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(54) **SATELLITE PUMP**

SATELLITENPUMPE

POMPE SATELLITE

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US-A- 3 852 002 US-A- 4 674 964

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Description

[0001] The invention refers to a satellite pump applicable particularly in hydraulic drives of machines and devices.

[0002] A satellite hydraulic motor consisting of a planet, tooth geared with numerous satellites geared with multi-humped external cam with numerous humps directed inwardly, referred to as curvature is known from the patent description PL no. 71329.

[0003] A satellite pump whose body is constructed in the form of an open cylindrical vessel containing centrally-located curvature and rotating shaft on which a planet is mounted is known from the Polish patent description PL 391422. Satellites cooperate with the curvature and the planet. A space created amidst planet, curvature and satellites is closed with the timing plates which in turn are pressed with the suction and discharge manifolds. The pump body, throughout its whole perimeter, features radially situated, preferably at equal distances, suction holes, preferably of circular cross-section, whereby the suction holes are located coaxially with the holes located in the inner pump manifold. The pump body, around the suction holes features rotationally placed suction manifold with possibly large cross-section of the transverse fluid flow duct, allowing the supply of the fluid from the suction duct to the suction holes in the pump body. Timing plate on the side of the high pressure acts simultaneously as a compensation plate.

[0004] A construction for the axial clearance compensation unit of satellites and planet in a hydraulic satellite motor in which one compensation space is connected by means of a duct with an inner duct supplying the working mechanism of the motor, while the other compensation space is connected by means of a duct with the inner discharge duct from the working mechanism of the motor is known from the Polish patent description PL 215061.

[0005] A construction for the axial clearance compensation unit of the satellites and planet in a positive displacement machine of the rotary-cam type in which one compensation space is connected by means of a duct featuring a check valve with an inner duct supplying the working mechanism of the motor, while the other compensation space is connected by means of a duct featuring a check valve with an inner discharge duct from the working mechanism of the motor whereby both compensation spaces are connected to each other with a circumferential backlash along the bolts which axially integrate the machine elements is known from the Polish patent description PL 185724.

[0006] A construction for the axial clearance compensation unit of satellites and planet in which each compensation space is connected by means of at least one duct with a flat gap created by the face of the planet and compensation plate is known from Polish patent description PL 219147.

[0007] A construction for the axial clearance compensation unit of satellites and planet in which the compen-

sation space is connected by means of single ducts with the socket housing a face gasket of the planet is known from the PhD dissertation entitled "The research on the axial clearance compensation unit in hydraulic satellite motors" written by Krzysztof Elgert, at the Faculty of Mechanical Engineering of Gdańsk University of Technology.

[0008] The axial clearance compensation unit of satellites and planet in a hydraulic satellite motor or pump reduces internal leaks in the machine and thus improves machine efficiency. However, providing - constructing and designing a correctly working compensation (compensation unit) is not a simple and obvious task. This constituted the objective of the invention, especially taking into account the drawbacks of the known constructions.

[0009] Known construction solutions for the axial clearance compensation unit of satellites and planet are burdened with the flaws - drawbacks listed below. Satellite pump known from PL 391422 features two inner manifolds: suction manifold and discharge manifold, and a collective suction manifold located rotary on the pump body. Due to that, the dimensions of the pump are significant and it is quite heavy. Moreover, only the timing plate with the discharge holes (on high-pressure side) is balanced. However, the timing plate with the supply holes is adversely bent towards the suction manifold by forces originating from the pressure in the working chambers. At the same time, the direction of the deformation is adversely on the outside of the working mechanism.

[0010] In the case when both compensation spaces are connected with each other through the circumferential backlash along the bolts which axially integrate the elements of the machines, as described in PL 185724, the pressure in both compensation chambers is the same as in the inner duct supplying the motor. Both compensation plates deform to the same extent. If the check valve does not operate properly, there is an undesirable leak of the fluid from the high pressure duct through the compensation chambers to the low pressure duct. This causes incorrect operation of the compensation, increase of the axial play and the occurrence of an additional, undesirable leak in the gaps of the working mechanism.

