

Fig. 3

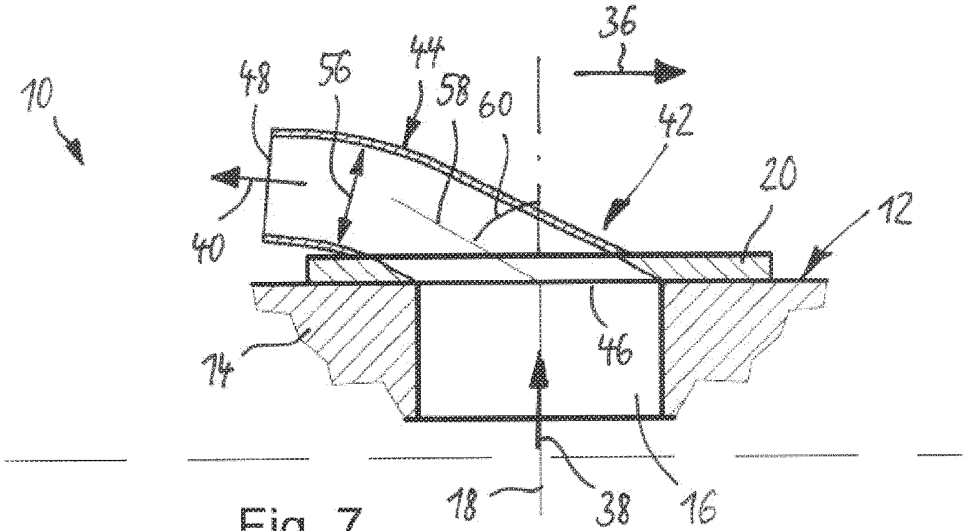


Fig. 7

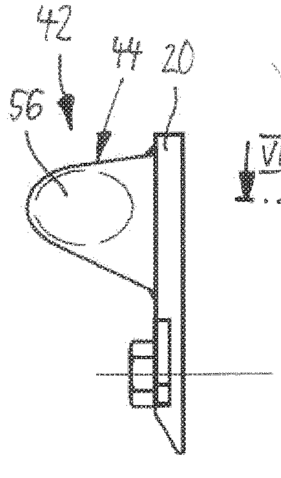


Fig. 8

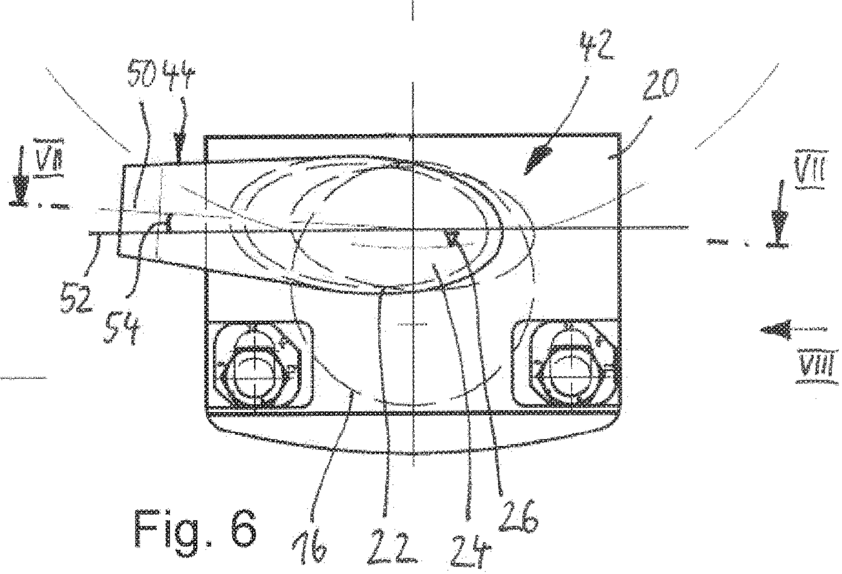


Fig. 6

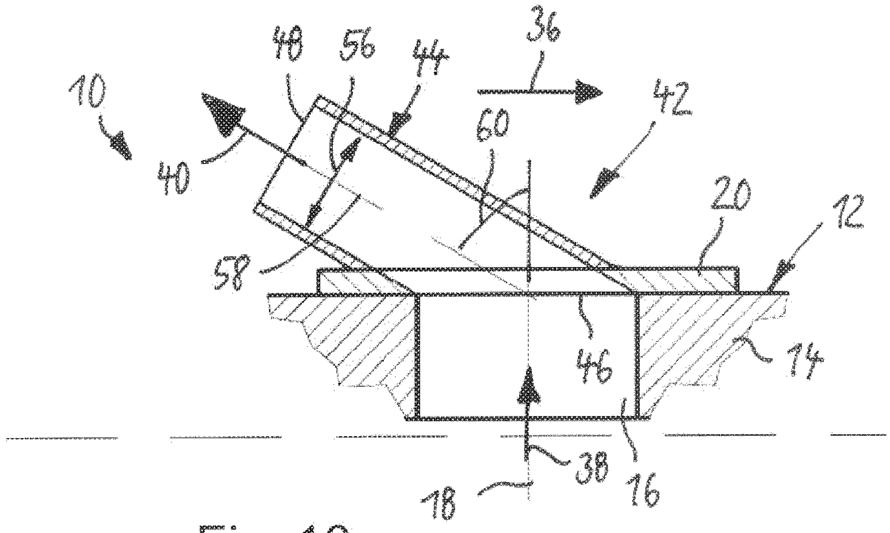


