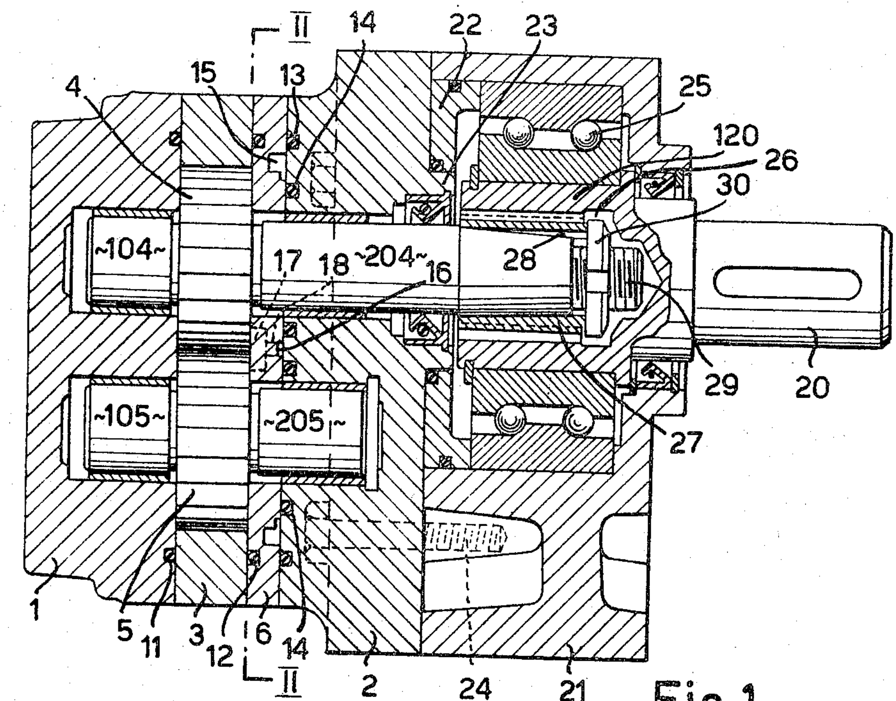

Fig.1

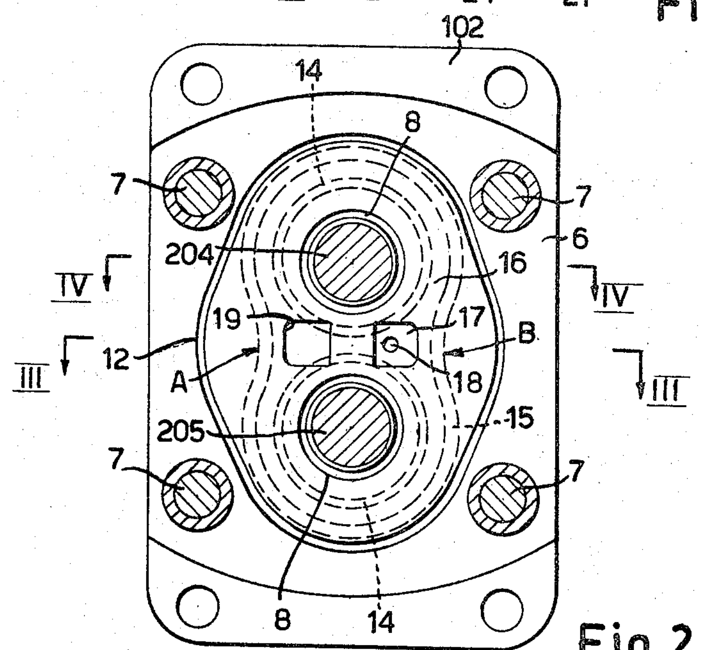

Fig.2

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GEAR PUMP

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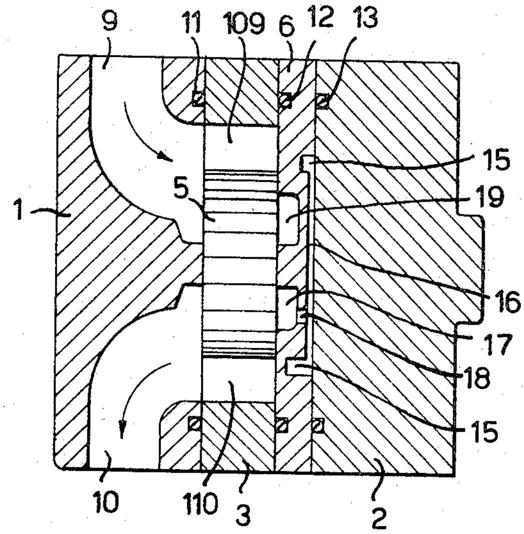

