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(54) Fuel pump for an internal combustion engine

(57) In a fuel pump for an internal combustion engine, a pumping device (28) is adapted to vary the volume of a first chamber (13) containing the fuel and is formed by a second chamber (20) adapted to contain oil, a deformable diaphragm (12) for the leak-tight separation of the chambers (13, 20) from one another, and by a piston (18) mounted to slide within the second chamber (20) and comprising an active end surface (19) bounding this second chamber (20); the diaphragm (12) being adapted to be deformed to vary the volume of the first chamber (13) under the action of the thrust exerted by the oil contained in the second chamber (20) following an alternating movement of the piston (18) within this second chamber (20).

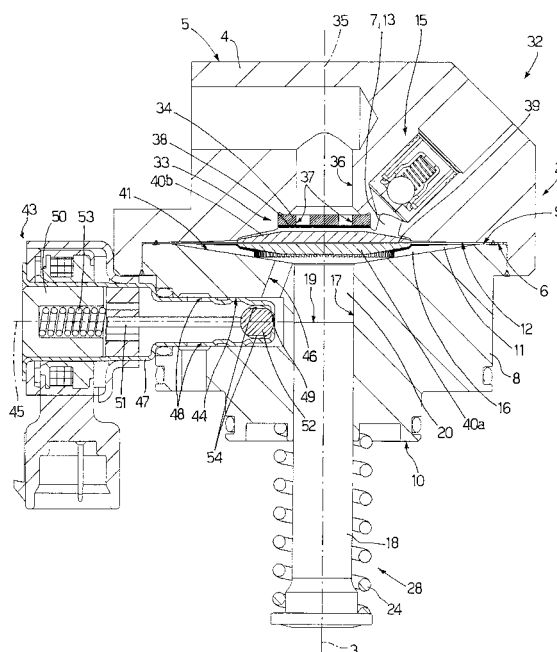


Fig.2

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Description

[0001] The present invention relates to a fuel pump for an internal combustion engine.

[0002] The present invention relates more particularly to a fuel pump for a unit for the direct injection of fuel, in this case petrol, to which the following description will refer without entering into superfluous detail.

[0003] In the sector of direct petrol injection units, it is known to use a petrol pump of the type comprising a cylinder having a predetermined longitudinal axis, a piston mounted to slide within the cylinder and actuator means adapted to provide the piston with an alternating rectilinear movement along this cylinder.

[0004] The piston comprises an active end surface which is disposed transversely with respect to the above-mentioned axis and defines, together with the cylinder, a first variable-volume chamber adapted to contain the petrol, is configured so as to define, together with the cylinder, a second chamber of substantially constant volume adapted to contain oil, and is lastly provided with an annular gasket keyed on the piston in order to separate the first chamber from the second chamber in a leak-tight manner.

[0005] Since the piston has to have a diameter substantially equal to a diameter of the cylinder in order to reduce leakage of the petrol and oil along the piston, known petrol pumps of the type described above have some drawbacks due chiefly to the fact that the contaminant particles which are inevitably present within the cylinder may cause the piston to jam within this cylinder.

[0006] Known pumps of the type described above also have a further drawback as the presence of the above-mentioned contaminant particles entails relatively high wear of the annular gasket.

[0007] US-5520523-A1 discloses a diaphragm-type pump including a disk-like diaphragm made of an elastic material which is held between an upper housing and a lower housing. In this diaphragm-type pump, the diaphragm, which has a flat shape before it is mounted in the pump, is bent along a diaphragm stopper and mounted in the pump; consequently, an urging force is constantly applied to the diaphragm in such a direction as to press it on the diaphragm stopper. The diaphragm is deformed in response to reciprocation of a plunger, and when the plunger reaches the bottom dead center and a cylinder chamber is decreased in pressure, the diaphragm is pressed on the diaphragm stopper by the urging force toward the diaphragm stopper and a feed pressure of a feed pump