Fig. 10

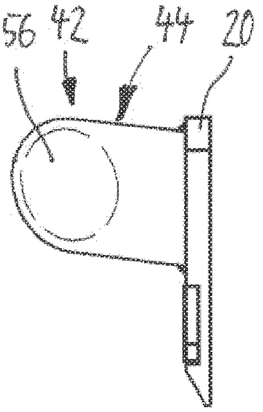


Fig. 11

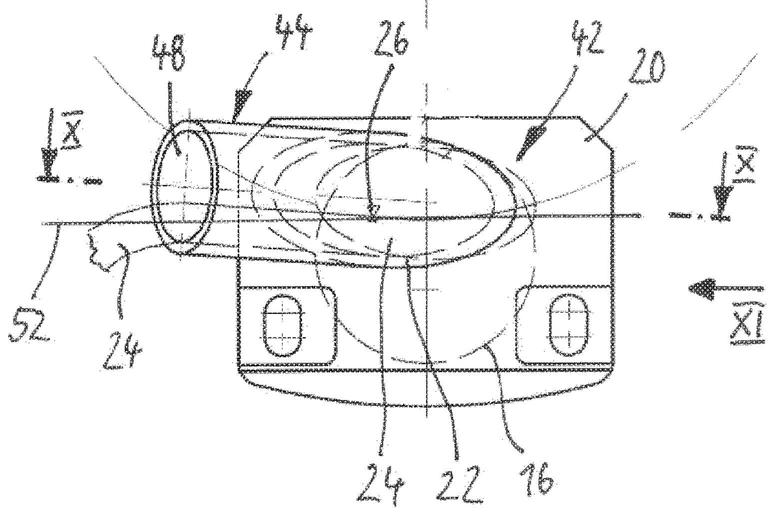


Fig. 9

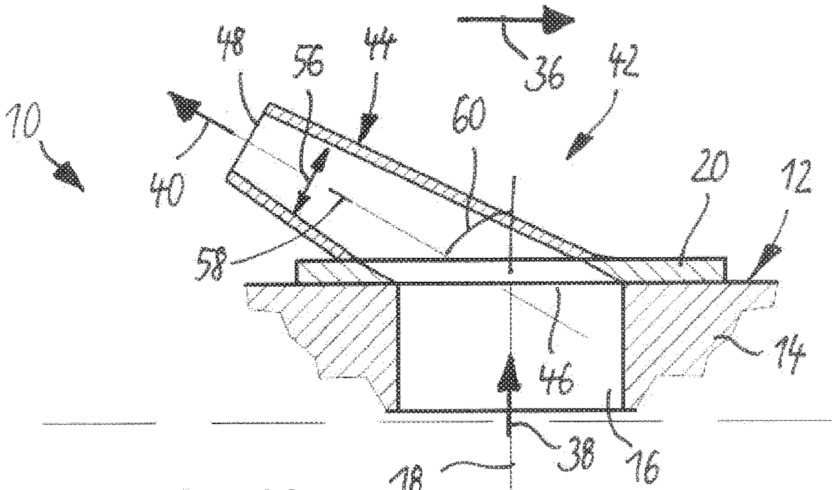
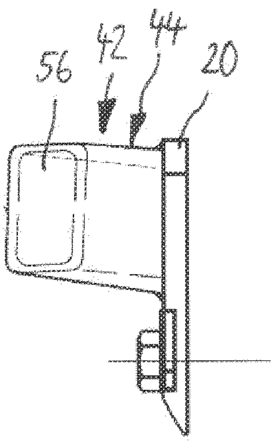