Fig.3

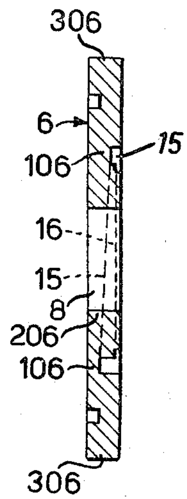

Fig.4

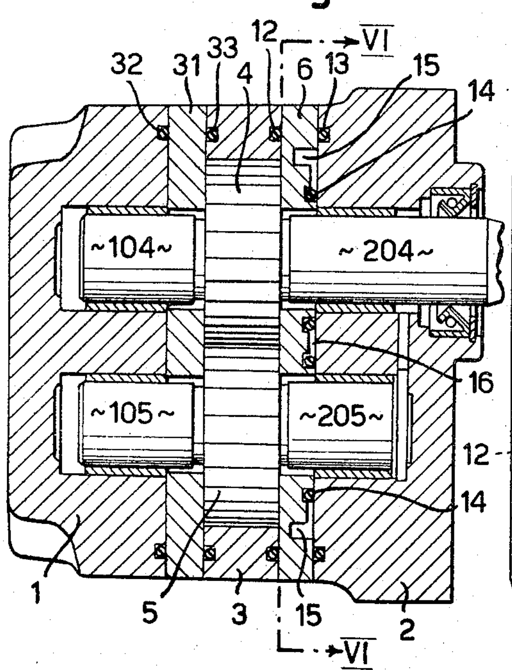

Fig.5

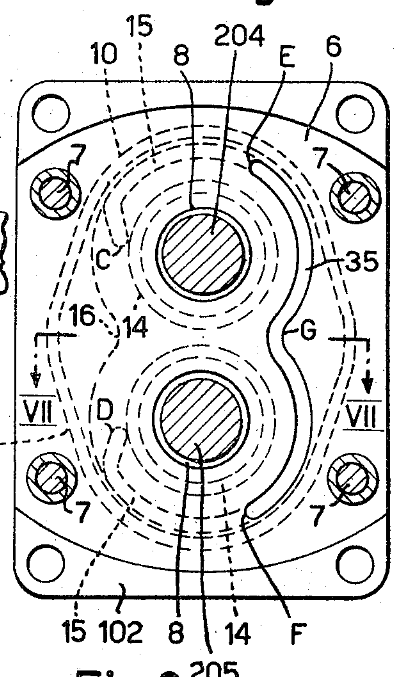

Fig.6

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April 9, 1968 M. TUROLLA 3,376,824