[0008] US-6071089-A1 discloses a high pressure hydraulic diaphragm pump having a pressure chamber on one side of a diaphragm and a fluid delivery chamber on the other side of the diaphragm with a reciprocating piston assembly including a piston member being provided for pressurizing the hydraulic fluid in the pressure chamber and having the pressure chamber connected with a pressure regulator which maintains the desired

discharge pressure of the fluid and in which the piston assembly is combined with a diaphragm positioning mechanism for maintaining the diaphragm at a desired position relative to the piston member so as to assure full stroke of the diaphragm during normal operation of the pump

[0009] GB-849557-A discloses a hydraulically actuated diaphragm pump; a hydraulic pressure chamber is placed in communication with a hydraulic reservoir by means of a valve secured to a diaphragm and having a part open to the chamber and connecting with either of parts which communicate through valves with the reservoir so that excess liquid is discharged or deficiency made up. In the event of excess pressure on the pumping side of the diaphragm a face carried by the diaphragm seats on a face on the housing. The pumping chamber communicates through a pair of inlet valves with inlet conduits and through a pair of outlet valves with outlet conduits. The pump may comprise a plurality of diaphragm chambers.

[0010] US-6554578-B1 relates to a diaphragm pump with a device for controlling the position of a diaphragm separating the conveying chamber from the displacement chamber. As a replacement of the mechanical control of the refilling process, a pressure sensor is arranged in the displacement chamber, which is connected with an evaluation unit designed for generating a refill signal, which is switched so it actuates a refill valve through an operative connection; advantageously, a second sensor for detecting the piston travel is provided, whose signal is linked with the signal from the pressure sensor.

[0011] The object of the present invention is to provide a fuel pump for an internal combustion engine which is free from the drawbacks described above and is simple and economic to embody.

[0012] The present invention therefore relates to a fuel pump for an internal combustion engine as claimed in the attached claims.

[0013] The present invention is described below with reference to the accompanying drawings, which show non-limiting embodiments thereof, and in which:

Fig. 1 is a diagrammatic longitudinal section through a preferred embodiment of the fuel pump of the present invention;

Fig. 2 is a diagrammatic longitudinal section through a variant of the fuel pump of Fig. 1;

Fig. 3 is a plan view of a detail of Fig. 2.

[0014] In Fig. 1, a petrol pump for an internal combustion engine (not shown) of the direct petrol injection type is shown overall by 1.

[0015] The pump 1 comprises a cylindrical body 2 having a predetermined longitudinal axis 3 and comprising, in turn, a first plate 4 which is coaxial with respect to the axis 3, is limited axially by two plane surfaces 5, 6 at right angles to the axis 3 and has a cylindrical cavity

7 which opens externally at the location of the plate 6 and is closed by a second plate 8 disposed in contact with the surface 6 and secured to the plate 4.

[0016] The plate 8 is bounded axially by two plane surfaces 9, 10 at right angles to the axis 3, the surface 9 being disposed in contact with the surface 6 and having a cylindrical cavity 11 which is obtained through the plate 8 coaxially with respect to the axis 3, and opens externally at the location of the both the surface 9 and the surface 10.

[0017] The cavities 7 and 11 are separated from one another by means of a deformable diaphragm 12 which is made from stainless steel, is welded between the plates 4 and 8 at the location of its peripheral edge, and defines, together with the cavity 7, a variable-volume chamber 13 adapted to contain the petrol provided with an intake ball valve 14 and a delivery ball valve 15 of known type.

[0018] The cavity 11 comprises a widened portion 16 disposed in a position facing the diaphragm 12 and a contracted portion 17 engaged in a sliding manner by a piston 18 having an active end surface 19 which extends at right angles to the axis 3 in order axially to limit this piston 18 and defines, together with the cavity 11 and the diaphragm 12, a chamber 20 of substantially constant volume adapted to contain the oil of the engine (not shown).

