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(54) **INTERNAL GEAR PUMP THAT DOES NOT CONTAIN ANY FILLER ELEMENTS**

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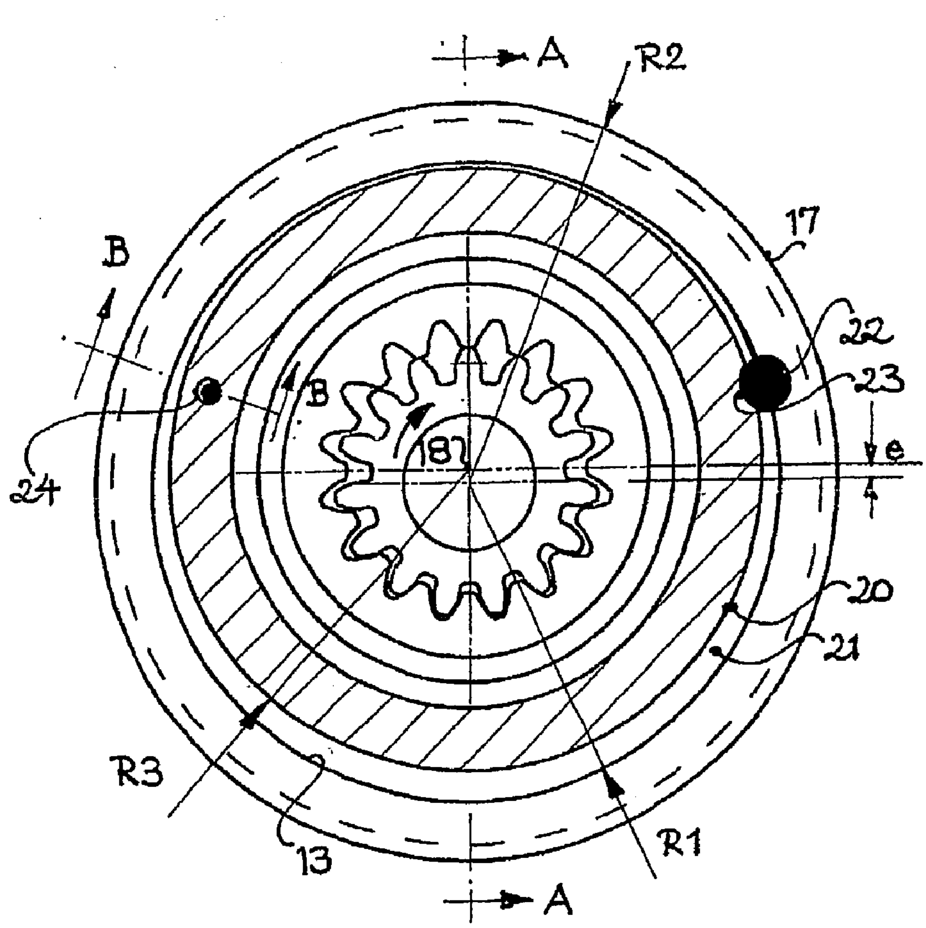
(57) **ABSTRACT**

An internal gear pump that does not contain any filler elements comprises a housing **(1)** and a bearing ring **(5)**, which is accommodated inside a recess **(13)** of the housing in a manner that permits it to transversally move in relation to its axis but not to rotate. The internal gear pump also comprises an internal-geared ring gear **(3)**, which is mounted inside the bearing ring in a manner that permits it to revolve, and a pinion **(2)**, which is mounted inside the housing in a manner that permits it to rotate and which meshes with said ring gear. The inner peripheral surface of the housing recess **(13)** coaxially extends in relation to the pinion **(2)**, and the bearing ring, which is eccentrically arranged with regard to the pinion axis **(15)**, can pivot in relation to the housing recess about a parallel pivotal axis **(22, 23)** that is parallel to the axis thereof. The bearing ring can pivot without the tight contact between the tooth tips of the pinion **(2)** and ring gear **(3)** being lost. The inner peripheral surface of the bearing ring **(5)** that forms the bearing surface for the ring gear **(3)** coaxially extends in relation to its outer peripheral surface **(20)**, and the pivotal path of the bearing ring is delimited to a pre-designated measure by a pin **(25)**, which passes therethrough or which is arranged in the sickle-shaped gap **(21)**, or by a projecting step located inside this gap.