[0011] In the case when both compensation spaces are connected through single ducts with the socket housing the face gasket of the planet, as described in the PhD dissertation written by Krzysztof Elgert, entitled "The research on the axial clearance compensation unit in hydraulic satellite motors", in both compensation chambers there is pressure whose value is the mean of the pressures present in the working chambers of the satellite machine, provided that the face gasket works properly. Should a leak through a gasket (or both of them) appear, a loss of pressure in the compensation chamber (or in both compensation chambers if both gaskets do not work properly) can occur, as well as nonuniform deformation of the compensation plates, increase of the axial

clearance of the planet and satellites and, consequently, an increase of undesirable leaks from high-pressure working chambers to low-pressure working chambers.

[0012] In the case when the compensation space is connected through at least one duct with the flat gap created by the face of the planet and compensation plate as in PL219147, the pressure in the compensation chamber depends on the location of the duct in relations to the flat gap created by the planets and compensation plates. Moreover, a large compensation field is required which causes an increase of the dimensions of the positive displacement machine.

[0013] The document EP 3 187 733 discloses a pump of the type planetary gearing with humped inner curvature of the outer cam ring.

[0014] The goal of the invention was to provide a construction of a satellite pump free of the drawbacks. The subject matter of the invention are described in the claims.

[0015] This goal - objective has been reached in such a way that in the satellite pump according to the invention as defined by the accompanying claims, in the inner of rear body of the pump - separate part of the whole body of the pump - inside it there is an inner suction duct make coaxial with the body, whose cross-section is preferably circular and whose diameter is at least equal to the outer diameter of the bearing mounted at the end of the shaft. The suction duct's inner diameter is not larger than the inner diameter of the central body both in the case when the central body constitutes a separate part and in the case when it constitutes a single, whole part in which central body is combined with the front body. The rear body features - there is - at least two inner ducts, preferably of circular cross-section, placed, preferably, parallel to the axis of the shaft, preferably spaced equally around the bearing placed in the rear body and preferable between this bearing and the edge of the suction duct. The front of the pump is where the shaft end neck is visible, while the rear is on the opposite side, which regards the explanation of the usage of the rear body located on the opposite side in relations to the shaft end neck. The pump comprises a satellite working mechanism known also as satellite mechanism pump, constituting a curvature with humps, a planet and satellites. The pump mechanism is explained in details in the examples and shown in figures.

[0016] The inner ducts connect the suction duct with the ring duct. The ring duct is lead - form in the rear body coaxially with the shaft and coaxially with the rear body and it is adjacent - is in neighbouring - adjoin to the rear compensation plate situated between the satellite mechanism and rear body. Compensation plate is, at the same time, the timing plate. In the rear compensation plate, at the height of the ring duct, there are suction holes whose number equals the number of the humps of the curvature in the satellite mechanism, located at equal distance from one another and at the same distance from the axis of the pump shaft. The suction holes connect the

ring duct with the low-pressure chambers in the satellite mechanism. The low pressure chamber is a space created by the planet, curvature and two adjacent satellites in such a way that it increases its volume during the revolution of the planet. A ring-shaped compensation chamber is placed coaxially with the shaft in the rear body. This compensation chamber is adjacent - adjoin to the rear compensation plates on which it creates a ring-shaped compensation field, whereby the inner diameter of the compensation chamber and ring-shaped compensation field is larger than the diameter of the opening for the shaft in the rear compensation plate, compensation plate features at least one compensation hole connecting the compensation chamber with at least one high-pressure working chamber in the pump satellite mechanism. High-pressure chamber is an area created by the planet, curvatures and two adjacent satellites in such a way that it decreases its volume during the revolution of the planet.