[0019] The chamber 20 is provided with an intake valve 21 of known type adapted to supply the chamber 20 with a quantity of oil substantially equal to the quantity of oil emerging from this chamber 20 by drawing between the portion 17 and the piston 18 and therefore adapted to maintain the quantity of oil in the chamber 20 constant, and a maximum pressure valve 22 adapted to be disposed in an open position when the value of the oil pressure within the chamber 20 is substantially equal to a predetermined value.

[0020] The piston 18 may move along the portion 17 in order to perform, under the thrust of an actuation device 23, an alternating rectilinear movement comprising an outward stroke, during which the diaphragm 12 is displaced from an operational pumping position (shown by a continuous line in the accompanying Figure) to a rest position (shown in dashed lines in the accompanying Figure) and the volume of the chamber 13 increases in order to cause the opening of the intake valve 14, and a return stroke, during which the diaphragm 12 is displaced from its rest position to its operational pumping position and the volume of the chamber 13 decreases in order to cause the opening of the delivery valve 15.

[0021] The device 23 comprises a spring 24, which is keyed on the piston 18 coaxially with respect to the axis 3, and is interposed between the plate 8 and the piston 18 in order to provide this piston 18 with its outward stroke, and a cam 25 which is mounted in a rotary manner to rotate about its longitudinal axis 26 perpendicular to the axis 3, and cooperates with a tappet roller 27 coupled in a rotary and axially fixed manner to the piston 18

in order to provide this piston 18 with its return stroke.

[0022] The diaphragm 12, the chamber 20, the piston 18 and the actuation device 23 form a pumping device 28 adapted to use the oil in the chamber 20 to deform the diaphragm 12 and thus to vary the volume of the chamber 13. The deformation of the diaphragm 12 is controlled selectively by providing the diaphragm 12 and the piston 18 such that the value of the ratio between the surface of the diaphragm 12 and the surface of the face 19 is at least equal to five.

[0023] The opening of the valve 15 during the return stroke of the piston 18 and, therefore, the quantity of petrol supplied via the valve 15 at each operating cycle of the pump 1 are controlled selectively by a flow regulation device 29 comprising an electromagnetic actuator 30 mounted at the location of the valve 14. The actuator 30 comprises an output rod 31 which extends within the valve 14 parallel to the axis 3, and is mounted in a sliding manner in order to move between an operating position (shown in dashed lines in the accompanying Figure), in which the rod 31 is disposed so as to cause the opening of the valve 14, and a rest position (shown in continuous lines in the accompanying Figure), in which the rod 31 is disposed so as to enable the closure of the valve 14.

[0024] Since the valve 15 is calibrated so as to open, during the return stroke of the piston 18, only when the valve 14 is closed, the actuation of the actuator 30 makes it possible selectively to control the opening of this valve 15.

[0025] The operation of the pump 1 can be readily deduced from the above description and no further explanation is required.

[0026] The variant shown in Fig. 2 relates to a pump 32 which differs from the pump 1 in that the intake ball valve 14 is replaced by an intake valve 33 comprising a plate 34 which is mounted at right angles to a longitudinal axis 35 of a duct 36 supplying petrol to the chamber 13 and is provided with a plurality of supply holes 37 obtained through the plate 34 parallel to the axis 35, and a deformable sheet 38 which is secured to the plate 34 at its peripheral edge, is normally disposed in a position closing (Fig. 2) the holes 37, and moves, during the outward stroke of the piston 18, from the closed position to an open position (not shown) of these holes 37 in order to enable the petrol to enter the chamber 13.

[0027] The pump 32 also differs from the pump 1 in that the diaphragm 12 comprises a central portion 39 clamped between two substantially cup-shaped stiffening members 40, one of which (designated hereafter by 40a) is disposed in the chamber 13 and the other of which (designated hereafter by 40b) is disposed in the chamber 20.

