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(54) **Title**: CLUTCH ARRANGEMENT

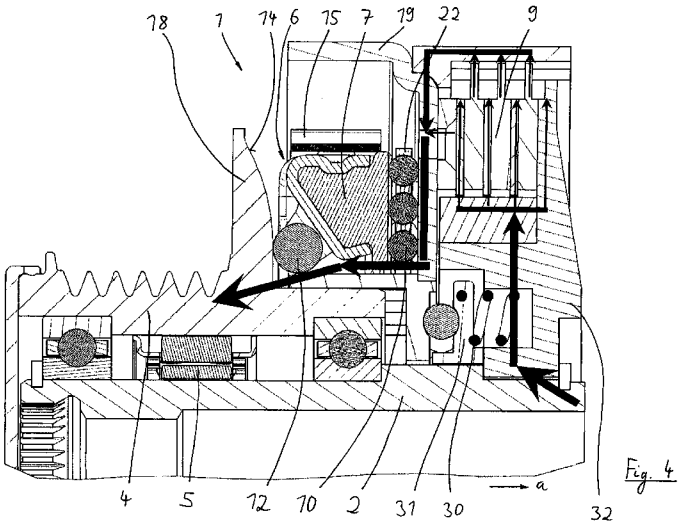

Fig. 4

(57) **Abstract**: The invention relates to a clutch arrangement (1) for coupling and decoupling of a shaft (2) which is connected with a starter-alternator (3) with a pulley (4), wherein a one-way clutch (5) is arranged between the shaft (2) and the pulley (4) to prevent a relative rotation between the shaft (2) and the pulley (4) when rotating in a first direction of rotation and to allow a free rotation between the shaft (2) and the pulley (4) when rotating in the opposite direction of rotation, wherein the clutch arrangement (1) comprises a centrifugal coupling element (6) which transmits a torque between the shaft (2) and the pulley (4) when the clutch arrangement (1) is not rotating and which transmits no torque between the shaft (2) and the pulley (4) when the clutch arrangement (1) is rotating with an operating speed, and wherein the centrifugal coupling element (6) comprises at least one centrifugal mass (7) which is forced radially outward due to centrifugal forces when the centrifugal coupling element (6) is rotating. To allow a precise controllable centrifugal coupling effect of the clutch arrangement, the invention is characterized in that the centrifugal coupling element (6) comprises means (8) for transferring the radial movement of the at least one centrifugal mass (7) into a movement in an axial direction (a) and wherein the means (8) for transferring the movement actuate a friction coupling element (9) by the axial movement, which friction coupling element (9) can transmit a torque between the shaft (2) and the pulley (4).

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Clutch Arrangement

Technical Field

The invention relates to a clutch arrangement for coupling and decoupling of a shaft which is connected with a starter-alternator with a pulley, wherein a one-way clutch is arranged between the shaft and the pulley to prevent a relative rotation between the shaft and the pulley when rotating in a first direction of rotation and to allow a free rotation between the shaft and the pulley when rotating in the opposite direction of rotation, wherein the clutch arrangement comprises a centrifugal coupling element which transmits a torque between the shaft and the pulley when the clutch arrangement is not rotating and which transmits no torque between the shaft and the pulley when the clutch arrangement is rotating with an operating speed, and wherein the centrifugal coupling element comprises at least one centrifugal mass which is forced radially outward due to centrifugal forces when the centrifugal coupling element is rotating.

Background

Such a clutch device is know from **EP 1 544 435 B1**. Here, centrifugal masses are arranged which are pressed outwardly when rotating. In this case a form-fit connection between two concentric coupling parts is released so that a relatively free rotation can take place. So, a coupling or de-coupling effect can take place depending on the speed of rotation of the centrifugal coupling element.

A preferred application of a coupling device is the torque connection between a pulley which is driven by a belt or a chain and a starter-alternator in an automotive.

Another solution for such a clutch device is shown in **WO 2010/079386 A1** and in **WO 2004/065811 A1**.

It has been found detrimental in the pre-known solutions that the sensitivity of the device is quite high and that the centrifugal coupling effect can vary depending on machine tolerances.

It is an object of the invention to propose a design for a clutch arrangement as defined above which works in a more stable manner and is not so sensitive with respect to tolerances as in the case of the state of the art. By doing so, it should specifically become possible to use an alternator of an automotive vehicle also as a starter for the combustion engine.

Summary of the invention

A solution according to the invention is characterized in that the centrifugal coupling element comprises means for transferring the radial movement of the at least one centrifugal mass into a movement in an axial direction and wherein the means for transferring the movement actuate a friction coupling element by the axial movement, which friction coupling element can transmit a torque between the shaft and the pulley.

Preferably, the means for transferring the radial movement of the at least one centrifugal mass into an axial movement comprise:

- the at least one centrifugal mass having first rolling or ball elements at a first face side facing the friction coupling element and having second rolling or ball elements at its other face side,

- a guiding surface being arranged at the pulley, which guiding surface is contacted by the second rolling or ball elements,

- at least one spring element which exerts a spring force onto the at least one centrifugal mass being directed radially inward,

wherein the guiding surface of the pulley has a radially inner section which is located at a first axial position relatively to the friction coupling element and which has a radially outer section which is located at a second axial position relatively to the friction coupling element, wherein the second axial position is arranged with bigger axial distance from the friction coupling element than the first axial position.

Thus, when the centrifugal masses of the centrifugal coupling element are forced radially outward they have to act against the force of the spring element. Due to the defined shape of the guiding surface the centrifugal masses which act with an axial force onto the friction coupling element relieve the axial pressure onto the same so that the friction coupling element opens and stops transmitting a torque between the shaft and the pulley.

Preferably, the guiding surface has a curved shape between the radially inner section and the radially outer section. Specifically, it can have a convex shape directed to the friction coupling element. A tangent of the guiding surface in the radial inner section directed radially inward is preferably arranged to the axis under an angle between 85° and 90°. A tangent of the guiding surface in the radial outer section being directed radially inward is preferably arranged to the axis under an angle between 55° and 75°.

Preferably, two, three or four centrifugal masses are arranged around the circumference of the means for transferring the movement. Each centrifugal mass can have the shape of a ring section which extends along a part of the circumference of the means for transferring the movement.

The pulley and a flange-like part bearing the guiding surface can be made as a one-piece part. Also, it is possible that the arrangement consisting of pulley and flange-like part is assembled by two pieces.

The spring element can consist of at least one curved steel strap which is fixed at a housing of the centrifugal coupling element. The steel strap can be fixed by pins at the housing of the centrifugal coupling element. The steel strap can have long holes for the fixation by the pins, to enable the steel strap to slide with its ends relatively to the housing where it is fixed by means of the pins in

circumferential direction. Preferably, a number of steel straps is arranged which corresponds to the number of centrifugal masses.

Each centrifugal mass can have one second rolling or ball element being a roller which axis is preferably directed into the circumferential direction of the guiding surface.

The first rolling or ball elements are preferably arranged in a plate element which is arranged at the first face side of the centrifugal mass which plate element forming a cage for the first rolling or ball elements.

The friction coupling element can comprise a plurality of friction plates, wherein a plurality of steel disks (or disks made from another material) is arranged between the friction plates. The friction plates can be rotationally coupled with the shaft or with the pulley while the steel disks are rotationally coupled with the pulley or with the shaft.

Furthermore, spring elements can be arranged between the steel disks and/or between the friction plates, which spring elements exert an elastic axial force between the steel disks and/or the friction plates. The spring elements can have a corrugated shape, seen in a radial cross section. They can extend in the circumferential direction along an angle of between 3° and 15°. The spring elements are preferably made from sheet metal.

By arranging the mentioned spring elements between the friction plates and/or between the steel disks, the plates and disks can be held at equal axial distances.

As now the centrifugal masses are – compared with the pre-known solution – arranged at a location which is significant further away from the axis, the centrifugal forces are not so sensitive to tolerances as in the case of the pre-known solution. The outer spring element forces the centrifugal masses radially inward. This spring force can be adjusted with precision. So, the clutch arrangement has a higher degree of stability compared with the pre-known solution. The arrangement works thus more stably and is not so sensitive with respect to tolerances.

Brief description of the drawings

The drawings show an embodiment of the clutch arrangement according to the invention.