[0017] Preferably, the rear body of the pump is connected with the central body of the pump in a detachable manner, for example by means of at least two equally spaced screws. However, the central body is connected to the front body also in a detachable manner, for example by means of at least two equally spaced screws. Front body and central body can constitute a whole element in another design variant and in this case the part is defined as the central body. For the construction of the pump it is preferable if central body and front body constitute two separate elements connected, for example, with screws. The central body, apart from the satellite mechanism, houses the front compensation plate and the manifold. Front compensation plate is located between the satellite mechanism and the manifold. The manifold is adjacent to the front body if the front body constitutes a separate part or to the central body in its front part if the central and front body are a single part.

[0018] The advantage of this solution according to the invention, consists in obtaining a large inner diameter of the suction duct, i.e. due to making the inner diameter that is not larger than the inner diameter of the central body. Essential features of the invention include: at least two inner ducts and an aggregate ring duct distributing the fluid to the suction holes in the rear compensation plate. Due to this, there is a low drop of pressure in the inner ducts - from the external connection of the pump to the rear compensation plate, complete filling of the working chambers of the pump (avoiding cavitation) at the whole range of the rotation velocity of the pump and high volumetric efficiency of the pump.

[0019] Essential feature of the pump comprises in the ring-shaped compensation chamber placed in the rear body of the pump, adjacent to the rear compensation plate. The pressure in the compensation chamber equals the pressure occurring in the high-pressure working chamber of the pump and is obtained through the compensation holes in the timing plate. Pressure in the compensation chamber acts on the rear compensation plate. Due to this the compensation plate is exposed to the

action of the force pushing it towards the planet and satellites causing, at the same time, the decrease of the axial play of these elements. Decrease of the axial play causes preferable decrease of leaks and, hence, a preferable increase of the volumetric efficiency.

[0020] The invention is presented in more detailed in the embodiment and the drawings, where Fig. 1 presents the construction of the satellite pump, Fig. 2 presents the transverse cross-section A-A according to Fig. 1 through the satellite mechanism, indicating the curvature O, planet P, satellites S. Fig. 3 presents the detail A of the pump according to Fig. 1, Fig. 4 presents the transverse cross-section B-B of the pump according to Fig. 1. Fig. 1, Fig. 2, Fig. 3, Fig. 4 are shared by all the examples. Fig. 5 presents the view to the face of the rear body in the cross-section C-C according to Fig. 1 with circular inner ducts KW, while Fig. 6 presents the view to the face of the rear body in the cross-section C-C according to Fig. 1 with non-circular inner ducts KW.

[0021] Designations - marks shown in the drawings:

1 - front body,
2 - central body,
3 - rear body - back body,
4 - manifold,
5 - front compensation plate,
6 - rear compensation plate - back compensation plate,
7 - shaft,
8, 9 - bearing,
10, 11 - gasket,
12 - cover,
13 - screw 1,
14 - screw 2,
15 - pin,
16, 17 - gasket,
O - curvature,
P - planet,
S - satellite,
KK - ring-shaped compensation chamber,
KNC - low-pressure chamber,
KWC - high-pressure chamber,
KS - suction duct,
KW - inner duct,
KP - ring duct,
Dpk - diameter of the opening for the shaft in the rear compensation plate,
Dwkp - inner diameter of the ring duct KP,
D1 - inner diameter of the compensation chamber KK,
D2 - outer diameter of the compensation chamber KK,
OK - compensation hole,
OS - suction hole in the rear compensation plate,
OT - discharge hole in the front compensation plate,
This is the hole that supplies liquid to the high- or low-pressure working chamber - depending on the hole.
PK - compensation field of the ring-shaped compen-

sation chamber.

Example 1

[0022] Satellite pump applicable in hydraulic system was developed in a manner described below.