Fig. 13



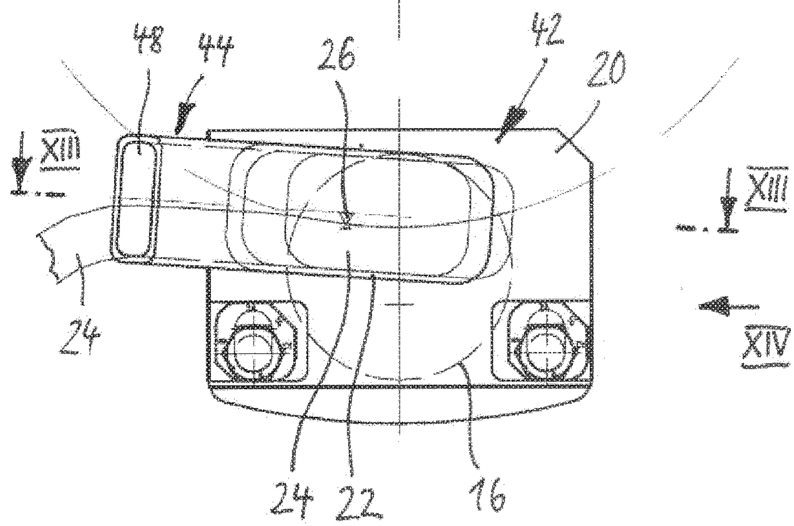


Fig. 14

Fig. 12

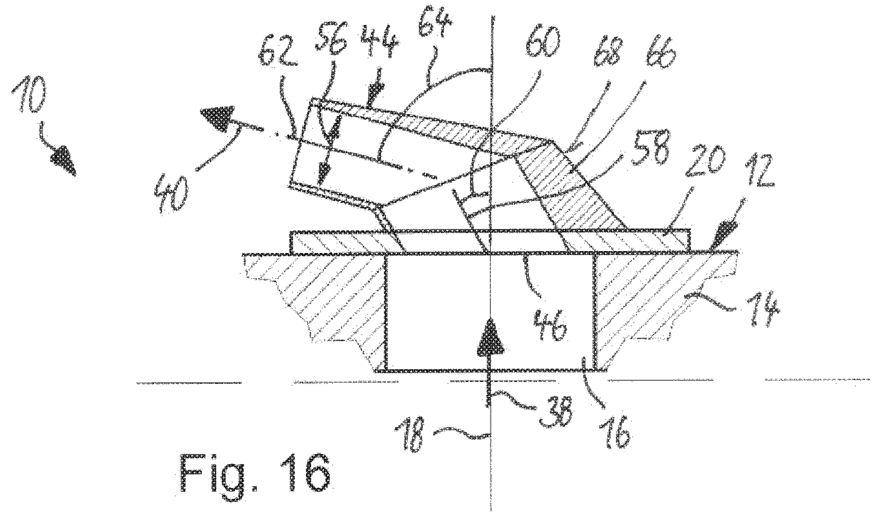


Fig. 16