GEAR PUMP

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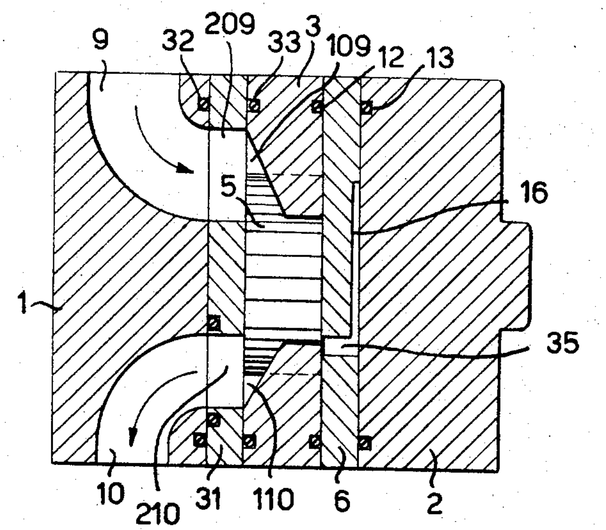

Fig.7

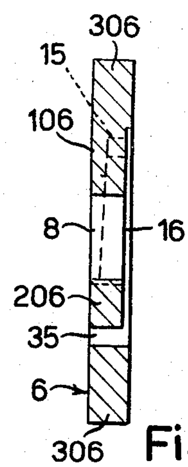

Fig.8

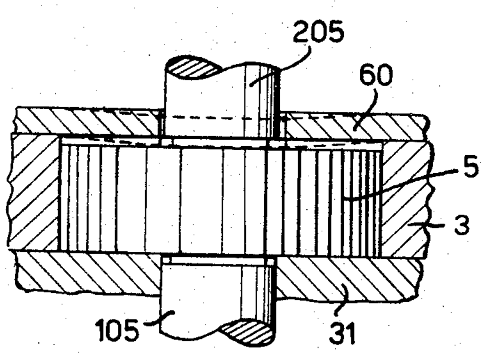

Fig.9

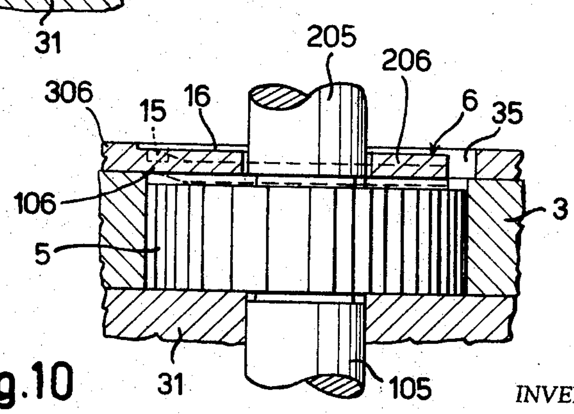

Fig.10

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3,376,824
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3,376,824
GEAR PUMP

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Claims priority, application Italy, July 1, 1965, 15,110/65; July 1, 1965 (utility model), 4,292/65; Aug. 9, 1965, 18,191/65
12 Claims. (Cl. 103—126)

This invention relates to a gear pump in which a sealing plate resiliently bendable in axial direction has its periphery fastened in the pump case, is situated at one side of the gears at least, and may be pressed against the corresponding lateral surface of the gears by hydraulic pressure which is generated in a pressure chamber situated at the outer side of the sealing plate and connected to the delivery side of the pump.

In known gear pumps of this kind, the sealing plate is of uniform thickness throughout and its bendability is thus limited, particularly since the overall thickness of the sealing plate must be relatively great for structural reasons. Since the sealing plate moreover has its entire periphery clamped in the pump case, it is deformed inwards in pot-like or cap-like manner, i.e. to dome-shape, by the delivery pressure of the pump acting on its outer side, so that a limited median portion of it can bear in sealing manner on a correspondingly limited portion of the lateral gear surfaces. At the side of the gears facing the sealing plate, leaks thus develop between the suction and pressure sides of the pump, causing substantial pressure losses, which considerably reduce the efficiency of the pump.

The main object of the present invention is to provide a gear pump in which these disadvantages are avoided and to influence the bendability of the sealing plate while retaining its required strength, so that the delivery pressure of the pump acting on the outer side of the sealing plate presses the plate as flat as possible and with a substantially greater proportion of its inner surface against the corresponding lateral surfaces of the gears, thereby forming a better seal between the suction and delivery sides of the pump than in the known pumps.