[0023] As it was shown in fig. 1 and fig. 2 a satellite pump has been constructed with the following parts: front body 1, central body 2, rear body 3, satellite working mechanism constituting the curvature O, planet P and satellite 5, manifold 4, front compensation plate 5, rear compensation plate 6, shaft 7, bearings 8 and 9, gaskets 10 and 11, and cover 12 which seals the bearing. Central body 2 is attached to the front body 1 with screws 13. Rear body 3 is attached to the central body 2 with screws 14. The shaft is supported by the bearing 8 mounted in the front body and by the bearing 9 mounted in the rear body 3. Planet P is fitted in the middle section of the shaft 7. Central body houses the curvature O which is fixed by means of at least one pin 15. Satellites S are fitted between the curvature O and planet P. The number of satellites S equals the sum of the number of the humps on the curvature O and planet P. In the embodiment presented in fig. 2, the number of satellites is 10. Adjacent to the working mechanism, on the side of the front body 1, there is the front compensation plate 5. Rear compensation plate 6 is located between the working mechanism and the rear body 5. In the central body 2, between the front body 1 and front compensation plate 5, the manifold 4 is located. The manifold houses a gasket 10. Gasket 11 is located in the rear body 3, between bearing 9 and rear compensation plate 6. The rear body 3 features the suction duct KS of a circular cross-section. The axis of the duct KS coincides with the axis of the shaft 7. Bearing 9 is separated from the suction duct KS with the cover 12. In the suction duct KS, around the bearing 9 and there are sixteen equally spaced circular inner ducts KW, whose axes are parallel to the axis of the shaft 7. The diameter Dkw of the inner duct KW is lower than a half of the difference of diameters of the suction duct KS and outer diameter of the bearing 9 and in this case it is 5 mm. In the front section of the rear body 3, adjacent to the rear compensation plate 6, a ring duct KP is implemented. Inner ducts KW connect the suction duct KS with the ring duct KP. Low-pressure working chambers KNC of the pump are connected to the ring duct KP with the holes OS made in the rear compensation plate 3. The number of the holes OS equals the number of the humps on the curvature O. In the embodiment presented in the drawings, i.e. fig. 1 and fig. 4, the number of the holes OS equals 6. The rear body 3 features ring-shaped compensation chamber KK (fig. 1 and fig. 3), situated coaxially with the body. The compensation chamber KK rests on the rear compensation plate 3 and is sealed with two gaskets 16 and 17. The inner diameter D1 of this chamber is larger than the diameter Dpk of the opening for the shaft 7 in the rear compensation plate 6 and is D1=30mm. However, the outer diameter D2 of this cham-

ber is lower than the inner diameter D_{kwp} of the ring duct KP and is $D_2=33\text{mm}$. The compensation chamber KK is connected to the high-pressure working chambers KWC through the compensation holes OK (fig. 3 and fig. 4). The number of the holes OK equals the number of the humps on the curvature O. In the embodiment presented in figures, the number of the compensation holes OK is 6.

[0024] During the operation of the pump, the increase of the volume of the low-pressure working chamber KNC makes the pressure in the chamber lower than the pressure occurring in the pump connection A. As a result, the flow of liquid from the suction connection PS through the inner ducts KW through the ring duct KP and six suction holes OS is forced to the working chambers KNC. However, the fluid flows from the high-pressure working chambers KWC through discharge holes OT through the manifold 4 to the discharge connection PT located in the central body 2.

[0025] This solution allowed obtaining a pump with low inner leaks and high volumetric efficiency applicable mostly in high-pressure hydrostatic systems.

Example 2

[0026] A satellite pump was developed similarly to the method described above with such an exception that instead of the inner ducts KW of a circular cross-section, a lower number of kidney-shaped ducts with a larger area of the cross-section was applied.

[0027] As it was shown in fig. 6, the suction body KS, around the bearing 9 there are eight equally spaced kidney-shaped inner ducts KW measuring L each and at the same distance from the axis of the shaft 7, which in this case is 35mm. The shape of the ducts KW is defined by the outer D_{zkp} and inner D_{wkp} diameter of the ring duct KP. The length L of each duct is $1,25 \cdot (D_{zkp} - D_{wkp})$, which in this case are $D_{zkp} = 45\text{mm}$, $D_{wkp} = 35\text{mm}$ and $L = 12,5\text{ mm}$.

