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[0001] The invention relates to a closure element for a valve device according to the preamble of claim 1.

[0002] From the DE 10 2012 211 926 A1, a valve is known in which a first bellows is provided in a first valve area which is attached to a valve stem and to a valve housing.

5 A second bellows is provided in a second valve area which is attached to the valve stem and to the valve housing.

[0003] From the DE 10 2013 215 294 a diaphragm arrangement with two diaphragm elements is known, wherein the two diaphragm elements abut each other in such a way that in the abutment portion, the diaphragm elements can move relative each other.

10 [0004] The DE 87 09 978 U1 discloses an outlet valve for brewing water. The separating diaphragm designed as a rolling diaphragm and the valve disk integrated therein are designed so that the working area of the rolling diaphragm in the opening direction is smaller than the working area of the valve disk which is effective in the closing direction.

15 [0005] DE 33 27 589 A1 discloses a solenoid valve. In this the surfaces acted upon by the medium pressure act on the valve plate and on the diaphragm, so that depending on the media pressure force component arises acting in the closing direction, i.e. supporting the force of a helical compression spring.

20 [0006] EP 1 596 109 A1 discloses a solenoid valve for liquid media, in particular hot water. A valve chamber is sealed against a magnet system by a separation diaphragm. The separation diaphragm extends from its outer edge, which is connected to the housing, at the level of an inlet of an inflow channel in a uniform and in the same direction downward curvature toward the valve stem.

25 [0007] Furthermore, it is known that in particular the necessary drive energy for closing a valve device in continuous operation is very high.

[0008] The problem underlying the invention is solved by a closure element according to claim 1. Advantageous developments are specified in the sub claims. Features which are important for the invention can also be found in the following description and in the drawings, wherein the features, both alone and in different combinations, can be important for the invention, without being explicitly referred to again.

30 [0009] By the fact that a diaphragm portion and an intermediate portion of the closure element are coordinated so that a pressure in an inflow section supports the closure

element when remaining in a closed position, it can be advantageously achieved that even at high pressure differences between the inflow section and a drain section only very low driving forces are required to move the closure element. Thus, the pressure of the medium advantageously supports the drive when closing the valve device. Also, the required space can be reduced because smaller drives can be installed to move the closure element. Further, the flow is better adjustable.

[0010] Other features, applications and advantages of the invention will become apparent from the following description of embodiments of the invention, which are illustrated in the figures of the drawing. All described or illustrated features, alone or in any combination thereof are inventive subject matter, regardless of their summary in the claims or their dependency and regardless of their formulation or representation in the description or in the drawing. The same reference numbers are used for functionally equivalent quantities and features in all figures, also in different embodiments.

[0011] FIG. 1 shows a valve device 2 with a closure element 6 arranged in a valve body 4. The valve body 4 is closed by a valve cover 5. The closure element 6 is shown in a closed position in which the closure element 6 presses in a feed direction 10 onto a valve seat 8 and thus separates an inflow section 12 from an outflow section 14, whereby the valve device 2 is closed. Opposite to the feed direction 10, a valve drive (not shown) is arranged.

[0012] The closure element 6 has a diaphragm section 16 which is received radially outwardly between the valve body 4 and a fastening element 18. The diaphragm portion 16 is formed substantially torus section formed. A plate spring 20 presses onto the fastening element 18 and thus on a radially outer mounting region of the diaphragm portion 16 to provide a bias of the outer mounting region and to compensate for other tolerances and length expansions with temperature changes.

Furthermore, the fastening element 18 comprises an outer abutment region 22, against which the diaphragm section 16 rests at least partially, in particular when the closure element 6 is open. In the feed direction 10, the closure element 6 comprises a closing portion 24, which is designed in particular for abutment against the valve seat 8.

Opposite to the feed direction 10, the closure element 6 is connected to a drive rod 26. The drive rod 26 provides an inner abutment region 28 against which the diaphragm portion 16 at least partially rests, in particular in a closed position of the closure

element 6.

[0013] In the closed condition of the valve device 2, a first pressure p1 prevails in the inflow section 12, which acts on the valve body. A second pressure p2 prevails in the outflow section 14.