Fig. 1 shows a cross sectional view of a starter-alternator of an automotive vehicle which is coupled with a clutch arrangement according to an embodiment of the invention,

Fig. 2 shows a perspective sectional view of the clutch device according to claim 1,

Fig. 3 shows a perspective view of a part of the clutch device,

Fig. 4 shows a cross sectional view of the clutch arrangement when the clutch arrangement is closed, i. e. when it is not rotating,

Fig. 5 shows a cross sectional view of the clutch arrangement when the clutch arrangement is opened, i. e. when it is rotating,

Fig. 6 shows a perspective sectional view of a part of the clutch arrangement, namely of the pulley with a flange-like part with a guiding surface,

Fig. 7 shows the centrifugal masses of the clutch arrangement when the clutch arrangement is not rotating and is thus closed,

Fig. 8 shows a cross sectional view of a part of the clutch arrangement when the clutch arrangement is not rotating and is thus closed,

Fig. 9 shows a cross sectional view of a part of the clutch arrangement when the clutch arrangement is rotating and is thus opened,

Fig. 10 shows the centrifugal masses of the clutch arrangement when the clutch arrangement is rotating and is thus opened,

Fig. 11 shows an exploded view of a friction coupling element of the clutch arrangement,

Fig. 12 shows a cross sectional view of the friction coupling element when the clutch arrangement is closed,

Fig. 13 shows a cross sectional view of the friction coupling element when the clutch arrangement is opened,

Fig. 14 shows an exploded view of a housing of the clutch arrangement and of a spring element and

Fig. 15 shows a perspective sectional view of the friction coupling element of the clutch arrangement.

Detailed description of the invention

In Fig. 1 a starter-alternator 3 of an automotive vehicle shown which has a central shaft 27. The starter-alternator 3 is connected with a clutch arrangement 1. More specifically, the shaft 27 of the starter-alternator 3 is rotationally coupled with a shaft 2 of the clutch arrangement 1. The clutch arrangement 1 has a pulley 4 which is driven by a – not depicted – belt.

To allow to use the starter-alternator 3 also as a starter for the combustion engine of the automotive vehicle, the clutch arrangement must have the ability to establish a torque transfer connection between the shaft 27 of the starter-alternator 3 with the pulley 4 when the combustion engine is to be started, i. e. when the clutch arrangement 1 does not rotate. When the combustion engine has started and is operating at a certain speed, the torque transfer connection between the shaft 27 of the starter-alternator 3 and the pulley 4 must be loosened.

For the second case, a one-way clutch 5 is arranged between the shaft 2 and the pulley 4 which is known as such and need not to be described here. In general, the one-way clutch 5 prevents a relative rotation between the shaft 2 and the pulley 4 when relatively rotating in a first direction of rotation and allows a free rotation between the shaft 2 and the pulley 4 when relatively rotating in the opposite direction of rotation.

The pulley 4 is supported by means of bearings 28, 29 relatively to the shaft 2.

Furthermore, a centrifugal coupling element 6 with centrifugal masses 7 is arranged which cooperates with means 8 for transferring the radial movement of the centrifugal masses 7 into an axial movement, i. e. into a movement in the direction of the axis a. This axial movement of the means 8 actuates a friction coupling element 9 which couples or de-couples the rotation of the shaft 2 with the pulley 4.

The means 8 for transferring the radial movement of the centrifugal masses 7 into an axial movement comprise firstly the centrifugal masses 7 themselves. Each centrifugal mass 7 is equipped with first ball elements 10 at a first face side 11, which faces the friction coupling element 9. The ball elements 10 are guided in a plate element 22 (see Fig. 12 and Fig. 13). Furthermore, each centrifugal mass 7 has a second rolling element 12 at its other face side 13.

Furthermore, a guiding surface 14 is arranged at a flange-like part 18 which is part of the pulley 4 or is connected with the same. The guiding surface 14 is contacted by the second rolling elements 12 of the centrifugal masses 7.

Furthermore, a spring element 15 is arranged which exerts a radially inward directed spring force onto the centrifugal masses 7 (the spring element 15 is specifically apparent in Fig. 3 and Fig. 14). The spring element 15 is fixed at a housing 19 of the centrifugal coupling element 6.

The spring element 15 has a certain preload in order to not allow a radially outward movement of the centrifugal masses 7 until a certain rotational speed of the system is achieved.

The clutch arrangement 1 is seen in a perspective sectional view in Fig. 2. In Fig. 3 the spring element 15 is shown, which in the depicted embodiment is a steel strap in the form of a closed non-circular curve

In Fig. 4 and Fig. 5 the situation is shown when the clutch arrangement is in its closed position (Fig. 4) and when it is in its opened position (Fig. 5). For the understanding of the function it is important that the guiding surface 14 has a specific form which is specifically depicted in Fig. 6.

Here it can be seen that the guiding surface 14 of the pulley 4 has a radially inner section 16 which is located at a first axial position a_1 relatively to the friction coupling element 9 and more specifically to an end plate 32 of the same (see Fig. 4 and 5).

Furthermore, it has a radially outer section 17 which is located at a second axial position a_2 relatively to the friction coupling element 9 and more specifically to an end plate 32 of the same (see Fig. 4 and 5).

The second axial position a_2 is arranged with a greater axial distance from the friction coupling element 9 and the end plate 32 respectively than the first axial position a_1.

Turning now back to Fig. 4 it can be seen here that the clutch arrangement 1 is engaged; thus the centrifugal masses 7 are in a radially inner position, forced by the spring elements 15. Due to the described shape of the guiding

surface 14 the rolling element 12 presses axially against the guiding surface 14 and as a counter-force against the centrifugal mass 7 and urges it to the right side in Fig. 4. This axial force is transferred by the ball elements 10 onto the left face side of the friction coupling element 9 which thus transfers a torque between the shaft 2 and the pulley 4.

The flow of torque – when the clutch arrangement 1 is closed – is shown by arrows in Fig. 4: The torque is transferred from the shaft 2 via a spline connection into steel disks (described later) and further into friction plates (described later) which are parts of the friction coupling element 9. The friction plates transfer the torque via spline connections further into the housing 19 of the centrifugal coupling element and via spline connections into the pulley 4.

A general pre-load of the arrangement is established by means of axial springs 30 which act onto a pressure plate 31. The axial springs 30 are supported by an end plate 32 which is fixed on the shaft 2.

When now the clutch element 1 rotates with an operation speed the centrifugal masses 7 are forces radially outward as shown in Fig. 5. The clutch arrangement loosens the torque connection between the shaft 2 and the pulley 4. This is the result of the fact that the centrifugal masses 7 travel to a position which is farther away from the axis a. Thus, the roller element 12 which is connected with the centrifugal mass 7 also attains a radial position which is farther away from the axis a. Due to the described shape of the guiding surface 14 the axial force between the guiding surface 14, the rolling element 10, the centrifugal mass 7, the ball elements 10 and the friction coupling element 9 is released. Consequently, the axial pressure between the

friction plates and steel disks of the friction coupling element 9 is also released so that the torque transmission is interrupted.

Thus, the centrifugal masses 7 travel in the radial direction as shown by the arrow in Fig. 5 and also to the left side axially as also shown by an arrow in Fig. 5.

In Fig. 6 is can be seen that the guiding surface 14 has a general convex shape which is directed towards the friction coupling element 9. When tangents to the guiding surface 14 are applied in the radial inner section 16 and the radial outer section 17 angles α and β can be defined under which the axis a is enclosed. The angle α is mostly between 85° and 90°. The angle β is preferably between 55° and 75°. The guiding surface 14 has a curved shape between the radial inner section 16 and the radial outer section 17.

The closed and opened position of the clutch arrangement 1 are also depicted in Figures 7 to 10.

In Fig. 7 the centrifugal masses 7 are shown when the clutch arrangement is not rotating. Fig. 8 shows the corresponding cross sectional view. When the clutch arrangement rotates the centrifugal masses 7 travel radially outwardly as shown in Fig. 10. Consequently, the centrifugal masses 7 can also travel to the left side in Fig. 9 and thus release the friction coupling element 9 (see arrows in Fig. 9 and Fig. 10)

Details of the friction coupling element 9 are shown in Figures 11, 12, 13, and 15.

The friction coupling element 9 consists of a plurality of friction plates 23 which are arranged axially movable but torque proof with the housing 33 of the friction coupling element 9. The torque proof connection is established by means of splines. Between the friction plates 23 steel disks 24 are arranged which are arranged axially movable, but rotationally fixed with the pulley 4. Also here the torque connection is established by means of splines.

To hold the friction plates 23 as well as the steel disks 24 at equal axial distances, a number of spring elements 25 and 26 is arranged in the radially outer and inner end of the friction plates 23 and steel disks 24 respectively. As can be seen best in Fig. 13 the spring elements 25, 26 have a corrugated shape, whereby the corrugations receive the outer and inner radius respectively of the friction plates 23 and the steel disks 24.

When the friction coupling element 9 is thus released, the friction plates 23 and the steel plates 24 adopt an equidistant spacing as shown in Fig. 13 for the opened clutch arrangement.

In Fig. 11 it can be seen that six spring elements 25, 26 are arranged around the circumference of the friction plates 23 and steel disk 24 respectively, each extending along approximately 5° to 10° of the circumference.