According to the present invention, a gear pump comprises a pump case, a pair of gears rotatably mounted in cavities in the case, inlet and outlet opening in the case communicating with the gear cavities, a sealing plate mounted in the case at one side of the gears and resiliently bendable axially of the case and clamped at its periphery in the case, a pressure chamber in the case on the side of the plate remote from the plate and in communication with the pressure side of the pump, the hydraulic pressure generated in the pressure chamber urging the plate into engagement with lateral surfaces of the gears, and a weakening groove in the plate which at least of the pressure side of the pump has an outline approximating to the circumferential profile of the gears.

This weakening groove preferably also extends on the suction side of the pump and has an annularly closed conformation. This outer weakening groove of the sealing plate is appropriately also acted upon by the delivery pressure of the pump. To this end, the weakening groove may be in communication with the pressure chamber arranged on the outer side of the sealing plate and in communication with the pressure side of the pump. In an advantageous and particularly simple pump the external pressure chamber is in the form of a median flat or shallow depression in the outer side of the sealing plate, and the much deeper weakening groove is arranged in the area of this depression, preferably along its external boundary thereof. The outer weakening groove and the shallow external depression of the sealing plate may be

of approximately oval form, which may be slightly constricted or waisted in the middle, i.e. in the meshing area of the gears.

The shape of the outer weakening groove divides the sealing plate into an outer marginal portion secured in the pump case and a median portion corresponding to the gears and cooperating with their corresponding lateral surfaces, this median portion having the same or a lesser thickness than the marginal portion secured in the pump case and being joined to the latter by a much thinner and thus much more yielding web in the area of the weakening groove. As a result, the sealing plate, when acted upon by delivery pressure of the pump on its outer side, behaves like a diaphragm reinforced in the middle, i.e. only the thinner joining web between the median and marginal parts of the sealing plate being deformed resiliently, whilst the median part of this plate bounded by the weakening groove is but slightly domed inwards and is displaced and pressed against the gears approximately parallel to itself with retention of a substantially plane form. The sealing plate is thus pressed with area contact against a substantially greater part of the lateral surfaces of the gears and effects lateral sealing of the gear compartment.

According to a further feature of the invention, the outer weakening groove of the sealing plate has a varying depth, increasing at either side from the suction side of the pump in the peripheral direction towards its pressure side. The joining web left in the area of this weakening groove between the median and external immobilised marginal part of the sealing plate is thus thinner, more pliable and more resilient at the pressure side than at the suction side of the pump. The median part of the sealing plate bounded by the weakening groove is thus pressed against the gears with a force which increases progressively from the suction side to the pressure side of the pump according to the pliability and resiliency of the said joining web. The distribution of the pressure of contact of the sealing plate against the gears is thus adapted in the simplest manner to the internal pressure of the pump, which is not uniformly distributed across the pump cross-section, as known, but rises progressively from the suction side of the pump towards its pressure side.

The advantageous action of the sealing plate of the invention may be further improved by forming the weakening groove as a slit passing through the thrust plate at the pressure side of the pump, the slit being of limited length and preferably extending symmetrically to the median transverse axis of the pump cross-section lying between the gears. In this embodiment, the median part of the sealing plate partially bounded by the slit is separated even more from the marginal part of this plate secured in the pump case, so that it bends even less on being thrust against the gears and retains its plane form with even greater reliability. At the same time, the contact pressure of the sealing plate against the gears is substantially increased at the pressure side of the pump, and can in practice assume an optimum approximately equal to the delivery pressure of the pump. The contact pressure of the sealing plate is thus adapted more adequately to the irregularly distributed internal pressure of the pump.