[0014] An optional compression spring 30 presses via the drive rod 26 onto the closure element 6 and thus acts opposite to the second pressure p2, which acts in the closed position of the valve device 2 via the closing portion 24 against the feed direction 10.

[0015] The closure element 6 is designed such that a force F1 acting on the closure element 6 by the pressure p1 in the feed direction 10 is greater than a force F2 acting on the closure element 6 by the pressure p1 against the feed direction 10. This assists in closing the valve seat 8 with little force to be used for the valve drive. By means of an increase in a spring force of the compression spring 30, the valve device 2 can be adapted to a correspondingly high pressure p2 in the discharge section 14, without the geometry of the closure element 6 having to be adapted.

[0016] Figure 2 shows a variant of the valve device 2 without inner diaphragm support as shown in Figure 1 by the abutment area 28. The diaphragm section 16 merges into a center section 32 of the closure element 6 in a circular ring section A1 oriented perpendicular to the feed direction 10 with a diaphragm thickness y3.

[0017] The diaphragm section 16 has an outer radius of curvature R1 and an inner radius of curvature R2 with a common annular axis 34 about a central longitudinal axis 36 of the closure element 6 between the central section 32 and the radially outer attachment. A diaphragm thickness y3 results from the subtraction of the inner radius of curvature R2 from the outer radius of curvature R1. Of course, the diaphragm section 16 may have a varying diaphragm thickness in its radial course. A mean radius of curvature r results from Equation 1.

$$r = (R1 + R2) / 2 \quad (1)$$

[0018] At a pressure p1 in the inflow section 12, a tangential stress St is formed in the diaphragm section 16, which results from equation 2 in accordance with the so-called boiler formula according to DIN 2413. Of course, instead of the mean radius of curvature r, one of the radii R1 or R2 in Equation 2 can also be used.

$$St = (p1 * r) / y3 \quad (2)$$

[0019] The tangential stress St engages against the feed direction 10 via the circular ring cut surface A1 at the intermediate section 32. The force F2 against the infeed

direction 10 results according to equation (3).

$$F2 = St * A1 \quad (3)$$

[0020] An annular surface area A2 of the center section 32 of the closure element 6, which is effective hydraulically in the feed direction 10, results approximately by way of example according to equation 4.

$$A2 = PI * (((x5+x4) / 2)^2 - (x2)^2) / 4 \quad (4)$$

[0021] Consequently, the force F1 results in the feed direction according to equation (5).

$$F1 = p1 * A2 \quad (5)$$

[0022] The geometry of the closure element 6 supports the holding of the closed position shown in that the force F1 acting in the feed direction 10 is greater than the force F2 acting counter to the feed direction 10. Equations 2, 3 and 5 give inequalities 6.1 to 6.3.

$$p1 * A2 > St * A1 \quad (6.1)$$

$$p1 * A2 > ((p1 * r) / y3) * A1 \quad (6.2)$$

$$A2 / A1 > r / y3 \quad (6.3)$$

[0023] In accordance with inequality 6.3, a first ratio of the surface A2 acting hydraulically in the feed direction 10 onto the sectional area A1 of the diaphragm section 16 acting hydraulically counter to the feed direction 10 is greater than a second ratio of the mean radius of curvature r of the diaphragm section 16 to the wall thickness y3 of the diaphragm section 16. Hereby it is ensured that the pressure p1 supports the closing of the closure element 6 in the closed position in the direction of the valve seat 8.

[0024] The diameter x4 of the intermediate section 32 is greater than the distance y1 between the regions of the diaphragm section 16 oriented furthest opposite to the feed direction 10.

[0025] FIG. 3 shows an embodiment of the valve device 2 in which the drive rod 26 has the inner contact section 28. Thus, the tangential stress St acts within the diaphragm section 16 in a ring section surface A3. The ring section A3 lies in the cross section shown in FIG. 3 perpendicular to a course of the diaphragm section 16 in a plane 38, wherein the plane 38 adjoins the end of the inner contact section 28 oriented opposite to the feed direction 10.