Claims

1. Satellite pump which body is divided into at least two parts constituting bodies, comprising a rear body (3), wherein a center body (2) is integrated with a front body (1) as one part or the center body (2) and the front body (1) are separate parts, the satellite pump comprises a shaft (7), a satellite pump mechanism comprising a planet (P) fitted in the middle section of the shaft, geared with numerous satellites (S) geared with a multi-humped external cam with numerous humps directed inwardly, constituting a curvature (O) whereby the satellites (S) are fitted between the curvature (O) and the planet (P), and also comprising a manifold (4), a front compensation plate (5), a rear compensation plate (6), at least two bearings (8, 9), at least two gaskets (10, 11) and a cover (12), **characterized in that**, the cover (1) seals at least one of

the bearings (9), whereby in the rear body (3) there is a suction duct (KS) placed coaxially with the rear body (3) and at least two inner ducts (KW) routed throughout the whole length of the rear body (3) and a ring duct (KP) routed in the rear body (3) adjacent to the rear compensation plate (6) situated between the satellite pump mechanism and the rear body (3) and coaxially with the shaft (7) and also comprising a ring-shaped compensation chamber (KK) which is adjacent to the rear compensation plate (6), whereby the suction duct (KS) has a diameter not larger than the inner diameter of the central body (2) in both cases when the front body (1) and the central body (2) constitute one part, and when the front body (1) and the central body (2) constitute two separate parts and moreover, the inner ducts (KW) connect the suction duct (KS) with the ring duct (KP) and the ring duct (KP) is connected with the suction holes routed in the rear compensation plate (6).

2. Pump according to the claim 1, wherein the suction duct (KS) cross-section is circular.
3. Pump according to the claim 1, wherein the suction duct's (KS) diameter is at least equal to the outer diameter of the bearing (9) fitted in the rear body (3).
4. Pump according to the claim 1, wherein the inner duct (KW) has a circular cross-section.
5. Pump according to the claim 1, wherein the inner diameter (D_1) of the compensation chamber (KK) is larger than the diameter (D_{pk}) of the opening for the shaft in the rear compensation chamber (6), and the outer diameter (D_2) of the compensation chamber (KK) is lower than the inner diameter (D_{wkp}) of the ring duct (KP).
6. Pump according the claims 1 or 2, wherein in the rear compensation plate (6) there is at least one compensation hole (OK) connecting the compensation chamber (KK) with any high-pressure working chamber in the satellite mechanism of the pump.
7. Pump according to the claim 1, wherein a center body (2) is integrated with a front body (1) as one part.

Patentansprüche

1. Satellitenpumpe, deren Körper in mindestens zwei Teile geteilt ist, die Körper darstellen, und einen hinteren Körper (3) umfassen, in dem ein zentraler Körper (2) mit einem Frontkörper (1) als ein Teil verbunden ist, oder der zentrale Körper (2) und der vordere Körper (1) getrennte Teile sind, die Satellitenpumpe umfasst eine Welle (7), einen Satelli-