Together with or instead of the slit in the sealing plate, the outer weakening groove may moreover be omitted along a limited peripheral stretch on the suction side of the pump. This reduces or eliminates the contact pressure of the sealing plate at the suction side of the pump and the thrust exerted by the sealing plate on the gears is equally better adapted to the asymmetrical distribution of the internal pressure of the pump.

In order that the invention may be more fully understood some embodiments in accordance therewith will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 shows a longitudinal cross-section through a gear pump;

FIG. 2 is a cross-section along the line II—II of FIG. 1;

FIG. 3 is a cross-section along the line III—III of FIG. 2;

FIG. 4 shows a cross-section of the dismantled sealing plate along the line IV—IV of FIG. 2;

FIG. 5 shows a longitudinal cross-section of another construction of gear pump;

FIG. 6 is a cross-section along the line VI—VI of FIG. 5;

FIG. 7 is a cross-section along the line VII—VII of FIG. 6;

FIG. 8 is a cross-section of the dismantled sealing plate of the pump of FIGS. 5 to 7;

FIG. 9 shows diagrammatically the mode of operation of the conventional sealing plate in a known pump; and

FIG. 10 shows diagrammatically the mode of operation of the sealing plate in a pump of the invention.

In both the construction shown in the drawings, the gear pump comprises a middle case **3** having bores for two meshing gears **4** and **5**, between two lateral case covers **1**, **2**. A steel sealing plate **6** is disposed at one side of the gears **4**, **5** between the case **3** and the case cover **2**. The cover **2** has a radially projecting flange **102** which may serve to fasten the pump on a bearing element (not shown). The two case covers **1**, **2**, the middle case **3** and the sealing plate **6** are interconnected by axially parallel through-bolts **7**, the plate **6** thus being firmly clamped with its marginal part between the middle case **3** and the case cover **2**.

The gears **4**, **5** have lateral spindles **104**, **204** and **105**, **205**, respectively, rotatably mounted in bores of the covers **1**, **2**. The bearing bores for the spindles **104**, **105**, **205** are formed as blind holes, whereas the extended spindle **204** of the gear **4** passes through and out of the cover **2** and forms the driving shaft of the pump. The gear spindles **204**, **205**, facing the sealing plate **6** pass through appropriate bores **8** therein, the inner diameter of these bores **8** being greater than the outer diameter of the gear spindles **204**, **205** so as not to impede the deflection or deformation of the median, non-clamped part of the sealing plate in the axial direction of the pump. The suction passage **9** and the pressure outlet passage **10** of the pump are provided in the case cover **1** and open into a suction space **109** and pressure space **110** respectively of the middle case **3**, as seen in FIGS. 3 and 7.

In the construction of FIGS. 1 to 4, the cover **1** on the side of the middle case **3** remote from the sealing plate **6** bears directly on the middle case **3**. The seal between the middle case **3** and the adjacent cover **1** on the one hand, and between the middle case **3** and the marginal part of the sealing plate **6** on the other hand, is provided by annular end joints **11**, **12** respectively disposed as far as possible beyond the circumferential outline of the pair of gears **4**, **5**. An analogous end joint **13** is disposed between the marginal part of the sealing plate **6** and the other case cover **2**. Between the sealing plate **6** and the adjacent cover **2** an annular end joint **14** is arranged around the passage bore **8** of each gear spindle **204**, **205**.

In the external side of the sealing plate **6** facing away from the gears **4**, **5**, there is a relatively deep annularly closed weakening groove **15** within the area bounded by the outer joint **13**, this groove having a profile approximating to the outer profile of the pair of gears **4**, **5**, i.e. approximately oval and with a constriction in the middle, as seen in FIG. 2. This weakening groove **15** has a varying depth increasing at either side from the suction side of the pump towards its pressure side, so that its smallest depth is reached at say the point A in FIG. 2, and its greatest depth at say the point B in FIG. 2, as also seen in FIGS. 3 and 4.