[0026] A force F_m generated by the tangential stress St in the diaphragm section on the ring interface A_3 can be converted by means of an leading-in angle α according to equation 7 into a force F_2^* opposite to the feed direction 10. The leading-in angle α is between a tangential according to the course of the diaphragm portion

$$F_2^* = F_m * \sin \alpha \quad (7)$$

[0027] The force F_m , on the other hand, results from equation 8.

$$F_m = St * A_3 \quad (8)$$

[0028] Of course, equations 7 and 8 can also be applied to the case of FIG. 2, wherein the leading-in angle α has a value of 90° .

[0029] The geometry of the closure element 6 supports the holding of the closed position shown in that the force F_1 acting in the feed direction 10 is greater than the force F_2^* acting counter to the feed direction 10. With the equations 2, 7 and 8, the inequalities 9.1 to 9.3 result.

$$p_1 * A_2 > St * A_3 * \sin \alpha \quad (9.1)$$

$$p_1 * A_2 > ((p_1 * r) / y_3) * A_3 * \sin \alpha \quad (9.2)$$

$$A_2 / (A_3 * \sin \alpha) > r / y_3 \quad (9.3)$$

[0030] In accordance with inequality 9.3, a first ratio of the surface A_2 acting hydraulically in the feed direction 10 to the surface ($A_3 * \sin \alpha$) of the diaphragm section 16 acting hydraulically counter to the feed direction 10 is greater than a second ratio of the mean radius of curvature r of the diaphragm section 16 to the wall thickness y_3 of the diaphragm section 16. This ensures that the pressure p_1 supports the closing of the closure element 6 in the closed position in the direction of the valve seat 8.

[0031] An annular surface A_4 , which is hydraulically counter to the feed direction 10 and which results from abutment of the diaphragm section 16 on the abutment region 28 generates a force F_3 which, like the force F_2^* , is oriented counter to the feed direction 10. The annular area A_4 results according to equation 10 and the force component F_3 is given by equation 11.

$$A_4 = \pi * ((x_3)^2 - (x_2)^2) / 4 \quad (10)$$

$$F_3 = p_1 * A_4 \quad (11)$$

[0032] The geometry of the closure element 6 supports the holding of the closed position shown in that the force F_1 acting in the feed direction 10 is greater than the

forces F_2^* and F_3 acting counter to the feed direction 10. With the equations 2, 7, 10 and 1, the inequalities 12.1 to 12.8 result.

$$F_1 > F_2^* + F_3$$

$$p_1 \cdot A_2 > (St \cdot A_3 \cdot \sin \alpha) + p_1 \cdot A_4 \quad (12.1)$$

$$p_1 \cdot A_2 > ((p_1 \cdot r) / y_3) \cdot A_3 \cdot \sin \alpha + (p_1 \cdot A_4)$$

$$(12.2)$$

$$A_2 > (r / y_3) \cdot A_3 \cdot \sin \alpha + A_4 \quad (12.3)$$

$$A_2 / (A_3 \cdot A_4) > ((r / y_3) \cdot \sin \alpha) / A_4 + (1/A_3)$$

$$(12.4)$$

$$A_2 / (A_3 \cdot A_4) - (1/A_3) > ((r / y_3) \cdot \sin \alpha) / A_4$$

$$(12.5)$$

$$(A_2 \cdot A_4) / ((A_3 \cdot A_4) - (A_4/A_3) > r / y_3) \cdot \sin \alpha$$

$$(12.6)$$

10

$$(A_2 - A_4) / A_3 > (r / y_3) \cdot \sin \alpha$$

$$(12.7)$$

$$(A_2 - A_4) / (A_3 \cdot \sin \alpha) > (r / y_3)$$

$$(12.8)$$

[0033] According to inequality 12.8, a first ratio of the surface A_2 acting hydraulically in the feed direction 10 less the surface A_4 acting hydraulically counter to the feed direction 10 to the surface $(A_3 \cdot \sin \alpha)$ of the diaphragm section 16 acting hydraulically counter to the feed direction 10 is greater than a second ratio of the mean curvature radius r of the diaphragm portion 16 to the wall thickness y_3 of the diaphragm portion 16. This ensures that the pressure p_1 supports the closing of the closure element 6 in the closed position in the direction of the valve seat 8.