[0028] As shown in Fig. 2, the member 40b is shaped so as to be disposed in contact, during the outward stroke of the piston 18, with a wall 41 bounding the chamber 20 and thus to control the deformation of the diaphragm 12 and is further provided with a plurality of radial channels 42 adapted to enable the oil to pass

through the member 40b when this member 40b is disposed in contact with the wall 41.

[0029] According to a variant which is not shown, the channels 42 are replaced by a plurality of supply channels obtained on the wall 41.

[0030] The pump 32 lastly differs from the pump 1 in that the intake valve 21, the maximum pressure valve 22 and the electromagnetic actuator 30 are replaced by a single electromagnetic valve 43 mounted within a cavity 44 which is provided in the plate 8, has a longitudinal axis 45 transverse to the axis 3 and communicates with the chamber 20 via a hole 46 obtained through this plate 8.

[0031] The valve 43 comprises an outer tubular jacket 47 which is substantially cup-shaped, is housed within the cavity 44 coaxially with respect to the axis 45, and is provided with a plurality of radial holes 48 uniformly distributed about the axis 45 in order to enable oil to be supplied into this jacket 47 and with an axial hole 49.

[0032] The jacket 47 is closed axially by an electromagnet 50 and houses a ball shutter 51 which is coupled in a sliding manner to the jacket 47 and has a ball 52 closing the hole 49. The shutter 51 and therefore the ball 52 are normally disposed, under the thrust of a spring 53 interposed between the electromagnet 50 and the shutter 51, in a position (Fig. 2) closing the hole 49, and are displaced by the electromagnet 50, against the action of the spring 53, into a position (not shown) opening the hole 49 in which the oil is supplied to the hole 49 by means of a plurality of supply channels 54 obtained on the outer surface of the ball 52 parallel to the axis 45.

[0033] In an initial phase of filling of the chamber 20, the electromagnet 50 is excited in order to displace the shutter 51 and therefore the ball 52 into their position opening the hole 49 so as to supply a predetermined initial quantity of oil to the hole 46 and therefore to the chamber 20. The initial quantity of oil supplied to the chamber 20 may be maintained constant, in use, by selectively opening the valve 43 in order to supply the chamber 20 with a quantity of oil substantially equal to the quantity of oil emerging from time to time from the chamber 20 as a result of leakage between the portion 17 and the piston 18.

[0034] It will be appreciated from the above that the pressure exerted on the diaphragm 12 during the return stroke of the piston 18 and therefore the displacement of the diaphragm 12 from its rest position to its operational pumping position, i.e. the opening of the delivery valve 15, depend on the quantity of oil contained in the chamber 20 and are selectively controlled by means of the valve 43.

[0035] The positioning of the valve 43 within the oil supply circuit to the chamber 20 makes it possible to supply the petrol suctioned into the chamber 13 directly to the delivery valve 15 and to prevent, in contrast to what happens when using the electromagnetic actuator 30, the losses of energy deriving from the reflux of the petrol suctioned into the chamber 13 through the intake

valve 14.

[0036] The spring 53 is also calibrated so as to thrust the shutter 51 into its position closing the hole 49 with a force which is in all cases lower than the force of opposite direction exerted on the shutter 51 by the oil contained in the chamber 20 and in the hole 46 when the value of the pressure of the oil in the chamber 20 is substantially equal to a predetermined value. In this way, the oil is discharged through the holes 48 thus avoiding breakages of the diaphragm 12.