- tenpumpenmechanismus, der einen Planeten (P) umfasst, der im mittleren Abschnitt der Welle eingebaut ist, mit zahlreichen Satelliten (S) ausgestattet, die mit einer Mehrvorsprung-Nocke mit zahlreichen, nach innen gerichteten Vorsprüngen ausgestattet sind, die eine Krümmung (O) bilden, wobei die Satelliten (S) zwischen der Krümmung (O) und dem Planeten (P) eingefügt sind, und der auch einen Verteiler (4) umfasst, eine vordere Ausgleichsplatte (5), eine hintere Ausgleichsplatte (6), mindestens zwei Lager (8, 9), mindestens zwei Dichtungen (10, 11) und eine Abdeckung (12), **dadurch gekennzeichnet, dass** die Abdeckung (1) mindestens eines der Lager (9) abdichtet, wobei im hinteren Körper (3) eine Saugleitung (KS) vorhanden ist, die koaxial mit dem hinteren Körper (3) angebracht ist, und mindestens zwei innere Leitungen (KW), die durch die gesamte Länge des hinteren Körpers (3) geführt werden, und eine Ringleitung (KP), die im hinteren Körper (3) geführt wird, neben der hinteren Ausgleichsplatte (6), angebracht zwischen dem Satellitenpumpenmechanismus und dem hinteren Körper (3), und koaxial mit der Welle (7), und der auch eine ringförmige Ausgleichskammer (KK) umfasst, die an der hinteren Ausgleichsplatte (6) anliegt, wobei die Saugleitung (KS) einen Durchmesser hat, der nicht größer als der Innendurchmesser des zentralen Körpers (2) in beiden Fällen ist, wenn der Frontkörper (1) und der zentrale Körper (2) ein Teil bilden, und wenn der Frontkörper (1) und der zentrale Körper (2) zwei getrennte Teile bilden, und darüber hinaus verbinden die inneren Leitungen (KW) die Saugleitungen (KS) mit der Ringleitung (KP), und die Ringleitung (KP) ist mit den Saugöffnungen verbunden, die in der hinteren Ausgleichsplatte (6) geführt werden.
2. Die Pumpe nach Anspruch 1, wobei der Querschnitt der Saugleitung (KS) kreisförmig ist.
 3. Die Pumpe nach Anspruch 1, wobei der Durchmesser der Saugleitung (KS) mindestens gleich dem Außendurchmesser des im hinteren Körper (3) eingebauten Lagers (9) ist.
 4. Die Pumpe nach Anspruch 1, wobei die innere Leitung (KW) einen kreisförmigen Querschnitt hat.
 5. Die Pumpe nach Anspruch 1, wobei der Innendurchmesser (D1) der Ausgleichskammer (KK) größer als der Durchmesser (Dpk) der Öffnung für die Welle in der hinteren Ausgleichskammer (6) ist, und der Außendurchmesser (D2) der Ausgleichskammer (KK) kleiner als der Innendurchmesser (Dwkp) der Ringleitung (KP) ist.
 6. Die Pumpe nach den Ansprüchen 1 oder 2, wobei in der hinteren Ausgleichskammer (6) mindestens eine Ausgleichsöffnung (OK) vorhanden ist, die die Aus-

gleichskammer (KK) mit einer beliebigen Hochdruckbetriebskammer im Satellitenmechanismus der Pumpe verbindet.

7. Die Pumpe nach Anspruch 1, wobei ein zentraler Körper (2) mit einem Frontkörper (1) als ein Teil verbunden ist.

10 Revendications

1. Pompe satellite dont le corps est divisé en au moins deux parties constituant des corps, comprenant un corps arrière (3), dans laquelle un corps central (2) est intégré à un corps avant (1) en une seule pièce ou le corps central (2) et le corps avant (1) sont des pièces distinctes, les pompes satellites comprennent un arbre (7), un mécanisme de pompe satellite comprenant une planète (P) montée dans la section centrale de l'arbre, engrené avec de nombreux satellites (S) qui sont eux-mêmes engrenés avec une came externe multi-bosses possédant de nombreuses bosses dirigées vers l'intérieur, constituant une courbure (O) par laquelle les satellites (S) sont montés entre la courbure (O) et la planète (P), et comprenant également un collecteur (4), une plaque de compensation avant (5), une plaque de compensation arrière (6), au moins deux paliers (8, 9), au moins deux joints (10, 11) et un couvercle (12), **caractérisée en ce que** le couvercle (1) scelle au moins l'un des paliers (9), dans lequel, dans le corps arrière (3), il y a un conduit d'aspiration (KS) placé coaxialement avec le corps arrière (3) et au moins deux conduits internes (KW) acheminés sur toute la longueur du corps arrière (3) et un conduit annulaire (KP) acheminé dans le corps arrière (3) adjacent à la plaque de compensation arrière (6) située entre le mécanisme de pompe satellite et le corps arrière (3) et coaxialement avec l'arbre (7) et comprenant également une chambre de compensation annulaire (KK) adjacente à la plaque de compensation arrière (6), le conduit d'aspiration (KS) ayant un diamètre qui n'est pas supérieur au diamètre intérieur du corps central (2) dans les deux cas où le corps avant (1) et le corps central (2) constituent une seule pièce et lorsque le corps avant (1) et le corps central (2) constituent deux parties distinctes et, en outre, les conduits intérieurs (KW) relient les conduits d'aspiration (KS) au conduit annulaire (KP) et le conduit annulaire (KP) est relié aux orifices d'aspiration pratiqués dans la plaque de compensation arrière (6).
2. La pompe selon la revendication 1, dans laquelle la section transversale du conduit d'aspiration (KS) est circulaire.
3. La pompe selon la revendication 1, dans laquelle le diamètre du conduit d'aspiration (KS) est au moins