In the outer side of the sealing plate **6** there is moreover a flat depression **16** which is bounded externally by the weakening groove and internally by two annular end joints **14**, and thus is of approximately figure-8 shape. At its outer periphery, this depression **16** merges into the weakening groove **15** and in combination with the cover **2** forms a pressure chamber, in communication with the weakening groove **15** on the one hand and with the pressure side of the pump on the other. Connection to the pressure side of the pump is established through a cavity **17** in the inner side of the sealing plate in the area of the pump pressure space **110** and in communication with the space **110**, which cavity is connected to the pressure chamber **16** through a bore **18**. Symmetrically of the cavity **17**, an analogous cavity **19** is provided in the inner side of the sealing plate, which is in communication with the suction side or the suction chamber **109** of the pump, but not with the pressure chamber.

In operation, the delivery pressure of the pump prevailing in the pressure chamber **16** and in the weakening groove **15** acts on the outer side of the sealing plate **6**. The sealing plate is thus pressed inwards resiliently and its plate inner side is pressed in axial direction against the corresponding plane lateral surface of the gears **4**, **5**. Only the thinner, more pliable and more resilient web **106** is thereby preferentially deformed, which web is formed in the area of the weakening groove **15** and connects the rigid thicker median part **206** of the sealing plate **6** bounded by the weakening groove **15** with the outer marginal part **306** of the sealing plate secured between the case **3** and the cover **2**. The median part **206** of the sealing plate **6** pressed against the gears thus essentially retains its plane form, i.e. it is not excessively bent or deformed inwards, so that it bears against the gears in area contact and with sufficient surface area to provide the required lateral sealing of the pump spaces. At the same time, the sealing plate **6** is pressed against the gears **4**, **5** with a force rising progressively from the suction side to the pressure side of the pump, since the depth of the weakening groove **15** and thus the pliability or deformability of the corresponding joining web **106** increases at either side from the suction side (point A) towards the pressure side (point B). This irregular distribution of contact pressure corresponds to the distribution of the opposed internal pressure of the pump, so that the latter is balanced evenly, as will be described.

In FIG. 1, the driving spindle **204** of the gear pump is driven through an extension shaft **20** which is rotatably secured in an additional casing **21** releasably fastened to the pump case, and is coupled in formlocked and forcelocked manner with the driving shaft **204** of the pump. The bearing casing **21** of this extension shaft **20** is inserted with a centering ring **22** on an outer boss **23** of the pump cover **2** and secured by screwbolts **24** on the outer flange **102** of the cover **2**. The extremity **120** of the extension shaft **20** mounted in a roller bearing or ball bearing **25** in the case **21**, i.e. facing towards the pump spindle **204**, has a blind co-axial bore **26** with a longitudinally grooved inner side. In this bore engages the conical extremity of the pump spindle **204** projecting from the pump cover **2**, on which is placed a coupling sleeve or the like **27** with a correspondingly conical bore. This coupling sleeve **27** is secured in rotatory manner on the pump spindle **204** by a key **28** and a nut **30** screwed on an externally threaded pin **29** on the pump spindle **204**. The coupling sleeve **27** has a longitudinally grooved or splined outer surface and is in engagement with the correspondingly splined inner side of the blind bore **26** in the extension shaft **20**, **120**. This connects the two spindles **20**, **204** in a rotatory manner. This arrangement has the advantage that the bending stresses applied by the driving means on the projecting unconfined extremity of the extension shaft **20** are absorbed by the ball or roller bearing **25**, and by the additional bearing case **21** and are not transmitted to the pump spindle **204**. At the same time, the clearance between the splined coupling elements **120**, **27** allows small deviations in alignment between the axes of the two spindles.