Claims

1. A fuel pump for an internal combustion engine; which pump comprises:

a first variable-volume chamber (13) adapted to contain fuel, this first chamber (13) being provided with an intake valve (14) and a delivery valve (15);

pumping means (28) to vary the volume of the first chamber (13) and comprising a second chamber (20) adapted to contain oil, a piston (18) mounted to slide within the second chamber (20), actuator means (23) adapted to provide the piston (18) with an alternating movement within this second chamber (20), and separator means (12) to separate the first and second chambers (13, 20) from one another in a leak-tight manner; wherein the piston (18) has an active end surface (19) bounding the second chamber (20), and the separator means (12) comprise a deformable diaphragm (12) adapted, in use, to be deformed to vary the volume of the first chamber (13) under the action of the thrust exerted by the oil contained in the second chamber (20) following the alternating movement of the piston (18) within this second chamber (20); and

at least one stiffening member (40a, 40b) secured to a central portion (39) of the diaphragm (12), mounted within the second chamber (20) and adapted to be disposed, in use, in contact with a wall (41) bounding this second chamber (20);

the fuel pump is **characterised in that** the second chamber (20) is provided with a plurality of channels (42) for the passage of the oil provided through the stiffening member (40a, 40b).

2. A fuel pump as claimed in claim 1, in which the diaphragm (12) and the active surface (19) of the piston (18) comprise a first and second surface respectively, the ratio between the first and the second surface being at least equal to five.
3. A fuel pump as claimed in claim 1 or 2, in which the

second chamber (20) is provided with a maximum pressure valve (22) adapted to be disposed in an open position when the value of the pressure of the oil within the second chamber (20) is substantially equal to a predetermined value.