15

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[0034] An annular surface A_5 with respect to the diaphragm portion 16 is given by Equation 13. Instead of the diameter x_2 also the diameter x_3 can be used, as far as it is a question of a supported diaphragm portion 16.

$$A_5 = \pi \cdot ((x_1)^2 - (x_2)^2) / 4 \quad (13)$$

25

[0035] A third ratio of an area A_2 which acts hydraulically in the direction of the closing section 24 to a surface A_5 of the diaphragm section 16 projected hydraulically

in the opposite direction of the closing section 24 corresponds, according to the equation 14, to a factor f which lies between 0.2 and 0.6. The factor f is preferably in a range between 0.4 and 0.6. As a result, a geometry of the closure element 6 is achieved, which supports the closing and the closing state of the valve element 2.

5 $A_2 / A_5 = f$ (14)

[0036] At a high back pressure p_2 from the outflow section 14, the force to be applied by the valve drive in the feed direction 10 for closing the valve device 2 would rise.

This increase in the necessary closing force can be compensated by a modular adaptation of the compression spring 10 and/or a compression spring in the valve drive, whereby the desired force window for operating the valve drive is moved.

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P a t e n t k r a v

5 1. Lukkeelement (6) til en ventilindretning (2), hvor lukkeelementet (6) omfatter et mellemafsnit (32), som forløber mellem et lukkeafsnit (24) og et membran-
afsnit (16), og kan anbringes i et tilstrømningsafsnit (12) af ventilindretningen (2), hvor et første forhold mellem en flade (A2), som er hydraulisk virksom i retning mod lukkeafsnittet (24), og en snitflade (A1; A3) af membranafsnittet (16), hvilken snitflade er hydraulisk virksom i modsat retning af lukkeafsnittet (24), er større end et andet forhold mellem en central krumningsradius (r) af
10 membranafsnittet (16) i en lukkeposition af lukkeelementet (6) og en vægtykkelse (y3) af membranafsnittet (16), **kendetegnet ved, at** et forhold mellem en flade (A2), som er hydraulisk virksom i retning mod lukkeafsnittet (24), og en flade (A5) af membranafsnittet (16), hvilken flade er hydraulisk projiceret i modsat retning af lukkeafsnittet (24), ligger mellem 0,2 og 0,6.

15

2. Lukkeelement (6) ifølge krav 1, hvor mellemafsnittet (32) omfatter fladen (A2), som er hydraulisk virksom i retning mod lukkeafsnittet (24), og hvor mellemafsnittet (32) tilspidses mod tilførringsretningen (10).

20

3. Lukkeelement (6) ifølge krav 1 eller 2, hvor membranafsnittets (16) snitflade (A1), som er hydraulisk virksom i modsat retning af lukkeafsnittet (24), er anbragt ved en grænse mellem mellemafsnittet (32) og membranafsnittet (16).

25

4. Lukkeelement (6) ifølge krav 1 eller 2, hvor membranafsnittets (16) snitflade (A3), som er hydraulisk virksom i modsat retning af lukkeafsnittet (24), ligger inde i membranafsnittet (16) og forløber i et tværsnit i et lodplan (38) af membranafsnittets (18) forløb, og hvor lodplanet (38) forløber i området af en ende af et indvendigt anlægsafsnit (28) af en drivstang (26).

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5. Lukkeelement (6) ifølge et af de foregående krav, hvor lukkeelementets (6) side, som vender mod mediet, har en i det væsentlige jævn overflade.

6. Lukkeelement (6) ifølge et af de foregående krav, hvor lukkeelementet (6) er udført i ét stykke.

35

7. Lukkeelement (6) ifølge et af de foregående krav, hvor lukkeelementet (6) i ikke trykbelastet tilstand og/eller ikke trækbelastet tilstand indtager i det væsentlige lukkepositionen.