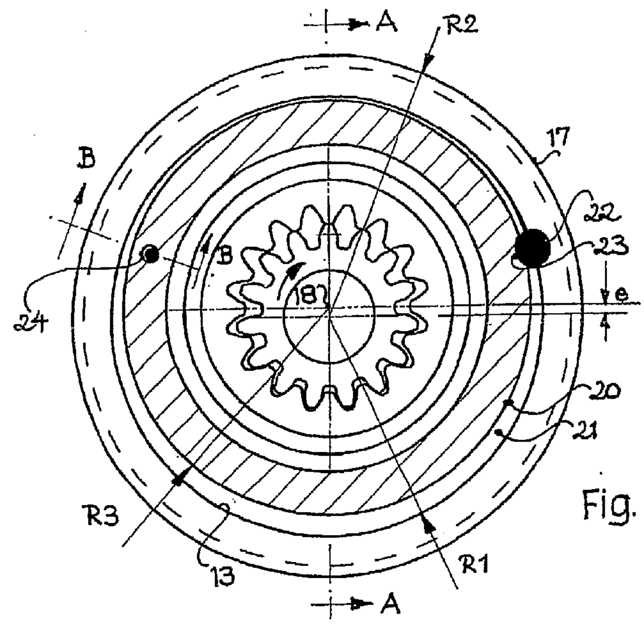



Fig. 1

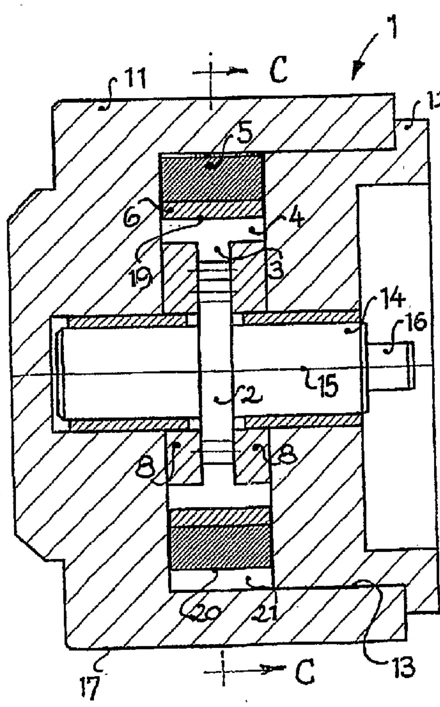



Fig. 2

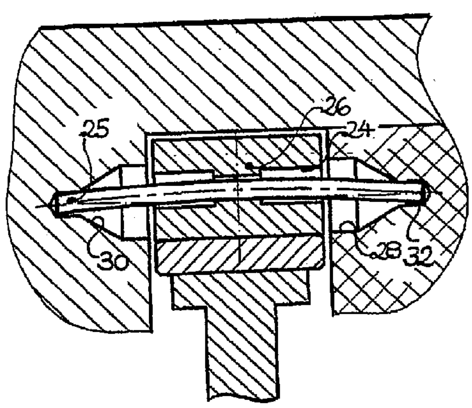



Fig. 3

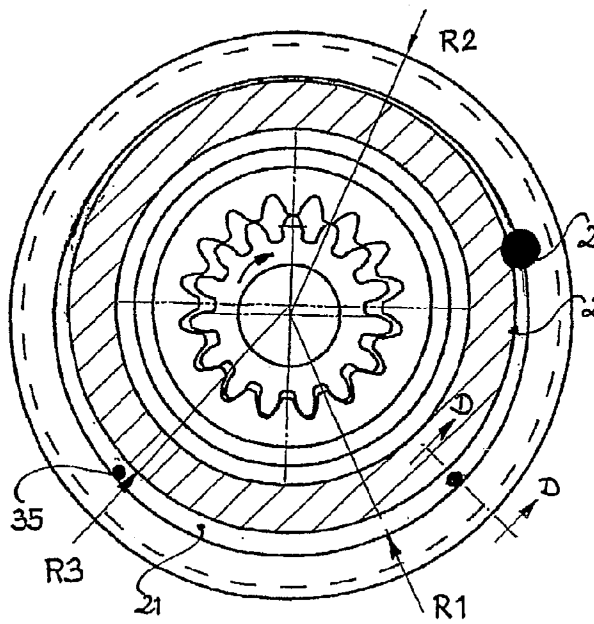



Fig. 4

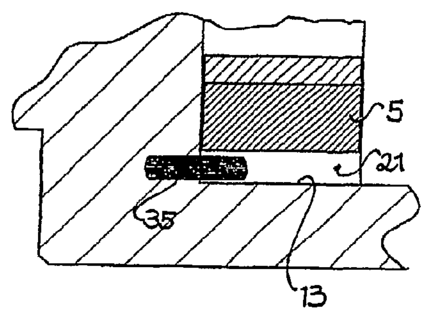



Fig. 5

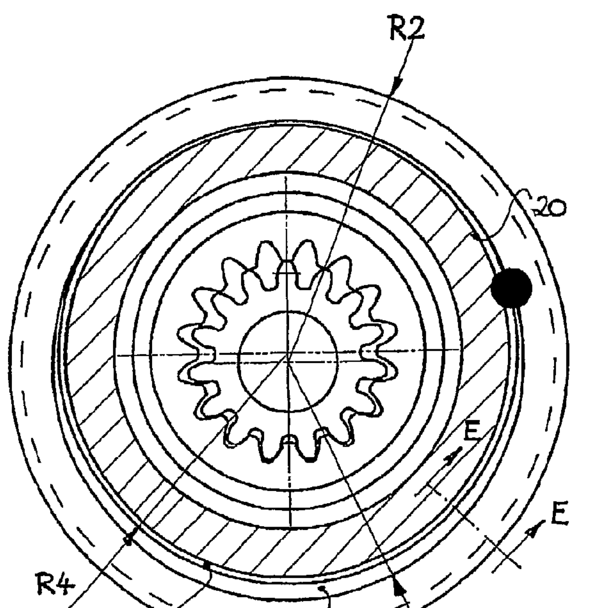



Fig. 6

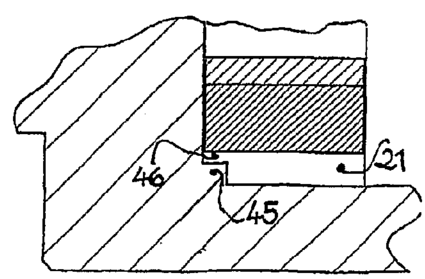



Fig. 7

## INTERNAL GEAR PUMP THAT DOES NOT CONTAIN ANY FILLER ELEMENTS

[0001] The invention relates to an internal gear pump with the characteristics according to the preamble of claim 1.

[0002] An internal gear machine of this type is known (U.S. Pat. No. 3,034,446). There, the inner peripheral surface of the recess of the housing in which the pinion/internal-geared ring gear/bearing ring unit is housed, is structured to be cylindrical and coaxial to the two bearing bores for the pinion, and therefore to the latter itself. Since the internal-geared ring gear must be mounted eccentric to the pinion, the inner peripheral surface of the bearing ring, which forms the bearing surface for the internal-geared ring gear, also lies eccentric to the pinion axis. The outer peripheral surface of the bearing ring, on the other hand, is structured to be eccentric to this bearing surface, so that the bearing ring is mounted to pivot in the housing recess, with a small amount of radial play. The suction space and the pressure space between the gear teeth of the pinion and the internal-geared ring gear are each delimited by housing inserts that lie against the faces of the pinion and the internal-geared ring gear, forming a seal, one of which is screwed onto an outside thread of the pinion shaft, and the other of which is screwed into an inside thread of the housing.