In Fig. 14 it can be seen how the spring elements 15 are arranged in the housing 19 of the arrangement. The curved steel strap 15 has long holes 21 at its ends, where it is fixed by means of pins 20 at the inner cylindrical circumference of the housing 19. The long holes 21 allow a certain movement of the axial ends in circumferential direction relatively to the housing 19.

The curved shape of the spring elements 15 define the spring force which is exerted onto the centrifugal masses 7.

The described starter-alternator operates as follows:

If the combustion engine of the automotive vehicle does not operate, i. e. if the speed of the crankshaft is zero, the clutch element comprising the centrifugal coupling element 6 and the friction coupling element 9 is engaged.

The spring elements 15 have enough force to press the second rolling elements 12 radially inward and thus to close the plates of the friction coupling element 9 in order to transmit enough torque for the engine start; the axial springs 30 are fully compressed in this status.

In between a speed of zero and a limit speed (roughly approximately between 450 and 500 rpm) the preload applied by the radial spring elements 15 is sufficient to lock the centrifugal masses 7 until the limit speed.

Then, there is a transition phase in between approximately 400 to 500 rpm and approximately 700 to 750 rpm where the engine starts pulling, so that the rotational speed of the pulley 4 rises and the centrifugal force of the centrifugal masses 7 overcomes the resistance of the radial spring elements 15, thus allowing the detachment of the friction coupling element 9.

The complete detachment of the friction clutch 9 occurs at around 650 to 700 rpm. This is in order to be sure that during the idling of the engine (assumed at around 700 to 750 rpm) the friction coupling element 9 is not working at all, thus allowing the normal working of the one-way clutch 5 to damp the engine vibrations on the belt.

Using the proper calibration of the spring elements 15 and the axial springs 30 in conjunction with the values of the centrifugal masses 7 and the profile of the pulley surface (i. e. of the guiding surface 14 forming a cam) also the return of the centrifugal masses 7 radially inward is guaranteed: When the engine stops, then the speed starts to go down; in the transition phase between approximately 700 and 500 rpm, the centrifugal masses 7 start to go back to their original position (i. e. in the most radially inward position).

Depending on the dynamics of the system, the centrifugal masses 7 will reach their radially inner position in a range between approximately 500 and 300 to 200 rpm, where a full torque transmission via the friction coupling element 9 is fully guaranteed (in this position the axial springs 30 are again fully compressed). So, a quick start of the engine is possible again, even if the complete stop of the engine is not acquired yet.

Reference Numerals:

1	Clutch arrangement
2	Shaft
3	Starter-Alternator
4	Pulley
5	One-way clutch
6	Centrifugal coupling element
7	Centrifugal mass
8	Means for transferring the movement
9	Friction coupling element
10	First rolling or ball element
11	First face side
12	Second rolling or ball element
13	Second face side
14	Guiding surface
15	Spring element (steel strap)
16	Radial inner section
17	Radial outer section
18	Flange-like part
19	Housing of the centrifugal coupling element
20	Pin
21	Long hole
22	Plate element
23	Friction plate
24	Steel disk
25	Spring element

26	Spring element
27	Shaft
28	Bearing
29	Bearing
30	Axial spring
31	Pressure plate
32	End plate
33	Housing

a	Axial direction
a_1	First axial position
a_2	Second axial position
α	Angle
β	Angle

Patent Claims:

1. Clutch arrangement (1) for coupling and decoupling of a shaft (2) which is connected with a starter-alternator (3) with a pulley (4),

wherein a one-way clutch (5) is arranged between the shaft (2) and the pulley (4) to prevent a relative rotation between the shaft (2) and the pulley (4) when rotating in a first direction of rotation and to allow a free rotation between the shaft (2) and the pulley (4) when rotating in the opposite direction of rotation,

wherein the clutch arrangement (1) comprises a centrifugal coupling element (6) which transmits a torque between the shaft (2) and the pulley (4) when the clutch arrangement (1) is not rotating and which transmits no torque between the shaft (2) and the pulley (4) when the clutch arrangement (1) is rotating with an operating speed, and

wherein the centrifugal coupling element (6) comprises at least one centrifugal mass (7) which is forced radially outward due to centrifugal forces when the centrifugal coupling element (6) is rotating,

characterized in that

the centrifugal coupling element (6) comprises means (8) for transferring the radial movement of the at least one centrifugal mass (7) into a movement in an axial direction (a) and wherein the means (8) for transferring the movement actuate a friction coupling element (9) by the axial movement, which friction coupling element (9) can transmit a torque between the shaft (2) and the pulley (4).

2. Clutch arrangement according to claim 1, characterized in that the means (8) for transferring the radial movement of the at least one centrifugal mass (7) into an axial movement comprise:

- the at least one centrifugal mass (7) having first rolling or ball elements (10) at a first face side (11) facing the friction coupling element (9) and having second rolling or ball elements (12) at its other face side (13),

- a guiding surface (14) being arranged at the pulley (4), which guiding surface (14) is contacted by the second rolling or ball elements (12),

- at least one spring element (15) which exerts a spring force onto the at least one centrifugal mass (7) being directed radially inward,

wherein the guiding surface (14) of the pulley (4) has a radially inner section (16) which is located at a first axial position (a_1) relatively to the friction coupling element (9) and which has a radially outer section (17) which is located at a second axial position (a_2) relatively to the friction coupling element (9), wherein the second axial position (a_2) is arranged

with a larger axial distance from the friction coupling element (9) than the first axial position (a_1).

3. Clutch arrangement according to claim 2, characterized in that the guiding surface (14) has a curved shape between the radial inner section (16) and the radial outer section (17).

4. Clutch arrangement according to claim 3, characterized in that the guiding surface (14) has a convex shape directed to the friction coupling element (9).

5. Clutch arrangement according to one of claims 2 to 4, characterized in that a tangent of the guiding surface (14) in the radially inner section (16) being directed radially inward is arranged to the axis (a) under an angle (α) between 85° and 90°.

6. Clutch arrangement according to one of claims 2 to 5, characterized in that a tangent of the guiding surface (14) in the radially outer section (17) being directed radially inward is arranged to the axis (a) under an angle (β) between 55° and 75°.

7. Clutch arrangement according to one of claims 1 to 6, characterized in that two, three or four centrifugal masses (7) are arranged around the circumference of the means (8) for transferring the movement.

8. Clutch arrangement according to claim 7, characterized in that each centrifugal mass (7) has the shape of a ring section which extends along a part of the circumference of the means (8) for transferring the movement.

9. Clutch arrangement according to one of claims 2 to 7, characterized in that the pulley (4) and a flange-like part (18) bearing the guiding surface (14) are made as a one-piece part.

10. Clutch arrangement according to one of claims 1 to 9, characterized in that the spring element (15) consist of at least one curved steel strap which is fixed at a housing (19) of the centrifugal coupling element (6).

11. Clutch arrangement according to claim 10, characterized in that the steel strap (15) is fixed by pins (20) at the housing (19) of the centrifugal coupling element (6).

12. Clutch arrangement according to claim 11, characterized in that the steel strap (15) have long holes (21) for the fixation by the pins (20).

13. Clutch arrangement according to one of claims 10 to 12, characterized in that a number of steel straps (15) is arranged which corresponds to the number of centrifugal masses (7).

14. Clutch arrangement according to one of claims 2 to 12, characterized in that each centrifugal mass (7) has one second rolling or ball element (12) being a roller which axis is preferably directed into the circumferential direction of the guiding surface (14).

15. Clutch arrangement according to one of claims 1 to 14, characterized in that the first rolling or ball elements (10) are arranged in a plate element (22) which is arranged at the first face side (11) of the centrifugal mass (7) which plate element (22) forming a cage for the first rolling or ball elements (10).

16. Clutch arrangement according to one of claims 1 to 15, characterized in that the friction coupling element (9) comprises a plurality of friction plates (23), wherein a plurality of steel disks (24) are arranged between the friction plates (23).

17. Clutch arrangement according to claim 16, characterized in that the friction plates (23) are rotationally coupled with the shaft (2) or with the pulley (4) and that the steel disks (24) are rotationally coupled with the pulley (4) or with the shaft (2).

18. Clutch arrangement according to claim 16 or 17, characterized in that spring elements (25, 26) are arranged between the steel disks (24) and/or between the friction plates (23), which spring elements (25, 26) exert an elastic axial force between the steel disks (24) and/or the friction plates (23).

19. Clutch arrangement according to claim 18, characterized in that the spring elements (25, 26) have a corrugated shape seen in a radial cross section.

20. Clutch arrangement according to claim 18 or 19, characterized in that the spring elements (25, 26) extend in the circumferential direction along an angle between 3° and 15°.

21. Clutch arrangement according to one of claims 18 to 20, characterized in that the spring elements (25, 26) are made from sheet metal.