5 **8.** Lukkeelement (6) ifølge et af de foregående krav, hvor forholdet mellem fladen (A2), som er hydraulisk virksom i retning mod lukkeafsnittet (24), og membranafsnittets (16) flade (A5), som er hydraulisk projiceret i modsat retning af lukkeafsnittet (24), ligger mellem 0,4 og 0,6.

10 **9.** Ventilindretning (2) til blokering og/eller påvirkning af en gennemstrømning af en fluid, der strømmer gennem ventilindretningen (2), omfattende et ventilelement (6) ifølge et af de foregående krav.

15 **10.** Ventilindretning (6) ifølge det foregående krav, hvor en trykfjeder (30) er anbragt mellem et ventillegeme (4) og en drivstang (26) til trykpåvirkning af lukkeelementet (6) i tilførselsretning (10).

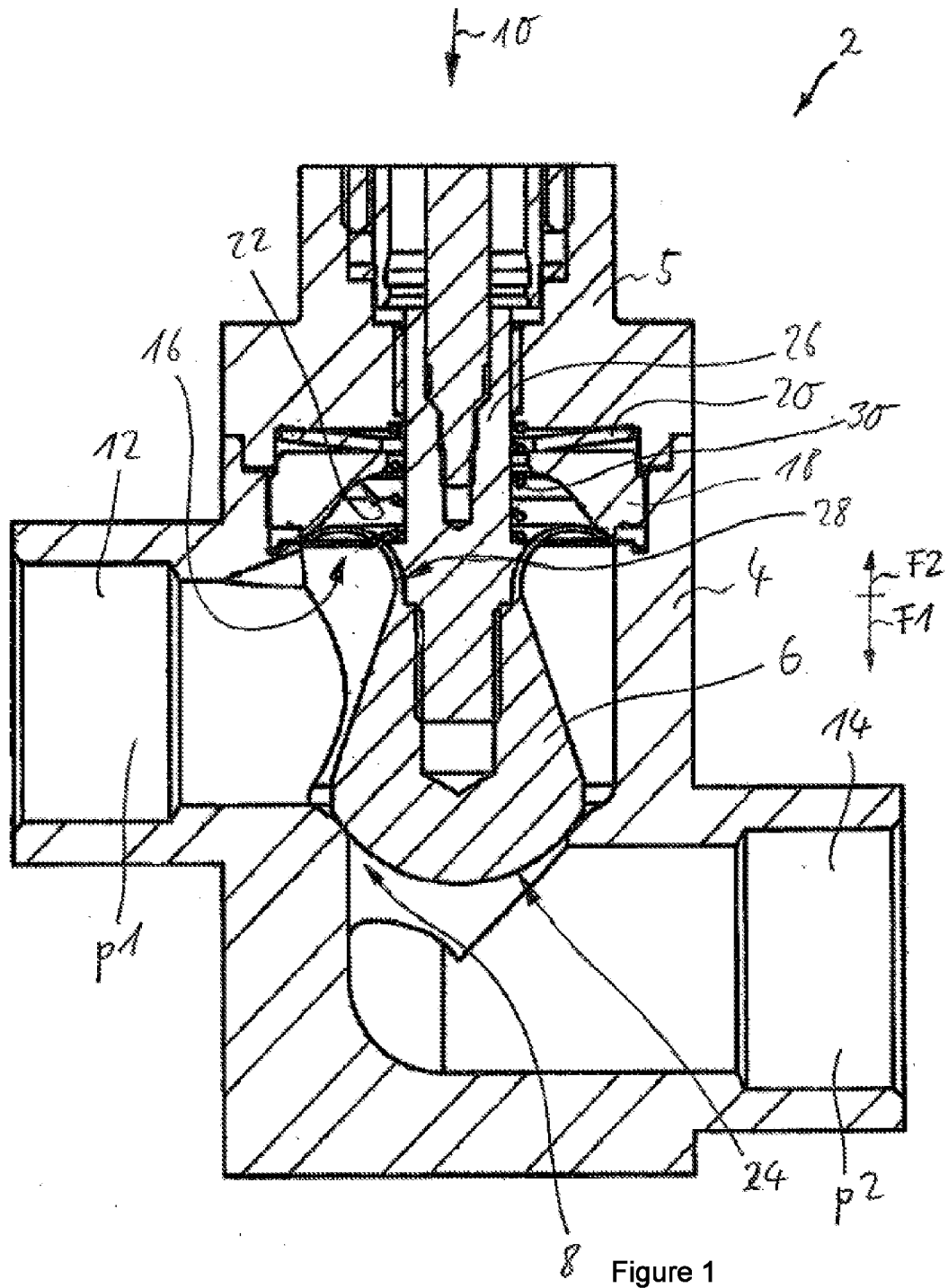
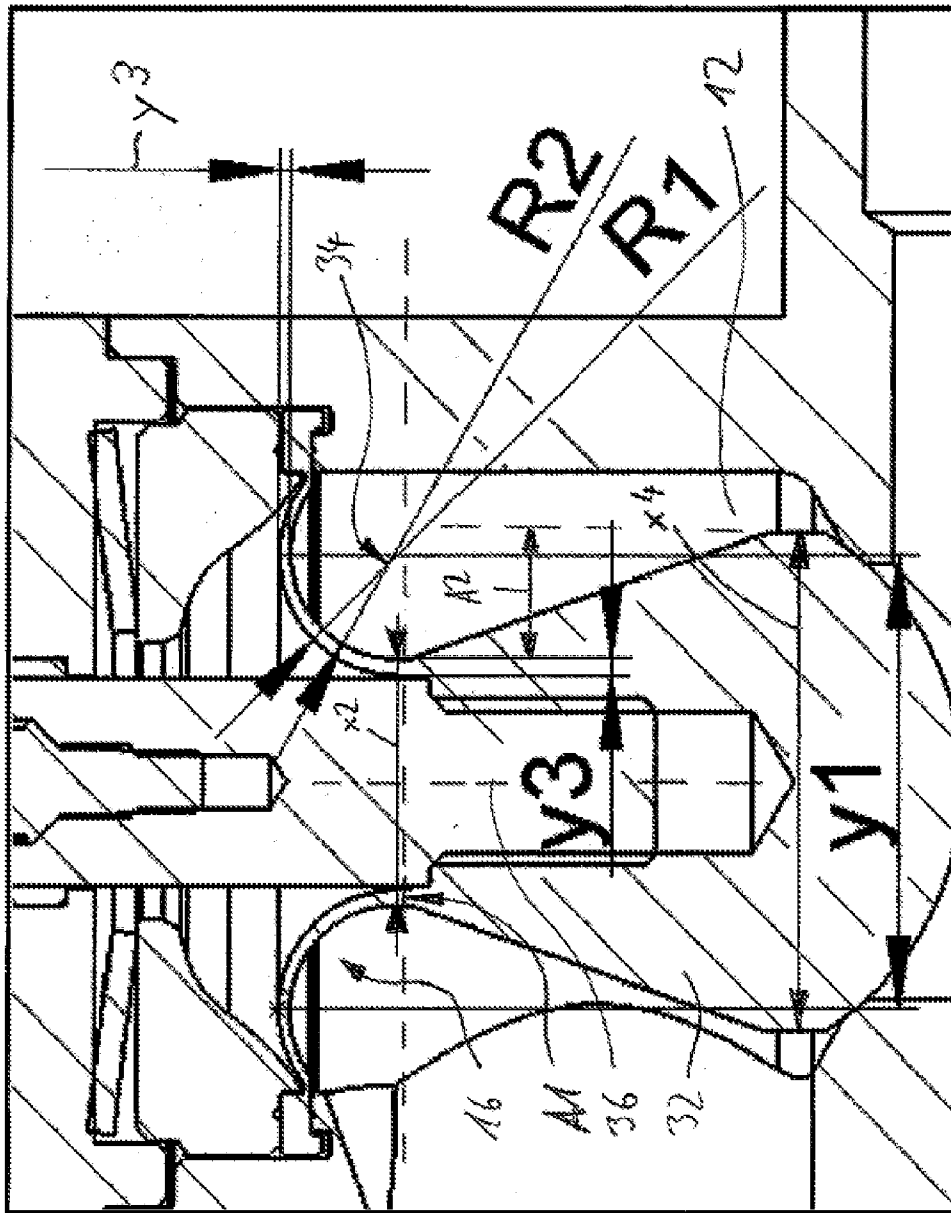