[0003] In terms of production technology, this structure of the housing, the housing inserts, and the bearing ring, with peripheral surfaces that are eccentric to one another, is complicated, because it is very difficult to adhere to the required great precision in production, which is particularly necessary at higher operating pressures.

[0004] Internal gear pumps that do not contain any filler elements, with a pivoting bearing ring for the internal-geared ring gear, are also known, whose bearing surface and outer peripheral surface are concentric to one another, and where the bearing ring is held in the housing recess with a small amount of radial play (EP-A 848 165). However, this structure of the bearing ring brings with it that the inner peripheral surface of the housing recess lies coaxial to the axis of the internal-geared ring gear, and consequently eccentric to the bearing structure of the pinion shaft. Taking this axis offset into consideration in the separate housing parts that contain the bearing structure of the pinion shaft is also complicated.

[0005] In the region of the gear teeth where these do not engage, where only the tooth tips are in contact with one another, the stress and therefore the wear is relatively the greatest, because of the small amount of contact surface. If, furthermore, the gearing between the pinion and the internal-geared ring gear is an involute gearing, as in the exemplary embodiments of EP-A 848 165, the teeth are only in reciprocal sealing contact with their flanks in the region of full engagement, and with their tooth tips in the region without engagement. In the remaining part of the suction space and the pressure space, the teeth are moved apart to such an extent that essentially the same pressure prevails over the suction space and the pressure space, in each instance, and they only come close to one another again in the region without engagement, to produce the sealing contact between the tooth tips. In this connection, the hydraulic pressure forces that prevail in the pressure space act in such a way that their resultant generates a pivotal moment at the bearing ring, with reference to the pivotal axis of the bearing ring, by means of which its segment assigned to the region without engagement, together with the internal-geared ring gear, is pushed radially towards the pinion axis. As a result, the tips of the teeth that come close to one another in the region without engagement run up against one another, whereby they are subject to a combined rolling and sliding process, which results in wear. Therefore it is desirable to limit the sealing contact to a necessary but sufficient measure, at which the wear as described above is minimal.

[0006] It is therefore the task of the invention to lower the production costs of the housing as well as of the bearing ring, without running the risk that the tooth tip wear caused by the sealing contact of the tooth tips against one another in the region of the gearing without engagement becomes excessive.

[0007] According to the invention, this task is accomplished by the structure according to claim 1.

[0008] Because the housing recess that holds the pinion/internal-geared ring gear/bearing ring unit runs concentric, i.e. coaxial to the pinion and its bearing bores, the corresponding surfaces can be produced very efficiently and economically by means of lathing operations, in a single chucking. This also holds true for the bearing ring, whose bearing surface is structured concentric to the outer peripheral surface. As a result of the required eccentricity between the pinion and the internal-geared ring gear, however, a non-uniform radial gap, namely a gap increasing in sickle shape, is formed between the bearing ring and the housing recess. Particularly in the case of internal gear machines of the type being discussed here, in which the gearing of the pinion and the internal-geared ring gear is an involute gearing, the teeth are not in sealing contact with one another during the entire revolution, in contrast to trochoid gearing, but instead run apart at first, after full engagement, and only in the region of the gearing that is without engagement do the tooth tips of some teeth touch one another with the required sealing contact. Therefore there is the risk of excessive wear of the tooth tips and thereby a reduced useful lifetime of the machine, if the tooth tips are excessively pressed against one another as a result of the pivotal moment that acts on the bearing ring, proportional to the pressure. According to the invention, this is prevented in that the contact pressure force of the tooth tips against one another can be kept within limits by delimiting the pivotal path of the bearing ring to a predetermined value.