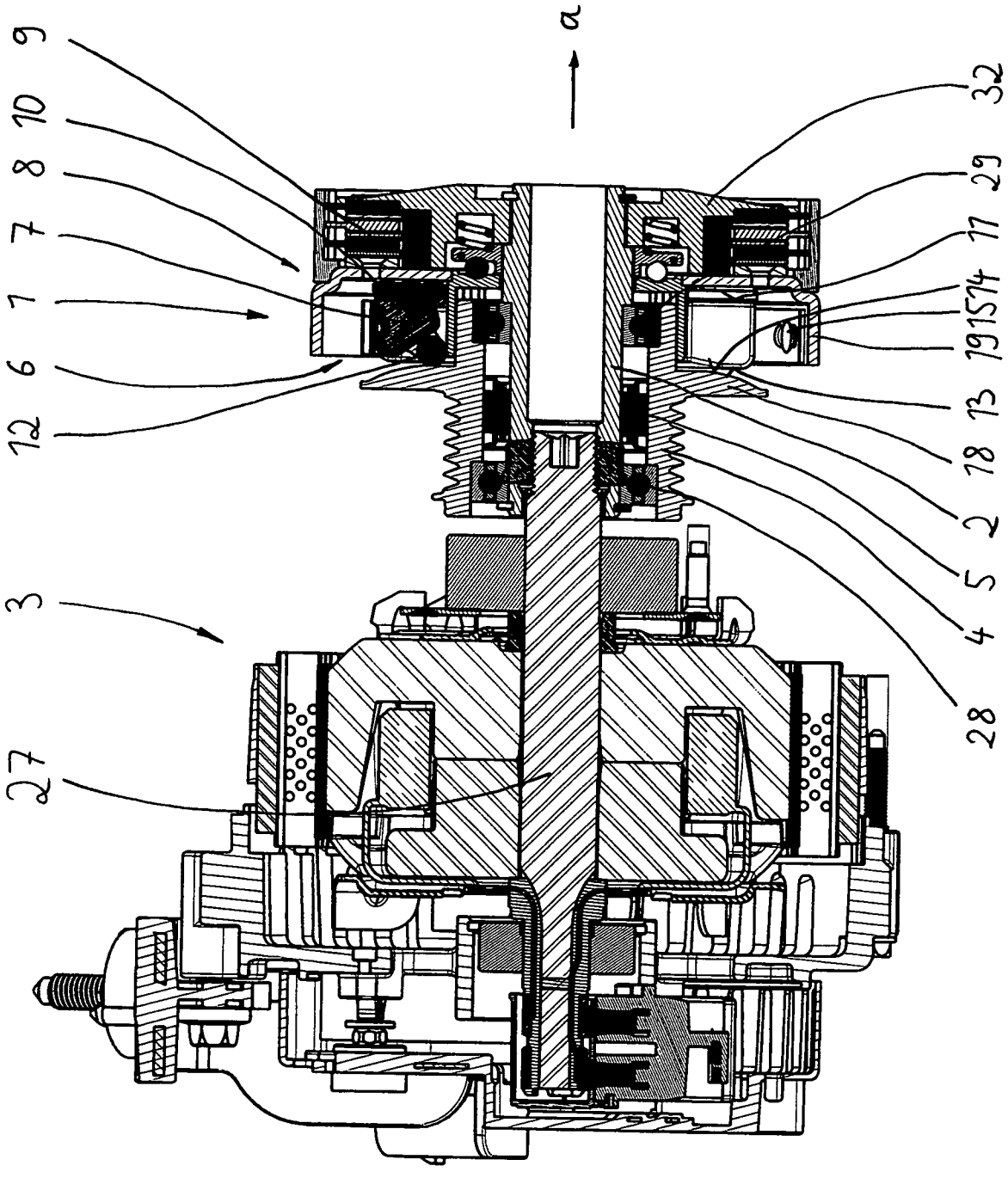


Fig. 1

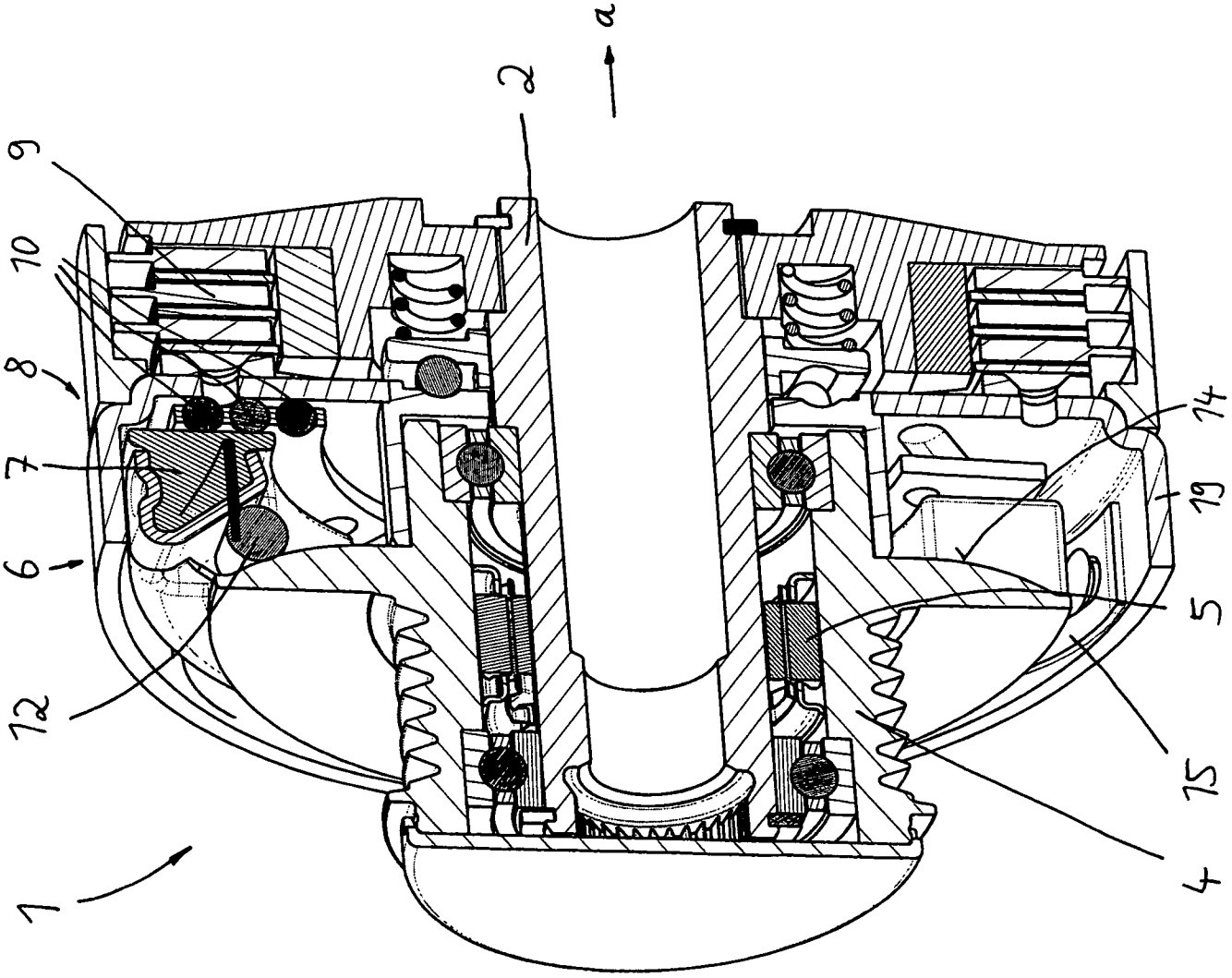


Fig. 2