Referring to FIGS. 5 to 8, these show a gear pump in which an intermediate plate **31** is disposed between the cover **1** and the middle case **3** at the opposite side of the gears from the sealing plate **6**, which plate has bores **209**, **210** in the area of the suction and pressure passages **9**, **10** for connection of these passages with the suction and pressure spaces **109**, **209** of the case **3**. The seal between this intermediate plate **31** and the cover **1** on the one hand, and the middle case **3** on the other, is established by annular end joints **32**, **33**. Around the traverse bores **8** of the gear spindles **204**, **205**, annular end joints **14** are disposed between the sealing plate **6** and the cover **2**. The pressure chamber on the outer side of the sealing plate **6** is again formed by a flat or shallow depression **16** in the outer side of the sealing plate **6**, corresponding to the peripheral profile of the pair of gears **4**, **5** and inwardly bounded by the joints **14**, so that it is of approximately figure-8 form. The outer side of the sealing plate **6** also has a weakening groove **15** which extends along the circumferential boundary of the depression **16** and is in communication therewith. Compared to the pump of FIGS. 1 to 4, the weakening groove **15** does not however extend along the entire periphery of the pressure chamber **10**, i.e. is not a closed circuit annularly, but is interrupted on the suction side of the pump and is of approximately figure-3 shape terminating at C and D approximately at the levels of the axes of the gears. At the pressure side of the pump, this weakening groove is made in the form of a slit **35** passing through the sealing plate **6** along a limited longitudinal section E–F. In its middle portion G, this slit **35** is in communication with the pressure space **110** of the pump and accordingly establishes communication between the pressure chamber **16** and the pressure side of the pump. The sections C–E and D–F of the weakening groove **15** have a depth increasing from the suction side of the pump towards its pressure side, seen in FIG. 8.

The mode of operation of the gear pump of FIGS. 5 to 8 essentially corresponds to that of FIGS. 1 to 4 and will be described in greater detail with reference to FIGS. 9 and 10. In FIG. 9, a detail of a known gear pump is shown, in which the sealing plate **60** lacks an outer weakening groove and is of the same thickness throughout. In this known construction, the sealing plate **60** acts like a uniformly bendable diaphragm clamped on all sides, and is thus bent inwards to dome-shape by the delivery pressure of the pump acting on its outer side, as indicated in dash-dotted lines in FIG. 9. As a result, only a relatively small part of its inwardly convex middle portion comes into contact with the corresponding lateral surface of the gears. This contact area is normally too small to provide satisfactory lateral sealing of the gears. The sealing plate **60** is moreover pressed against the gears with the same force at the suction side and pressure side of the pump. This uniform distribution of contact pressure does not however correspond to the distribution of internal pump pressure, which as known rises progressively from the suction side to the pressure side of the pump. The force directed inwards, i.e. against the gears, resulting from the uniformly distributed pressure on the outer side of the sealing plate **60** and from the irregularly distributed counterpressure on its inner side, is displaced towards the suction side of the pump out of the median plane of the pump passing through the axes of the gears. This offset thrust loading results in correspondingly irregular friction between the lateral surfaces in contact with the sealing plate **60** and gears, so that the inner surface of the sealing plate **60** wears more quickly at the suction side of the pump. This offset thrust loading moreover causes undesirable transverse loading of the gear spindles and corresponding unilateral wear of their bearings.

FIG. 10 shows the mode of operation of the sealing plate **6** with a weakening groove **15** and a corresponding slit **35**, as in FIGS. 5 to 8. In this construction the middle portion **206** of the sealing plate **6** is largely separated from the outer marginal part **306** of the sealing plate **6** secured in the pump case, being partially bounded by the weakening groove **15** and partially by the slit, being wholly separated in the area of the slit **35** from the marginal part **306**, and being connected to the marginal part **306** in the area of the sections C–E and D–F of the weakening groove **15** through the thinner and thus more pliable and resilient joining web **106**, as seen in FIG. 8. As a result, the middle portion **206** of the sealing plate **6** is only slightly domed inwards by the delivery pressure of the pump acting on the outer side, and is pressed almost parallel to itself and with retention of an approximately plane form, against the lateral surface of the gears, as shown in dash-dotted lines in FIG. 10. There is no bending at all of the sealing plate **6** in the area of the slit **35**, whereas in the area of the sections C–D and D–F of the weakening groove **15**, only the more resilient joining web **106** is deformed resiliently and preferentially. This ensures a more complete contact of the sealing plate **6** with a substantially greater part of the corresponding lateral surface of the gears and thus better lateral sealing compared with the known constructions.