[0009] There are different possibilities available for delimiting the pivotal path: According to one embodiment, a bore that runs approximately parallel to the axis direction of the bearing ring can be provided in the latter, with a pin attached in the housing projecting through this bore with an amount of play that determines the pivotal path. This pin can be structured as a spiral spring that presses the bearing ring in the pivotal direction in the pressure-free state of the internal gear pump, but prevents or hinders the bearing ring from pivoting further when it is released by the predominant hydraulic pressure forces.

[0010] According to another embodiment, a stop pin can project into the sickle-shaped radial gap between the bearing ring and the housing recess, from the bottom of the latter, on which the bearing ring makes contact after a certain pivotal path. The stop pin can be arranged fixed on the housing, e.g.

on the bottom of the housing recess, or fixed on the bearing ring. The pivotal path can be predetermined most precisely, right from the start, if this pin is arranged offset by about 90° with reference to the pivotal axis of the bearing ring. In another embodiment, the pivotal path of the bearing ring can be delimited by a step that projects axially into the sickle-shaped radial gap between the bearing ring and the housing wall, and can be produced within the course of the precision machining of the recess bottom, using a milling tool. Since this bottom is machined centric to the axis of the internal-geared ring gear, to provide sealing contact between the faces of the pinion and the internal-geared ring gear, i.e. corresponding axial plates on them, the said step receives a contour that corresponds to the sickle-shaped radial gap.

[0011] Additional advantages and characteristics of the invention will become evident from the following description of exemplary embodiments, using the attached drawings, as well as from the dependent claims. The drawings show:

[0012] **FIG. 1 a** frontal view of the pinion/internal-geared ring gear/bearing ring unit, as a cross-section along the line C-C in **FIG. 2**;

[0013] **FIG. 2 a** cross-section along the line A-A in **FIG. 1**;

[0014] **FIG. 3 a** partial cross-section along the line B-B in **FIG. 1**, as a detail on a larger scale, where the axial plates have been left out;

[0015] **FIG. 4 a** representation of a second embodiment, analogous to **FIG. 1**;

[0016] **FIG. 5 a** partial cross-section along the line D-D in **FIG. 4**;

[0017] **FIG. 6 a** representation of a third embodiment, analogous to **FIG. 1**, and

[0018] **FIG. 7 a** partial cross-section along the line E-E in **FIG. 6**.

[0019] The internal gear pump shown in **FIGS. 1 and 2** comprises a housing designated as a whole as **1**, which is composed of a pot-shaped housing part **11** and a housing lid **12**, also pot-shaped, attached to the face of the former. The housing **1** contains suction and pressure channels, not shown, which pass the transport fluid to the internal gear pump and out of it, in usual manner.

[0020] A pinion **14** is mounted to revolve in the housing **1**, by way of friction bearings, not shown in detail, with an axis of rotation **15**, and has a coupling part **16** for engaging in the drive shaft of a drive motor, not shown, on the right end in **FIG. 2**. A pinion **2** is formed in one piece on the pinion shaft **14** and engages with an internal-geared ring gear **3**. The internal-geared ring gear **3** is broadened at its outside circumference to form a bearing race **4**, and mounted to revolve in a bearing ring **5** that is held in a housing recess **13**. A bearing bushing **6** made of a bearing metal is pressed into the bearing ring **5**. Axial plates **8** rest against the faces of the housing part **11** and the lid **12**, on the one hand, and the faces of the pinion **2** and the internal-geared ring gear **3**, on the other hand, axially delimiting the tightly sealed suction space and pressure space within the gearing of pinion **2** and internal-geared ring gear **3**, and connecting them with the suction channel and the pressure channel, respectively, by way of a perforation, not shown.

[0021] As is evident from **FIG. 1**, the pinion **2** and the internal-geared ring gear **3** are mounted with an eccentricity e relative to one another. This distance between the pinion axis **15** and the internal-geared ring gear axis **18** corresponds to the theoretical gearing geometry of the pinion and the internal-geared ring gear, and presumes that the gears will roll off, i.e. slide along one another, without play. In the exemplary embodiment shown, the tooth flanks of the gears are structured as involute curves in each instance, i.e. there is involute gearing, with the tooth tips being rounded off in order to achieve impact-free running onto one another in the region without engagement, and for the purpose of a seal. The number of teeth of the internal-geared ring gear **3** differs from that of the pinion **2** by 1.