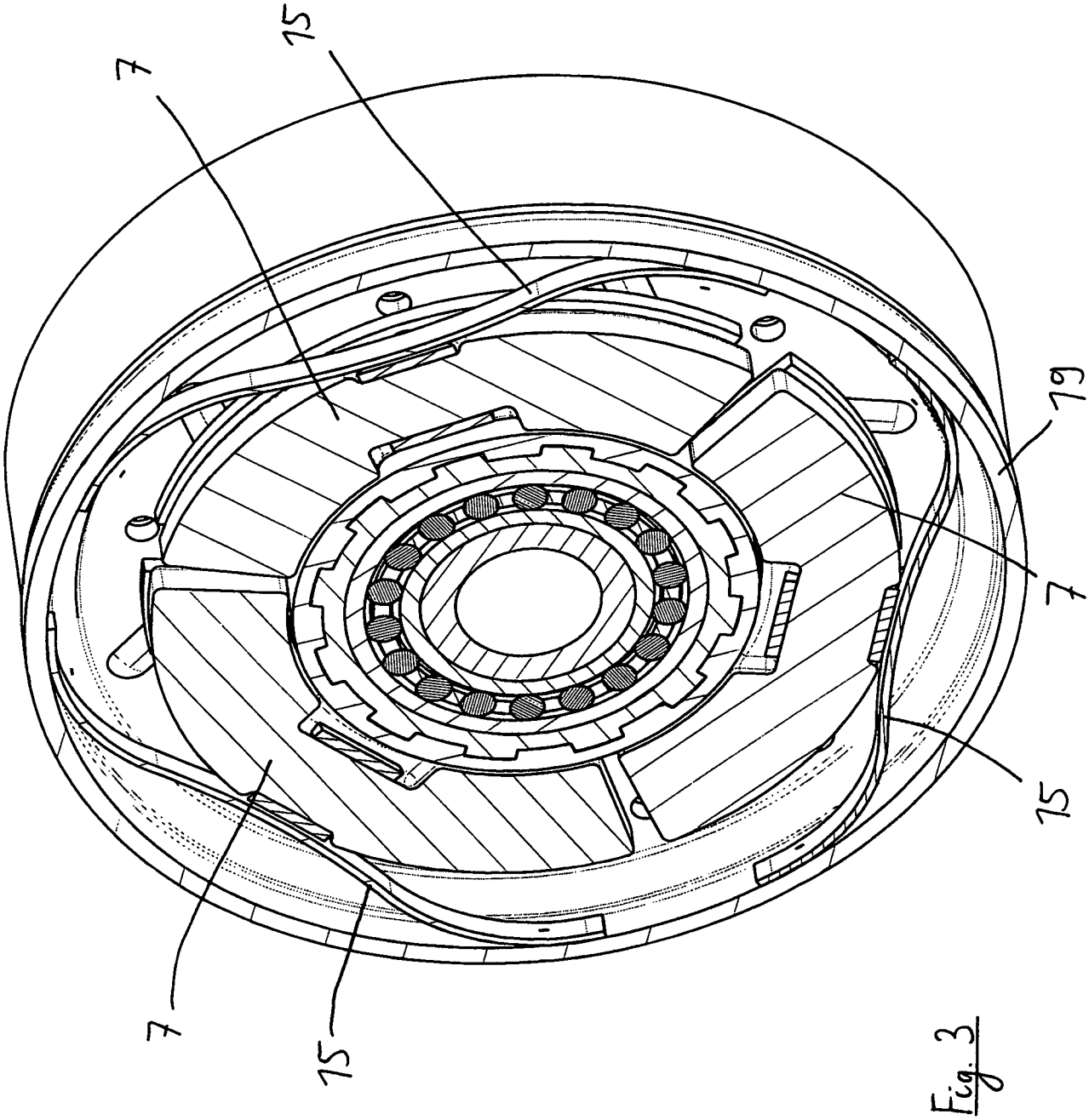


Fig. 3

Fig. 4

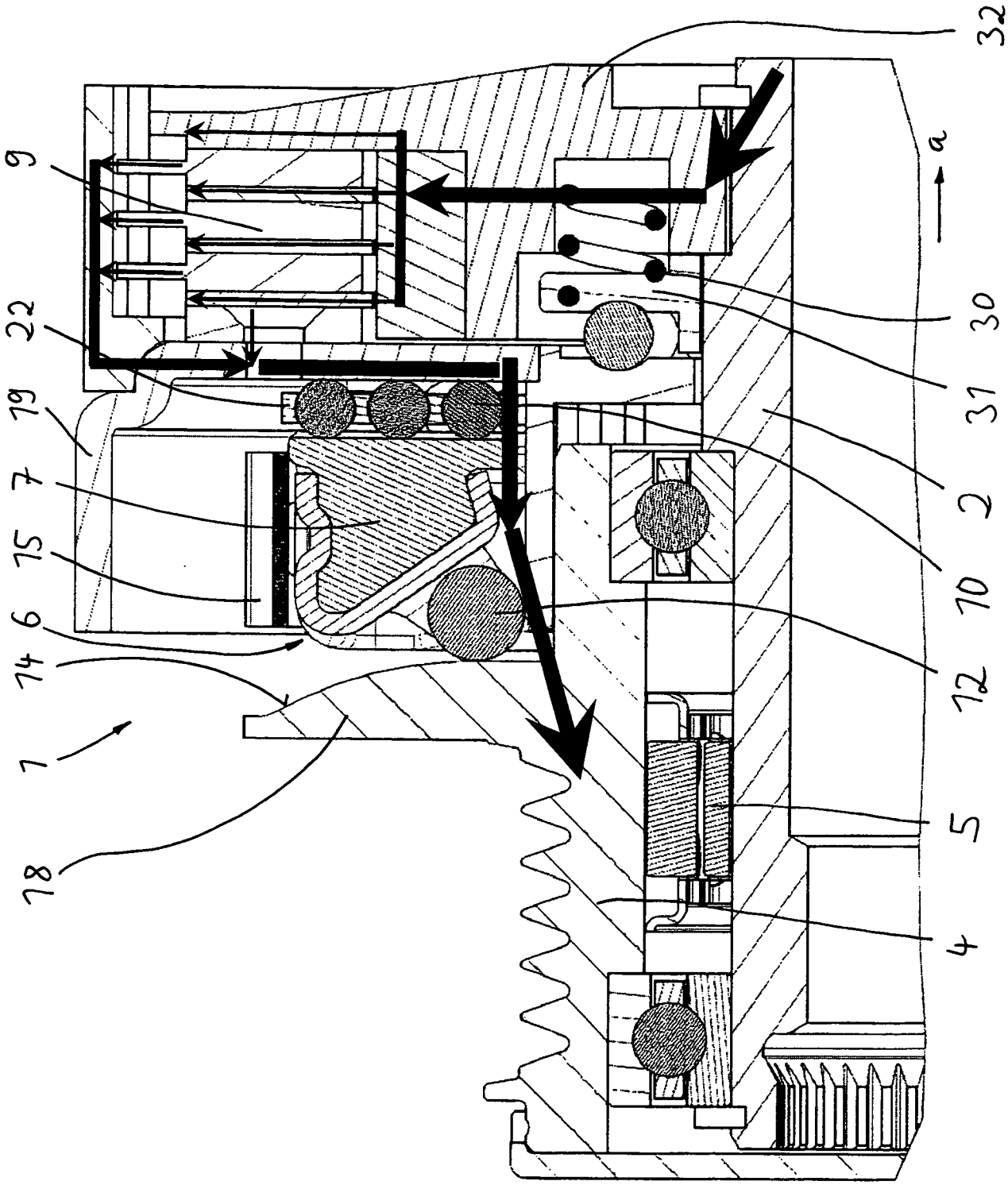
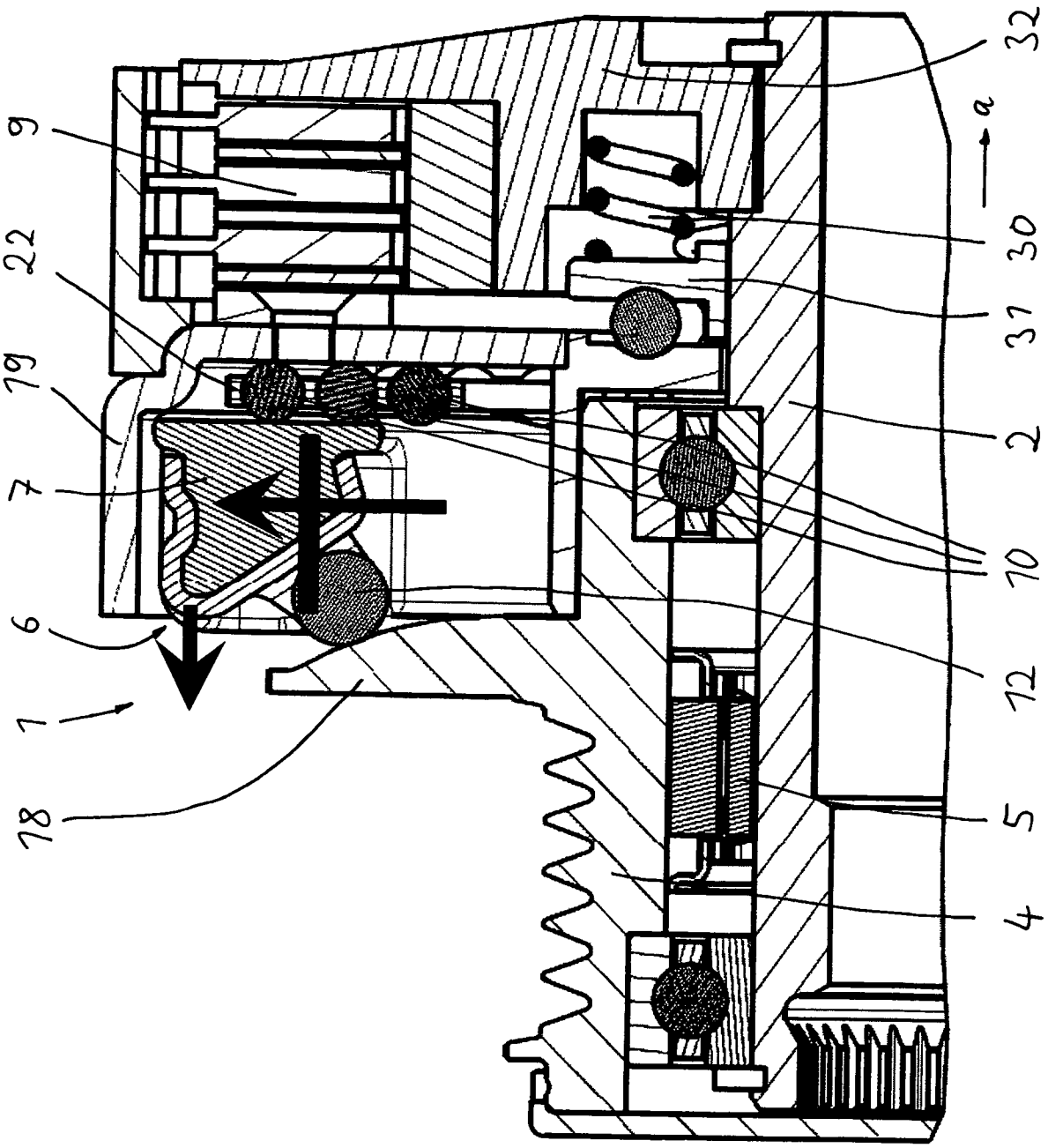