Figure 2



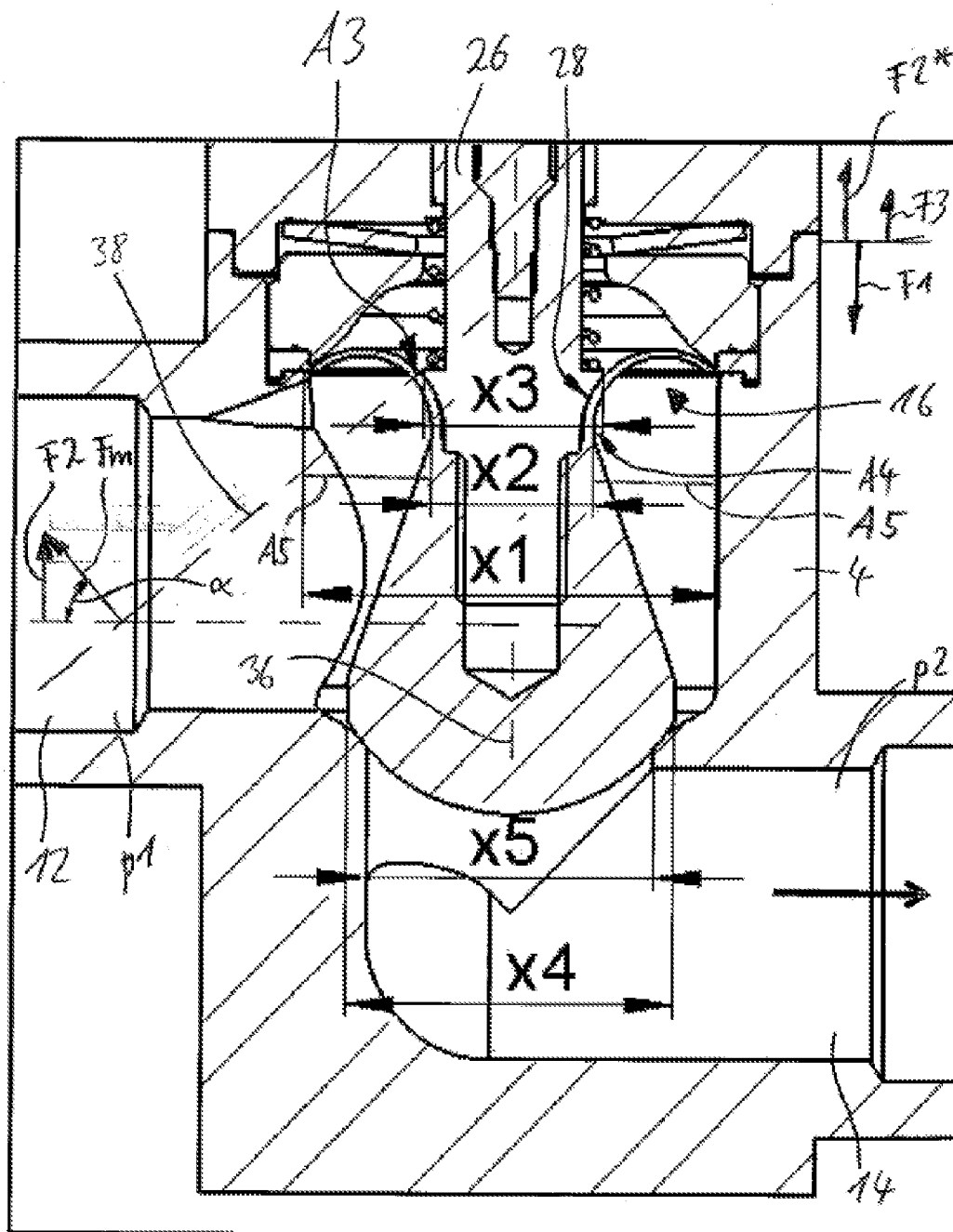


Figure 3