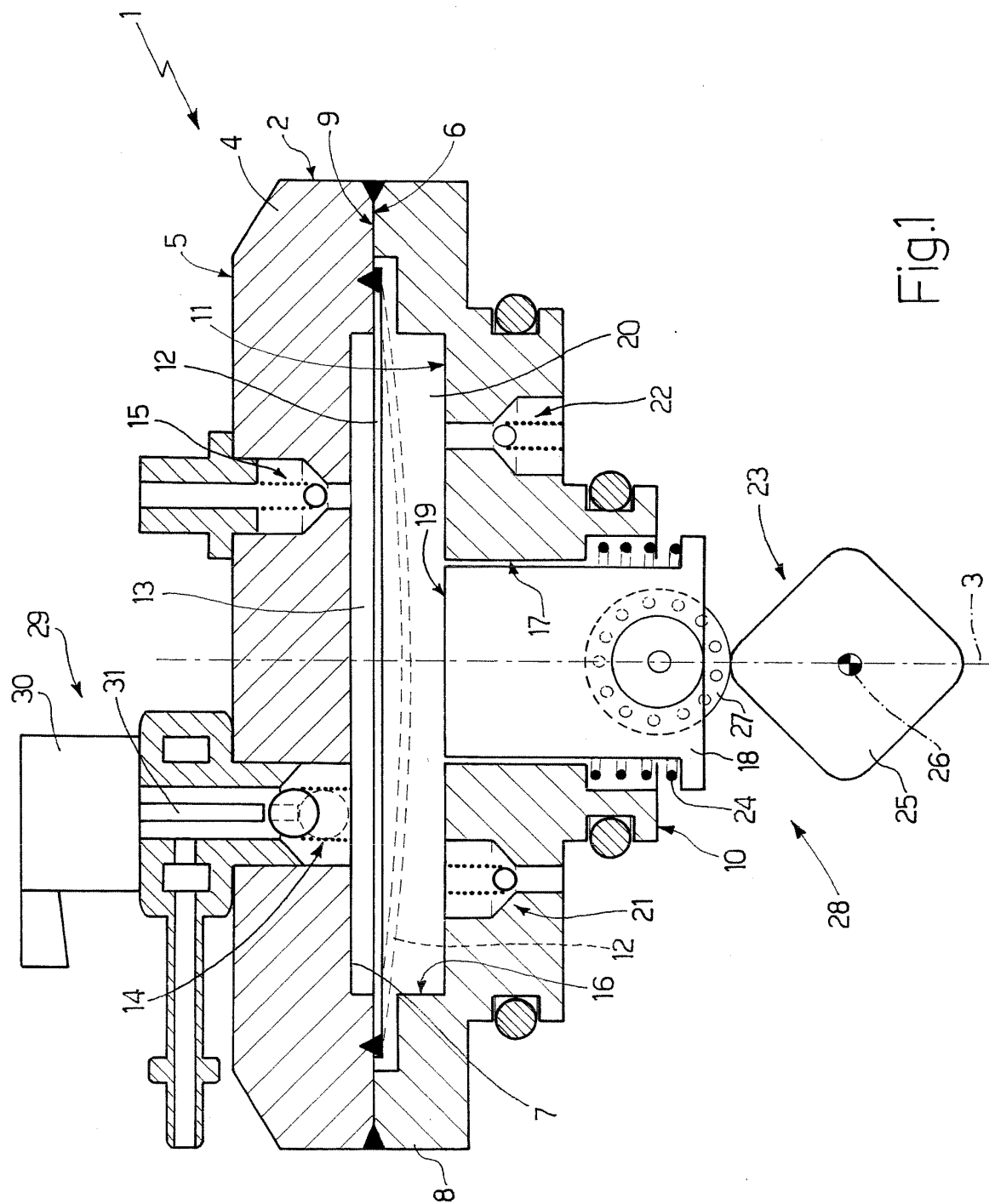
4. A fuel pump as claimed in any one of the preceding claims, in which the diaphragm (12) is a steel diaphragm. 5
5. A fuel pump as claimed in any one of the preceding claims, in which the alternating movement of the piston (18) comprises an outwards stroke and a return stroke, the actuator means (23) comprising first thrust means to provide the piston (18) with its out- 10
ward stroke and second thrust means to provide the piston (18) with its return stroke. 15
6. A fuel pump as claimed in claim 5, in which the first thrust means comprise resilient thrust means. 20
7. A fuel pump as claimed in claim 5 or 6, in which the second thrust means comprises a cam and a tappet roller (27) mounted on the piston (18) and cooperating with this cam (25). 25
8. A fuel pump as claimed in any one of the preceding claims, in which the second chamber (20) is provided with a further intake valve (21) adapted to maintain a quantity of oil contained in this second chamber (20) substantially constant. 30
9. A fuel pump as claimed in any one of the preceding claims, in which the alternating movement of the piston (18) comprises an outward stroke to increase 35
the volume of the first chamber (13) and control the opening of the intake valve (14) and a return stroke to decrease the volume of the first chamber (13) and enable the opening of the delivery valve (15), flow regulation means (29; 43) being provided in order 40
selectively to control the opening of the delivery valve (15) during the return stroke.
10. A fuel pump as claimed in claim 9, in which the flow regulation means (29) comprises further actuator 45
means (30) adapted to open the intake valve (14) during the return stroke, the delivery valve (15) being configured to open, during the return stroke, only when the intake valve (14) is closed. 50
11. A fuel pump as claimed in claim 10, in which the further actuator means (30) comprise an electro- 55
magnetic actuator.
12. A fuel pump as claimed in claim 9, in which the flow regulation means (43) comprise a supply valve (43) adapted selectively to control the supply of oil to the second chamber (20).

13. A fuel pump as claimed in claim 12, in which the supply valve (43) comprises a shutter (51), third thrust means (53) adapted normally to maintain the shutter (51) in a position closing the supply valve (43) and fourth thrust means (50) adapted to dis-
place the shutter (51) from the closed position to an open position of the supply valve (43).

14. A fuel pump as claimed in claim 13, in which the fourth thrust means (50) comprise a further electro-
magnetic actuator.

15. A fuel pump as claimed in claim 13 or 14, in which the third thrust means (53) are calibrated in order to maintain the shutter (51) in the closed position with a force which is in all cases lower than the force of opposite direction exerted on the shutter (51) by the oil contained in the second chamber (20) when the value of the pressure of the oil within this second chamber (20) is substantially equal to a predetermined value.

16. A fuel pump as claimed in any one of the preceding claims, in which the second chamber (20) is provided with a plurality of channels (42) for the passage of the oil provided on the wall (41).