Fig. 5



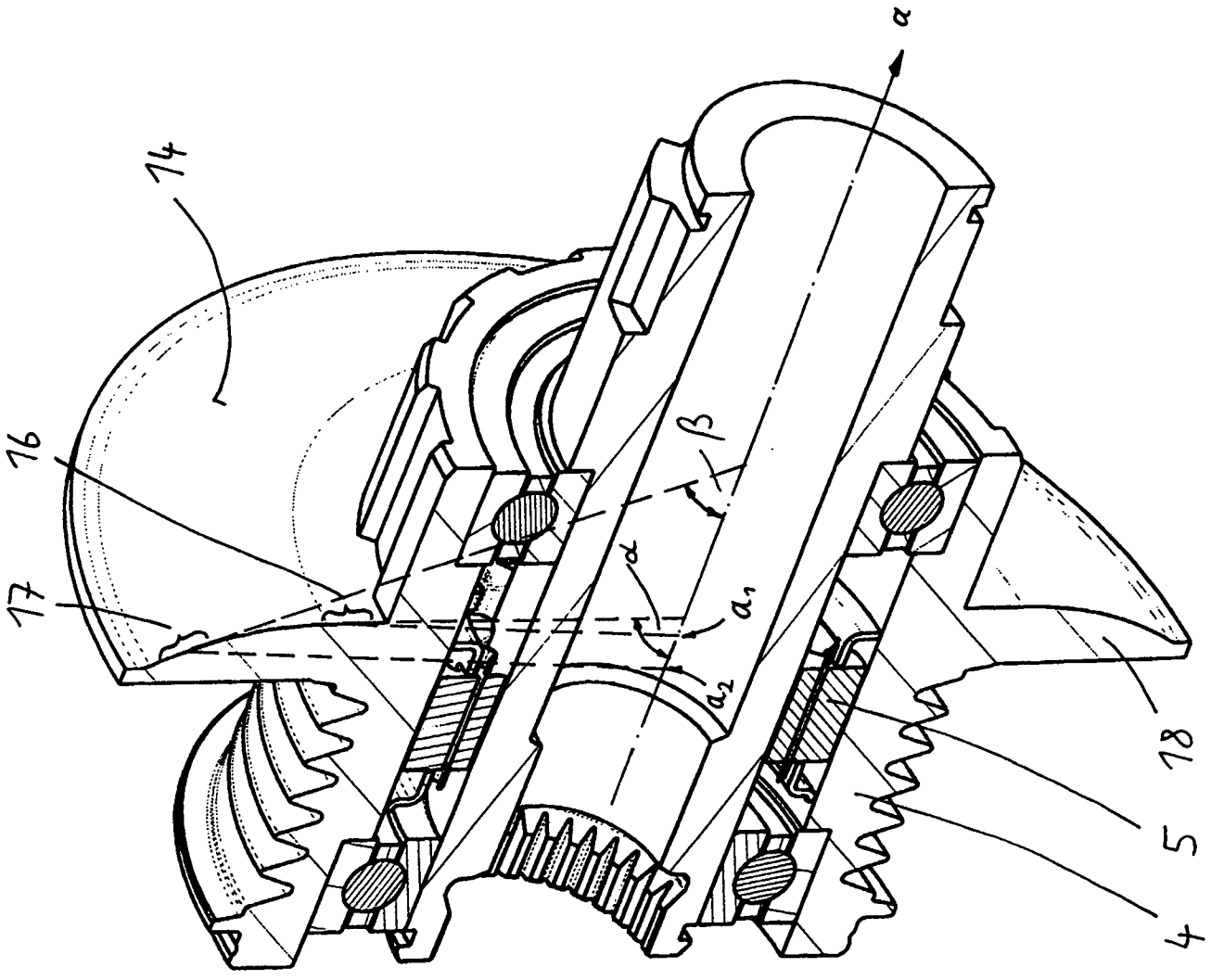


Fig. 6

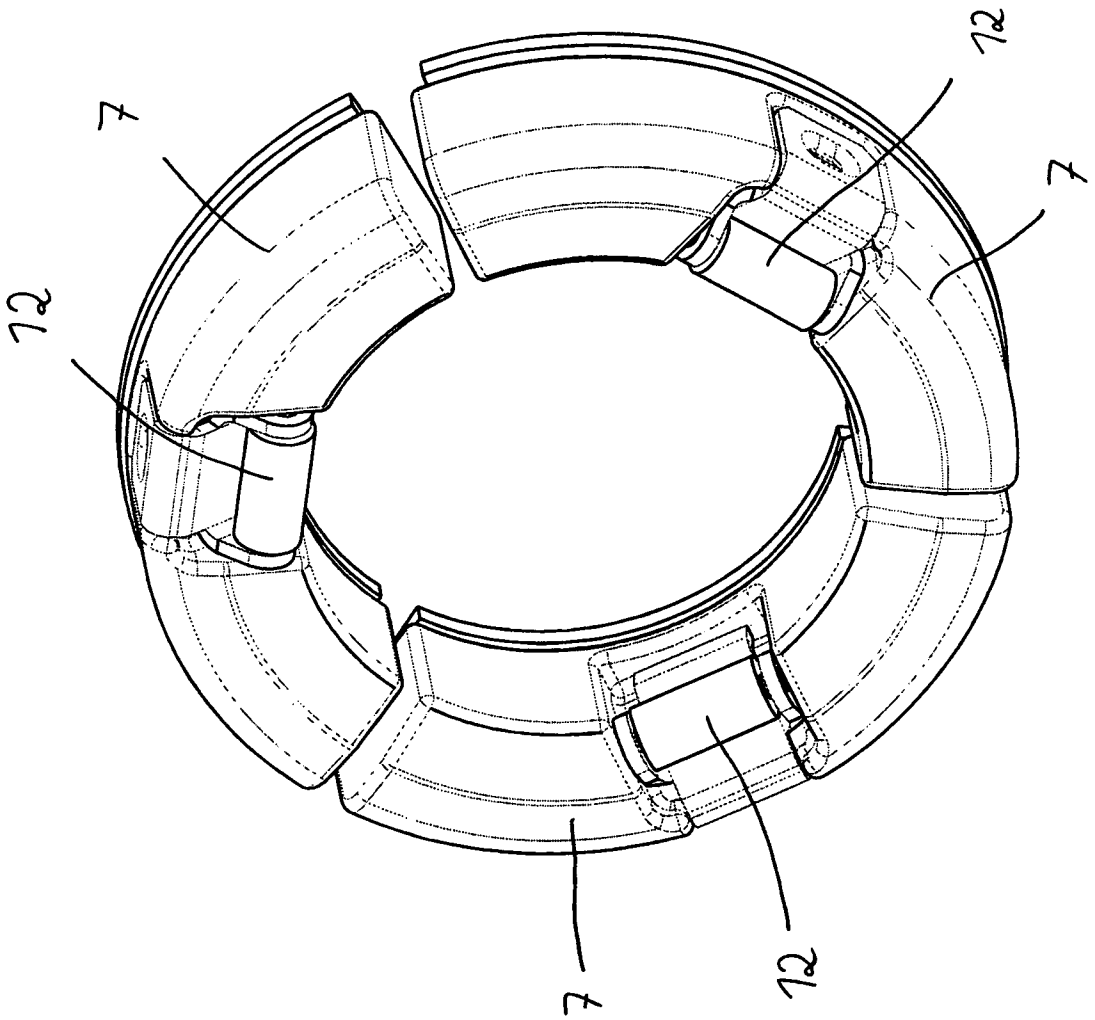


Fig. 7

Fig. 8

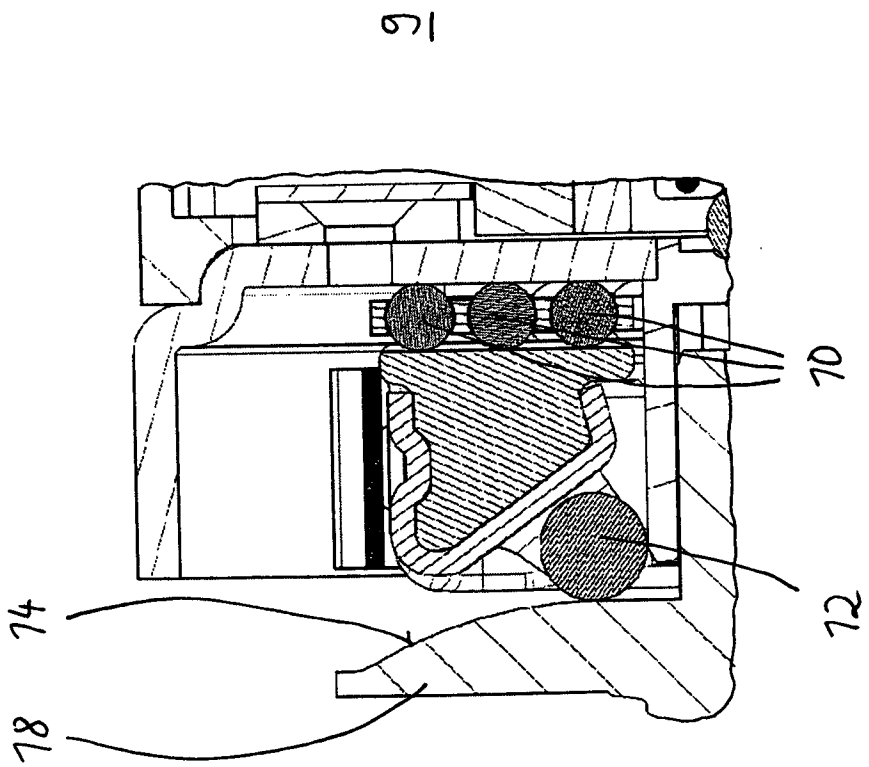
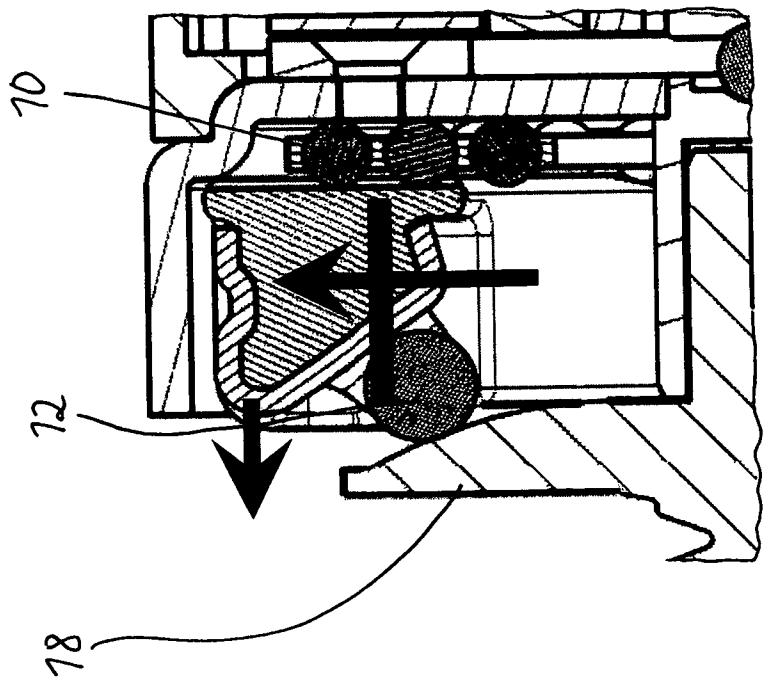