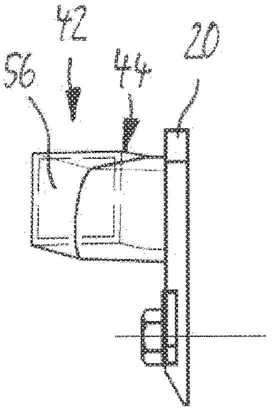


Fig. 17

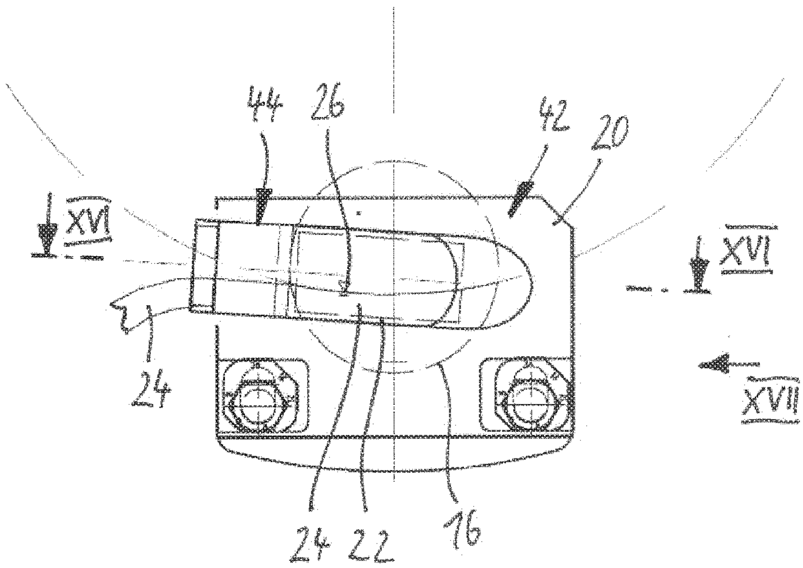
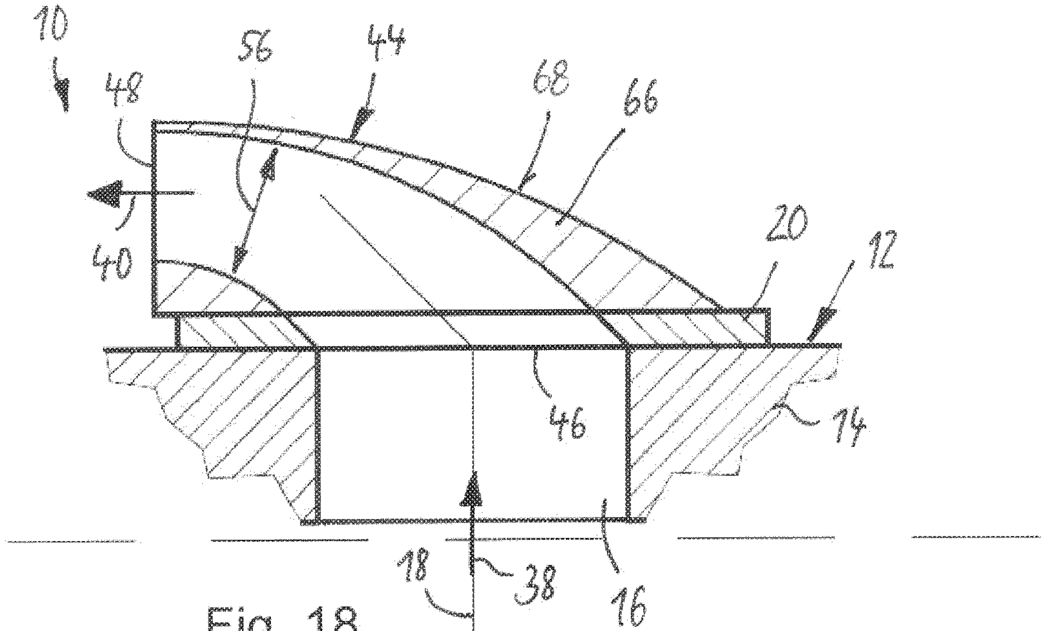