At the same time, the middle part **206** of the sealing plate **6** is pressed against the gears with a greater force at the pressure side of the pump than at its suction side, since the pressure-side section of the median part **206** of the sealing plate is wholly separated from the immobile marginal part **306** of the sealing plate **6** by the slit **35**, whereas the suction side section of the said middle part **206** merges into the marginal part **306** without any weakening. The intermediate sections C–D and D–F of the weakening groove extending around the gears, by virtue of their progressively increasing depth, cause the contact pressure of the sealing plate **6** against the gears to rise continuously from the suction side towards the pressure-side of the pump. This asymmetrical distribution of the contact pressure approximately corresponds to the intenal pump pressure distribution, so that the resulting inwardly directed force acts approximately in the median plane of the pump passing through the axes of both gears. This produces an even friction between the sealing plate **6** and the gears, and prevents undesirable transverse loadings of the gear spindles.

The gear pump may be provided with two sealing plates with weakening grooves **15** and slits **35** at either side of the gears.

What is claimed is:

1. A gear pump comprising a pump case, a pair of gears rotatably mounted in cavities in said case, inlet and outlet openings in said case communicating with said gear cavity, a sealing plate mounted at one side of said gears resiliently bendable axially of said case and clamped at its periphery in said case, a pressure chamber in said case on the outer side of said plate and in communication with the pressure side of said pump, the hydraulic pressure generated in said chamber urging said plate against the lateral surfaces of said gears, and a weakening groove in said plate which at least at said pressure side of said pump has an outline approximating to the circumferential profile of said gears.

2. A gear pump according to claim **1** wherein said groove extends over the suction side of said pump and has an annular closed contour.

3. A gear pump according to claim **1** wherein said groove has an oval contour slightly waisted in the meshing area of said gears.

4. A gear pump according to claim **1** wherein said groove has a figure-3 shape, interrupted at the suction side of said pump.

5. A gear pump according to claim 1 wherein said groove is in communication with said pressure chamber.

6. A gear pump according to claim 1 wherein said pressure chamber comprises a median shallow depression in said outer side of said plate and said weakening groove is substantially deeper than said depression and is disposed in the region of said depression.

7. A gear pump according to claim 1 wherein said pressure chamber comprises a median shallow depression in said outer side of said plate and said weakening groove is along the external boundary of said depression.

8. A gear pump according to claim 1 wherein the depth of said groove increases at either side in the peripheral direction from the suction side towards the pressure side of said pump.

9. A gear pump comprising a pump case, a pair of gears rotatably mounted in cavities in said case, inlet and outlet openings in said case communicating with said gear cavity, a sealing plate mounted at one side of said gears resiliently bendable axially of said case and clamped at its periphery in said case, a pressure chamber in said case on the outer side of said plate and in communication with the pressure side of said pump, the hydraulic pressure generated in said chamber urging said plate against the lateral surfaces of said gears, and a weakening groove in said plate which at least at said pressure side of said pump has an outline approximating to the circumferential profile of said gears,

said groove being in the form of a slit of limited length traversing said plate on the pressure side of said pump.

10. A gear pump according to claim 9 wherein said slit extends symmetrically to the median transverse axis of said pump cross-section between said gears.

11. A gear pump according to claim 9 wherein said pressure chamber is connected to the pressure side of said pump through said slit.

12. A gear pump according to claim 9 wherein bores are formed in said plate and said gears are mounted on spindles journalled in said case and passing through said bores, said bores having a substantially greater diameter than said spindles.

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