Fig. 9

9



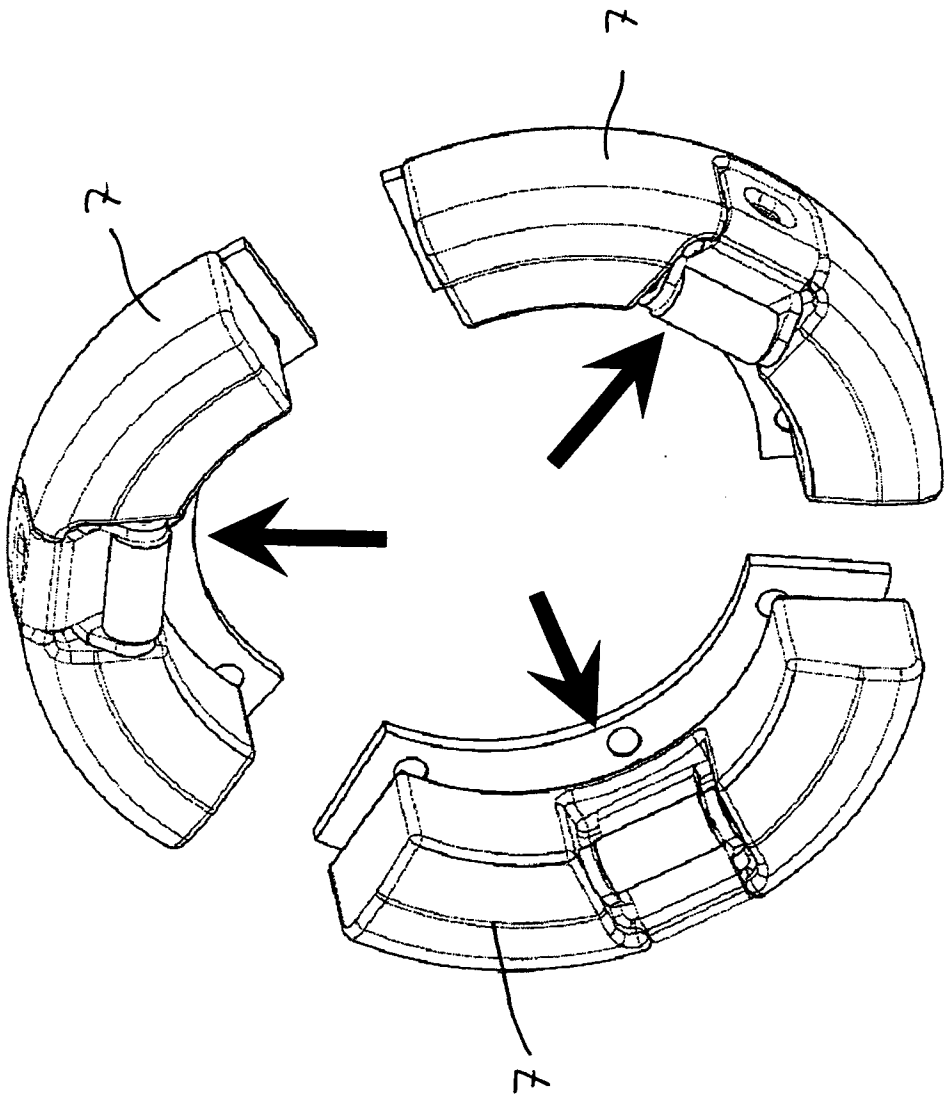


Fig. 10

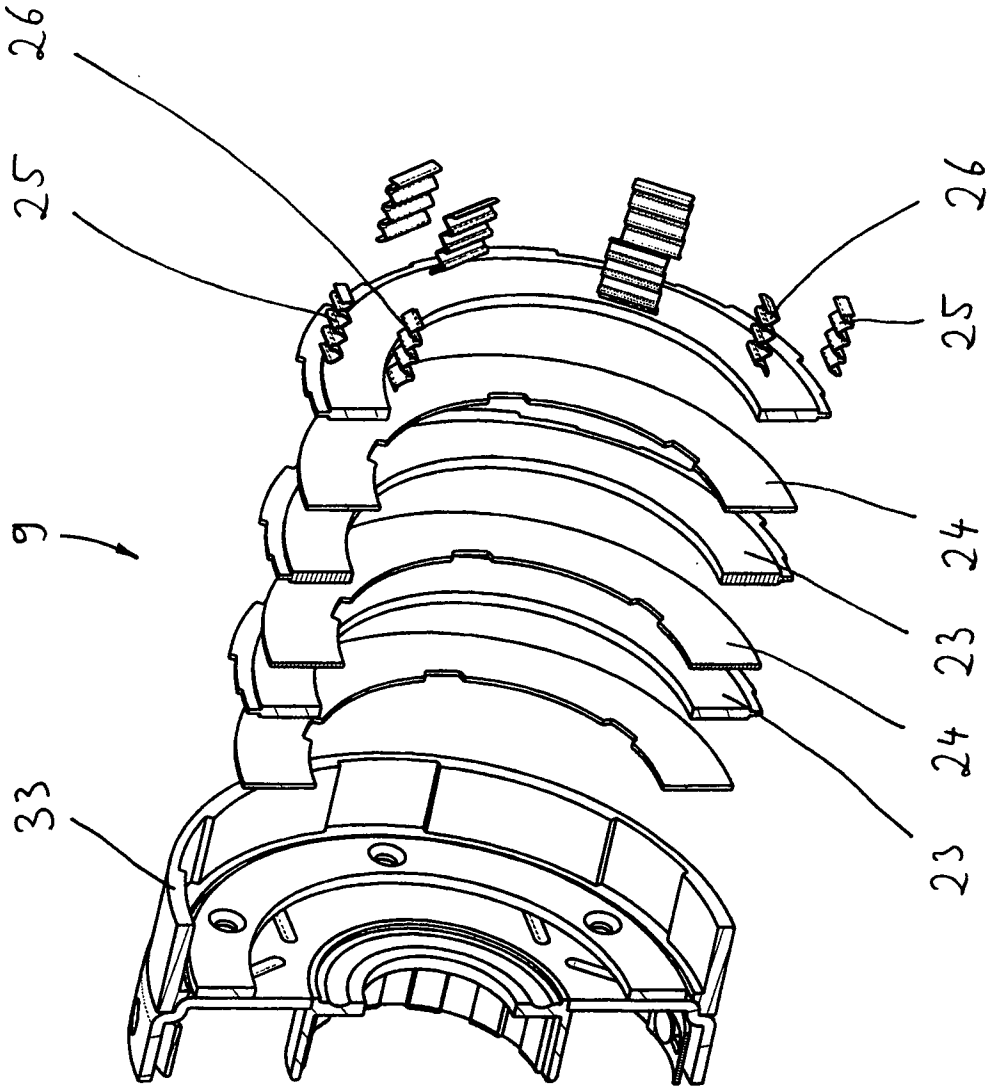


Fig. 11

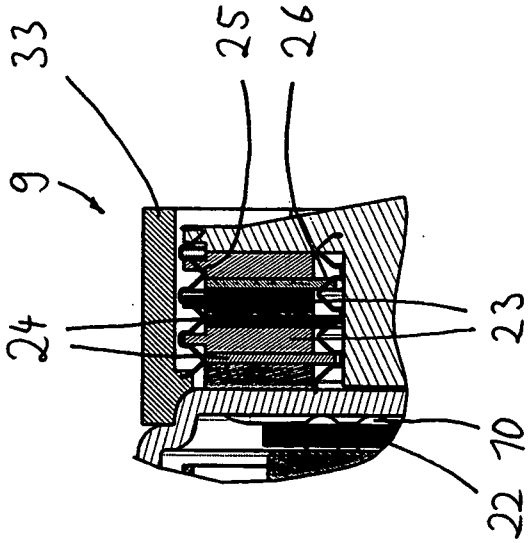


Fig. 12

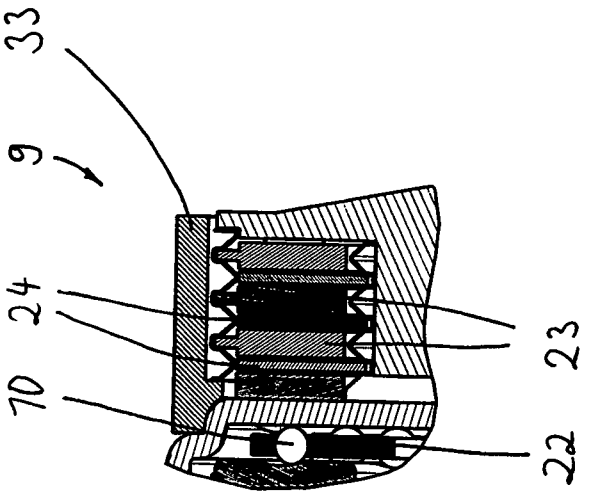


Fig. 13

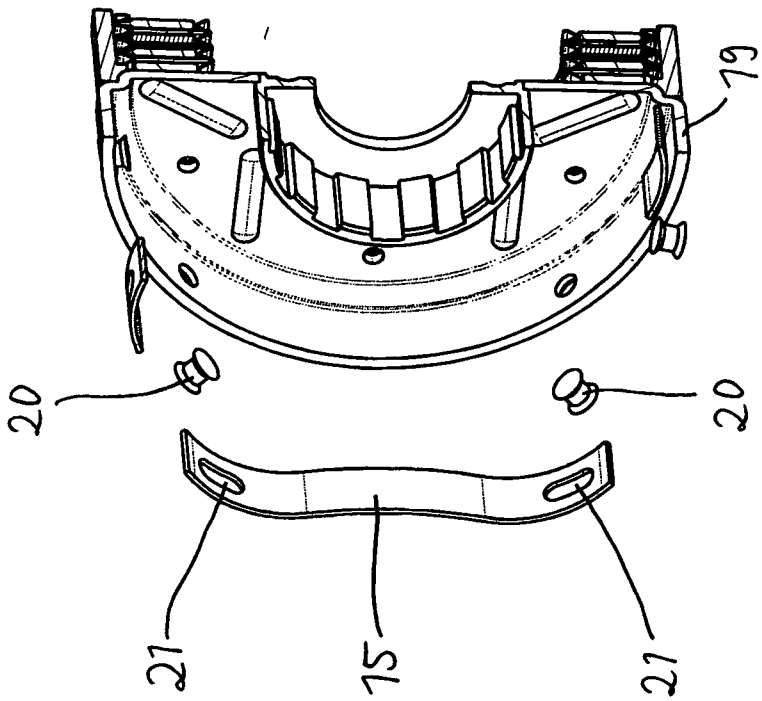


Fig. 14

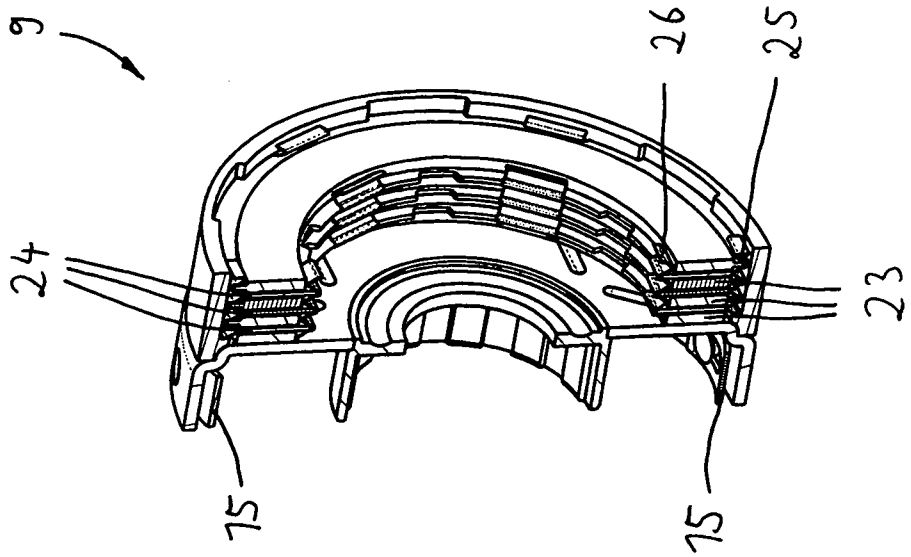


Fig. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/007868

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16D43/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16D F02N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2 432 591 A (SCHUCKERS JOHN M) 16 December 1947 (1947-12-16)	1
A	column 3; figures 1,2	2,16

Y	EP 1 544 435 A1 (INA SCHAEFFLER KG [DE] SCHAEFFLER KG [DE]) 22 June 2005 (2005-06-22) the whole document	1

A	US 3 051 284 A (FAWICK THOMAS L) 28 August 1962 (1962-08-28) figures 1,5,6,7	1,2

A	US 1 720 766 A (SPAHR MARTIN L) 16 July 1929 (1929-07-16) figures 1,2,4	1,2,7,8, 14,16

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 August 2011	11/08/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Székely, Zsolt

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/007868

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/308380 A1 (YOUNGWERTH ALBERT J [US] ET AL) 18 December 2008 (2008-12-18) figures 2-4	2-6

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/007868

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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EP 1544435 A1	22-06-2005	DE 10359632 A1	21-07-2005
US 3051284 A	28-08-1962	NONE	
US 1720766 A	16-07-1929	NONE	
US 2008308380 A1	18-12-2008	NONE	