Fig. 15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56
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40
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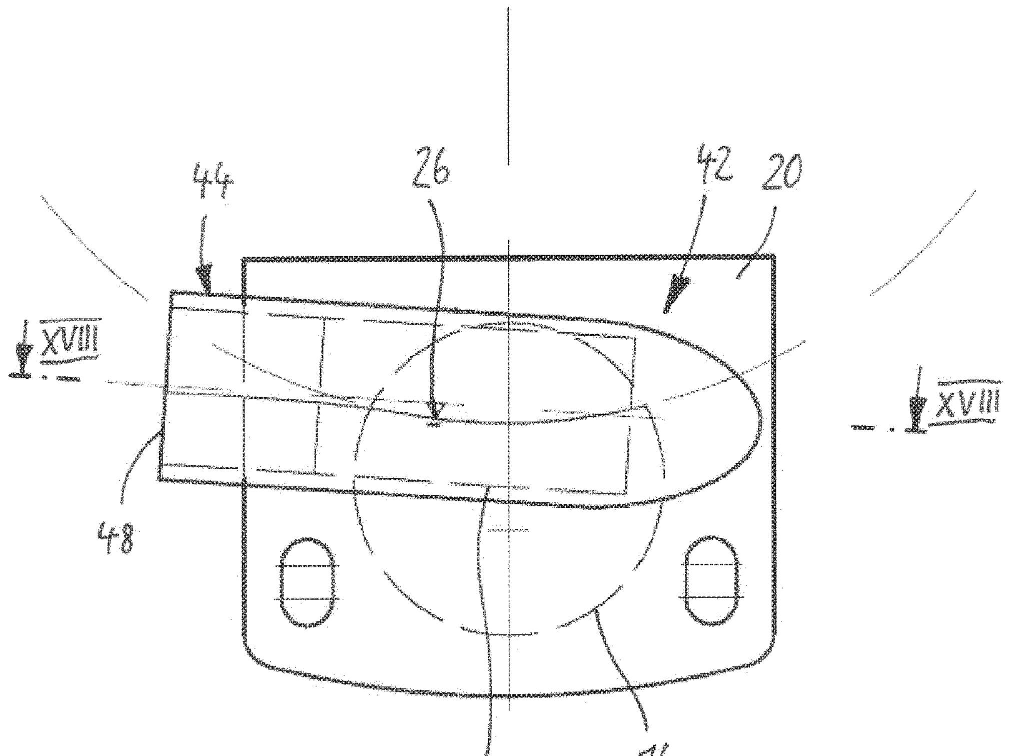
12
46
14
18
38
16