égal au diamètre extérieur du palier (9) monté dans le corps arrière (3).

4. La pompe selon la revendication 1, dans laquelle le conduit intérieur (KW) a une section transversale circulaire. 5
5. La pompe selon la revendication 1, dans laquelle le diamètre intérieur (D1) de la chambre de compensation (KK) est supérieur au diamètre (Dpk) de l'ouverture pour l'arbre dans la chambre de compensation arrière (6), et le diamètre extérieur (D2) de la chambre de compensation (KK) est inférieur au diamètre intérieur (Dwkp) du conduit annulaire (KP). 10 15
6. La pompe selon les revendications 1 ou 2, dans laquelle dans la chambre de compensation arrière (6) se trouve au moins un trou de compensation (OK) reliant la chambre de compensation (KK) à une quelconque chambre de travail à haute pression dans le mécanisme satellite de la pompe. 20
7. La pompe selon la revendication 1, dans laquelle un corps central (2) est intégré à un corps avant (1) en formant une seule pièce. 25

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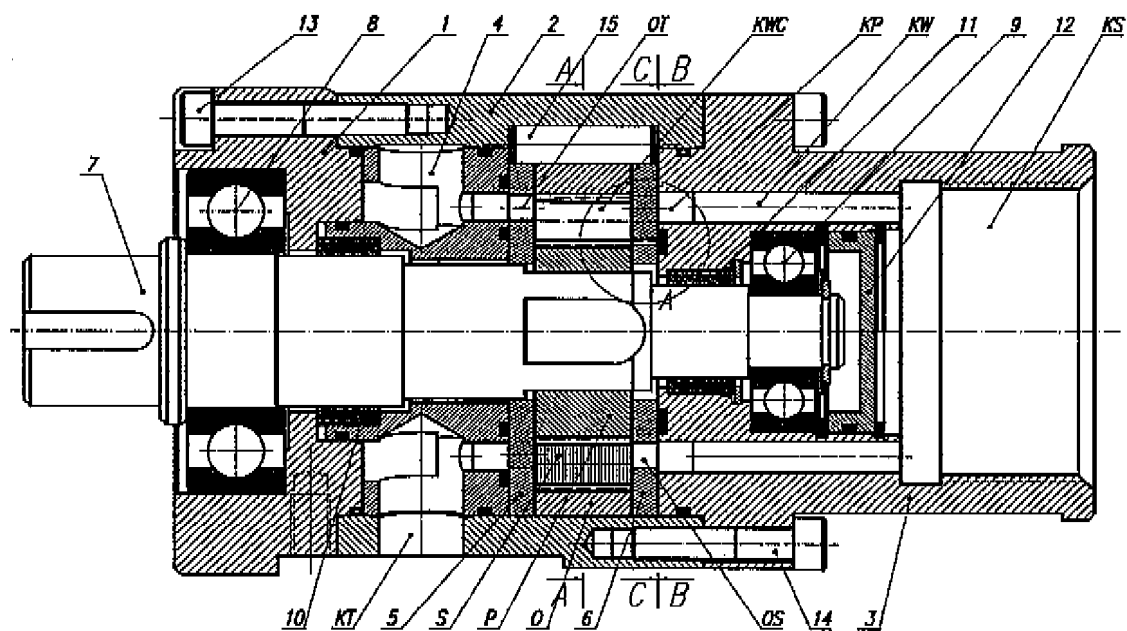


Fig. 1.