[0022] The gears mesh with one another in such a way that in **FIG. 1**, bottom, the teeth of the pinion **2** engage fully into the tooth gaps of the internal-geared ring gear **3**, and rest against one another at the flanks, forming a seal, while on the opposite side, at the top in **FIG. 1**, they have exited completely out of the tooth gaps of the internal-geared ring gear **3**. In this region of the internal-geared ring gear, without engagement, several tooth tips (in the exemplary embodiment, three tooth tips, in each instance) support themselves on one another, one after the other, over the course of the revolution, and thereby separate the suction space from the pressure space in the gearing.

[0023] In the exemplary embodiment shown, the housing recess **13** that holds the bearing ring **5**, and the outside surface **17** of the housing part **11**, are machined concentric to the pinion axis **15**, with the radii R1 and R2, respectively. The bearing surface **19** and the outer peripheral surface **20** of the bearing ring **5**, on the other hand, both lie concentric to the internal-geared ring gear axis **18**, which has the result that the outer peripheral surface **20** of the bearing ring **5**, with its radius R3, is in turn eccentric to the housing recess **13**, and forms a sickle-shaped radial gap **21** with the latter.

[0024] A bearing pin **22** passes through part of the wall of the recess **13** and is pressed into the bottom of this recess. With the essentially semi-cylindrical partial peripheral surface of the bearing pin **22** that projects beyond the wall, the pin projects into an axial groove **23** of the bearing ring **5**, which is adapted to the cylindrical cross-section of the bearing pin **22**. This bearing pin forms a pivotal axis for the bearing ring **5**, parallel to the axes of the pinion **2** and the internal-geared ring gear **3**, around which the bearing ring **5** can pivot in the recess **13**. As is evident from **FIG. 1**, this pivotal axis lies offset by about 80° in the direction of rotation indicated by the arrow, relative to the peak of the region without engagement, in which two tooth tips lie precisely opposite one another.

[0025] The bearing ring **5** has a through bore **24** offset by the same amount along the direction of rotation, directed parallel to the axes of rotation **15** and **18**, through which a pin **25** structured as a bar spring extends (**FIG. 3**). The bore **24** is set back to a shoulder, in each instance, from both ends, so that a ring projection **26** is created thereby in the lengthwise center of the bore. The bore **24** opens into the region of a recess **28** in the housing wall or lid wall, respectively, at both ends, in each instance, which recess has a bottom **30** that narrows conically, which in turn makes a transition into a housing bore **32** to support the bar spring **25**. The two housing bores **32** are aligned with one another in this exemplary embodiment, and lie radially offset towards the pinion axis **15**, with reference to the bore **24**. This results in the bending prestress of the bar spring **25** that is shown in **FIG. 3**, which spring makes contact with the contact projection **26** with its lengthwise center, and constantly puts stress on the bearing ring **5**, with a spring force directed towards the pinion axis **15**. For the remainder, the bar spring passes through the bore **24** and the housing recess **28** without making contact, in the state shown in **FIG. 3**. The support ends of the bar spring **25** are fixed in place in the housing bores **32**; the spring passes through the part of the bore **24** that is formed by the contact projection **26** with a play that has been predetermined, in terms of amount; the significance of this is explained further below.

[**0026**] The method of effect of the arrangement as described is as follows:

[**0027**] When the pinion **2** revolves in the direction of rotation shown by the arrow, the transport medium is transported into the suction space (to the left of the line A-A in **FIG. 1**) between the gears of pinion **2** and internal-geared ring gear **3**, through the suction channel. The transport medium is pressed through the pressure channel from the pressure space (to the right of the line A-A in **FIG. 1**) at elevated pressure. Since the gearing of the pinion and the internal-geared ring gear in the exemplary embodiment is an involute gearing, the gear teeth are in reciprocal sealing contact with their flanks only in the region of full engagement, and with their tooth tips in the region without engagement. In the remaining part of the suction space and the pressure space, the teeth move so far apart that essentially the same pressure prevails in the suction space and the pressure space, in each instance, and come close to one another again in the region without engagement, to produce the sealing contact between the tooth tips.