Fig. 18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XVIII
XVIII
48
22
16

Fig. 19

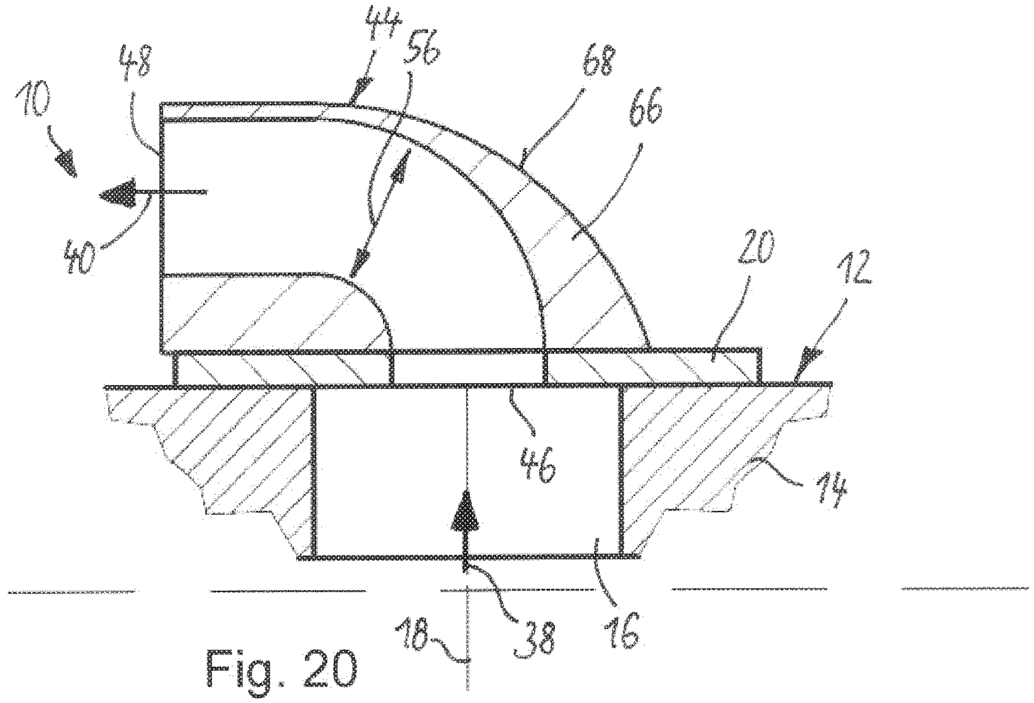

Fig. 20

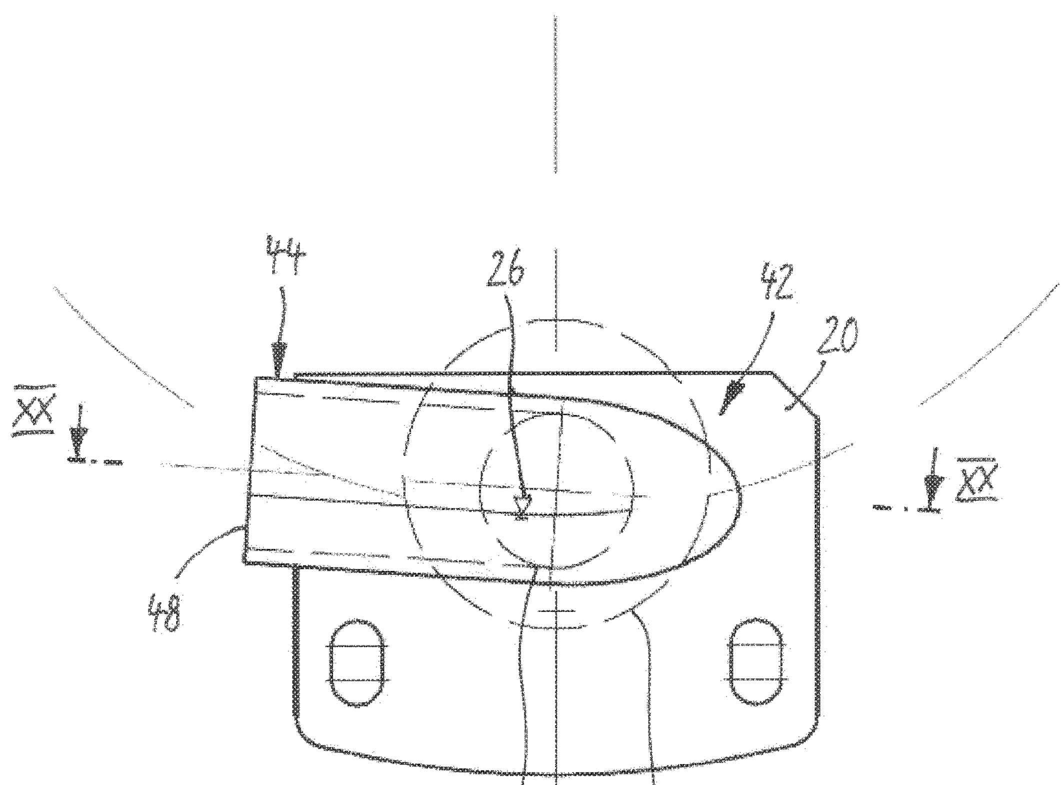

Fig. 21