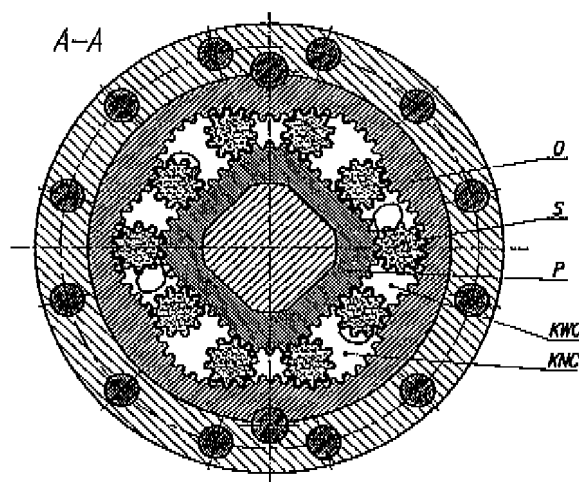


Fig. 2.

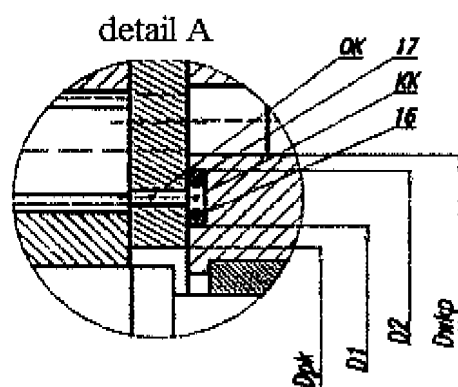


Fig. 3.

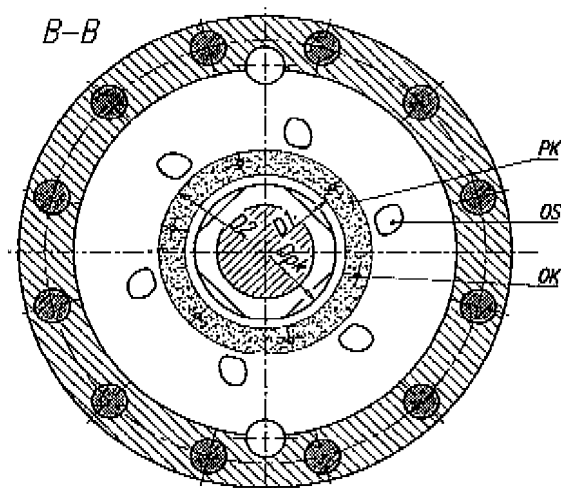


Fig. 4.

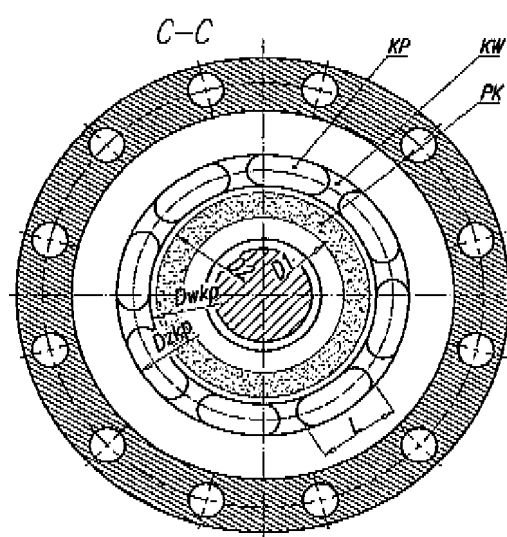


Fig. 6.

REFERENCES CITED IN THE DESCRIPTION

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