[**0028**] The hydraulic pressure forces that prevail in the pressure space act in such a way that their resultant generates a pivotal moment at the bearing ring **5**, with reference to the pivotal axis **22**, by means of which the ring, or, more precisely, its segment assigned to the region without engagement, is pressed radially towards the pinion axis **15**, together with the internal-geared ring gear **3**. As a result, the tips of the teeth that approach one another in the region without engagement run onto one another, whereby they are subject to a combined rolling and sliding process, which results in wear. During this process, they are held in reciprocal sealing contact in proportion to the pressure. Since this function is known from the reference EP-A 848 165 cited initially, no further explanation is necessary.

[**0029**] The prestressed bar spring **25** generates a pivotal moment at the bearing ring **5** in the pressure-free state, i.e. outside of the operation of the internal gear pump and during its start-up phase, in approximately the same direction as the pressure forces, and thereby assures both correct assignment and arrangement of the gears relative to one another, and the required sealing contact in the region without engagement, independent of the occurrence of the hydraulic pressure forces. However, it is desirable to limit the sealing contact to precisely the required amount, at which the wear as described above is minimal. For this reason, the prestress of the bar spring **25** is chosen in such a way that in the operating state of the internal gear pump, the hydraulic pressure forces alone assure the sealing contact, and the bar spring **25** is relieved of stress and makes contact in the ring-shaped contact projection **26**, at its opposite side, using up the play. In this position, the bar spring acts to limit any further pivoting of the bearing ring **5**, and thereby relieves the tooth tips of any further contact pressure.

[**0030**] The embodiment according to **FIGS. 4 and 5** differs from the preceding one in that instead of the bar spring **25**, two stop pins **35** are pressed into the bottom of the housing recess **13**, and project axially into the sickle-shaped ring gap **21**, one of which is offset by about 70° and the other by about 170° in the direction of rotation as indicated by the arrow, relative to the pivotal axis **22**. The thickness of the stop pins **35** and their position are coordinated with the local width of the ring gap **21** in such a way that when the bearing ring **5** rests against the housing wall on both sides, a predetermined distance from its peripheral surface **20** is obtained, defining the limited pivotal path of the bearing ring **5**.

[**0031**] In an embodiment modified relative to the embodiment shown in **FIGS. 4 and 5**, not shown, the stop pins **35** can be attached on or in the bearing ring **5**, for example welded onto or glued onto the outer peripheral surface of the bearing ring, instead of being attached in the housing, preferably held in an axially directed holding groove in the peripheral surface of the bearing ring **5**. Fundamentally, a desired tolerance equalization can be adjusted by an appropriate selection of the diameter of the stop pin **35**.

[**0032**] The embodiment according to **FIGS. 6 and 7** has a step **45** that projects axially into the ring gap **21** as the pivotal path delimiter for the bearing ring **5**, which runs concentric to the internal-geared ring gear axis with the radius R4, and whose contour is adapted to the sickle-shaped ring gap. The ring gap **46** that exists between the step **45** and the outside surface **20** of the bearing ring **5** determines the total pivotal path of the ring at the housing wall that lies diametrically opposite the step **45**.

[**0033**] In the embodiments according to FIGS. **4** to **7**, the bearing ring **5** is impacted solely by hydraulic pressure forces and the pivotal moment around the pivotal axis **22** that is generated by them, in order to maintain the sealing contact of the tooth tips in the region without engagement. During the course of the pivotal movement it comes to rest against the stop pins **35**, or against the step **45**, respectively, which then take(s) over part of the pivotal moment and thereby relieve(s) the stress of a stronger contact pressure from the tooth tips. In addition, this contact prevents the bearing ring **5** from lifting off from the pivotal axis **22** and from racing as a result. Also with these embodiments, a bar spring of the type described above can be provided, in addition, where this spring either helps to contribute to limiting the pivotal path of the bearing ring, or only assures sealing contact of the tooth tips in the pressure-free state of the pump, in the prestressed state.

**1**. Internal gear pump that does not contain any filler elements, with a housing (**1**), a bearing ring (**5**), which is accommodated inside a recess (**13**) of the housing in a manner that permits it to transversely move in relation to its axis, but not to rotate, an internal-geared ring gear (**3**), which is mounted inside the bearing ring in a manner that permits it to revolve, and a pinion (**2**), which is mounted inside the housing in a manner that permits it to rotate, and which meshes with the internal-geared ring gear, the teeth of which define a suction space and a pressure space in the gears, by means of a complete engagement into tooth gaps of the internal-geared ring gear, on the one hand, and sealing contact with the tooth tips of the internal-geared ring gear in a region of the internal-geared ring gear that lies approximately diametrically opposite the tooth gap engagement region, on the other hand, whereby the inner peripheral surface of the housing recess (**13**) that holds the bearing ring (**5**) coaxially extends in relation to the pinion (**2**), and the bearing ring, which is eccentrically arranged with regard to the pinion axis (**15**), can pivot in relation to the housing recess, around a pivotal axis (**22**, **23**) parallel to the recess axis, in such a way that the sealing contact between the tooth tips of the pinion (**2**) and the internal-geared ring gear (**3**) is maintained,

characterized in that

the inner peripheral surface of the bearing ring (**5**) that forms the bearing surface (**19**) for the internal-geared ring gear (**3**) coaxially extends in relation to its outer peripheral surface (**20**), and the pivotal path of the bearing ring is delimited to a predetermined measure.

**2**. Internal gear pump according to claim 1,

characterized in that

the pivotal path is delimited by a pin (**25**) that passes through a bore that runs approximately parallel to the axis direction of the bearing ring (**25**) [sic], with a predetermined amount of play, and is supported on the housing.

**3**. Internal gear pump according to claim 2,

characterized in that

the pin (**25**) is a bar spring that stresses the bearing ring, in the pressure-free state of the internal gear pump, in such a way that sealing contact exists between the tooth tips of the pinion and the internal-geared ring gear, in the region of the gears without engagement.

**4**. Internal gear pump according to claim 1,

characterized in that

the pivotal path is limited by at least one stop pin (**35**), which is arranged in the sickle-shaped gap (**21**) between the outer peripheral surface (**20**) of the bearing ring and the inner peripheral surface of the housing recess (**13**).

**5**. Internal gear pump according to claim 4,

characterized in that

the stop pin (**35**) is attached in the housing (**1**), preferably in the housing recess (**13**), or in or on the bearing ring (**15**), preferably in the region of the outer circumference of the bearing ring (**15**).

**6**. Internal gear pump according to claim 5,

characterized in that

the stop pin (**35**) is preferably attached parallel to the axis of the pinion, in the bottom of the housing recess.

**7**. Internal gear pump according to claim 5,

characterized in that

the stop pin is attached in or on an outer peripheral surface of the bearing ring, preferably parallel to the axis of the bearing ring.

**8**. Internal gear pump according to one of claims 4 to 7,

characterized in that

the stop pin is arranged offset by about 90° relative to the pivotal axis (**22**) of the bearing ring.

**9**. Internal gear pump according to one of claims 4 to 8,

characterized in that

two stop pins are provided, which are arranged offset by the same angle on both sides of the pressure space peak point.

**10**. Internal gear pump according to claim 1,

characterized in that

the pivotal path is limited by a step (**45**) that projects axially into the gap (**21**) between the bearing ring and the housing recess, from the bottom of the housing recess (**13**).

**11**. Internal gear pump according to claim 10,

characterized in that

the contour of the step is adapted to the gap and the step forms a ring gap (**46**) with the outer peripheral surface (**20**) of the bearing ring.

* * * * *