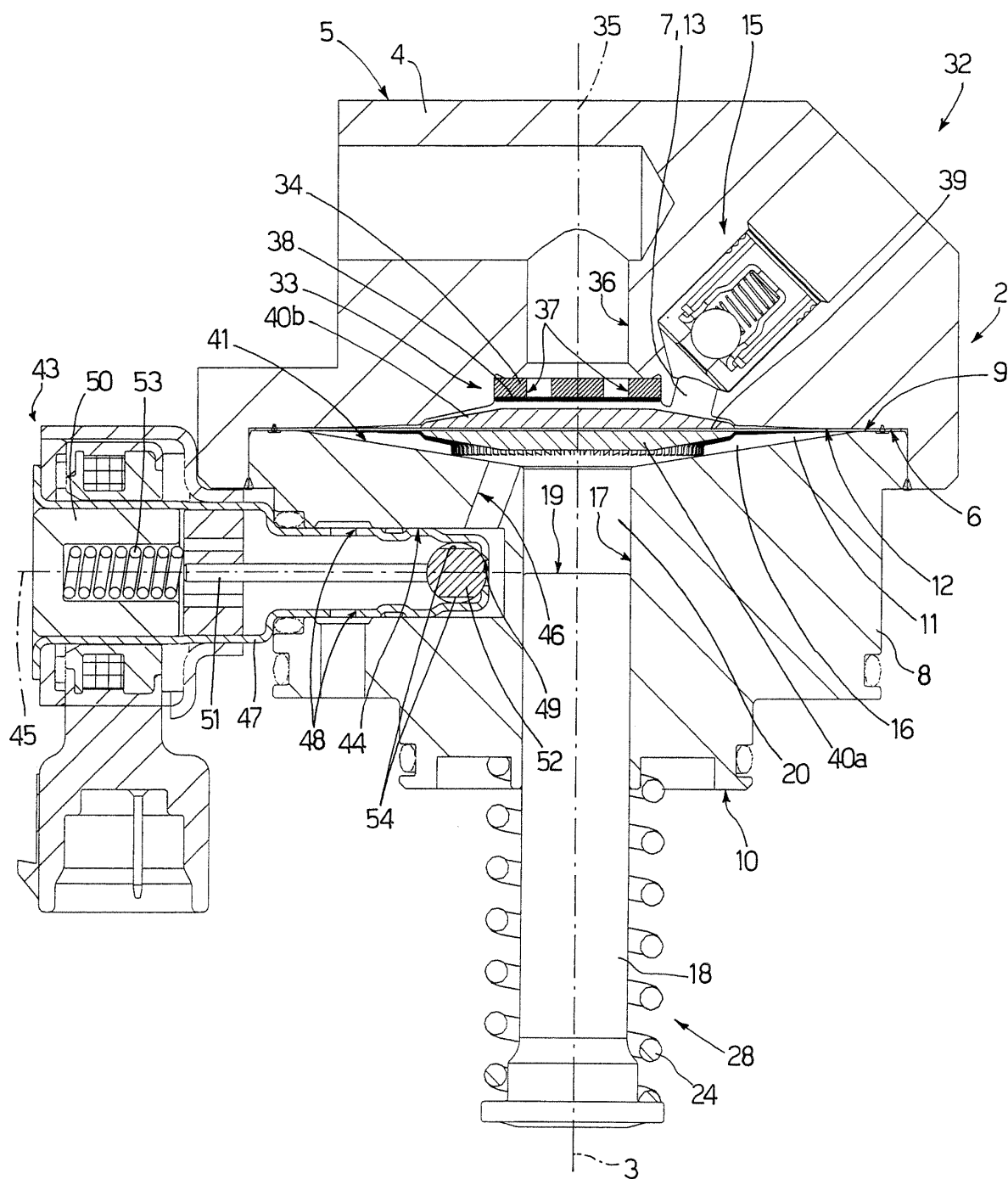
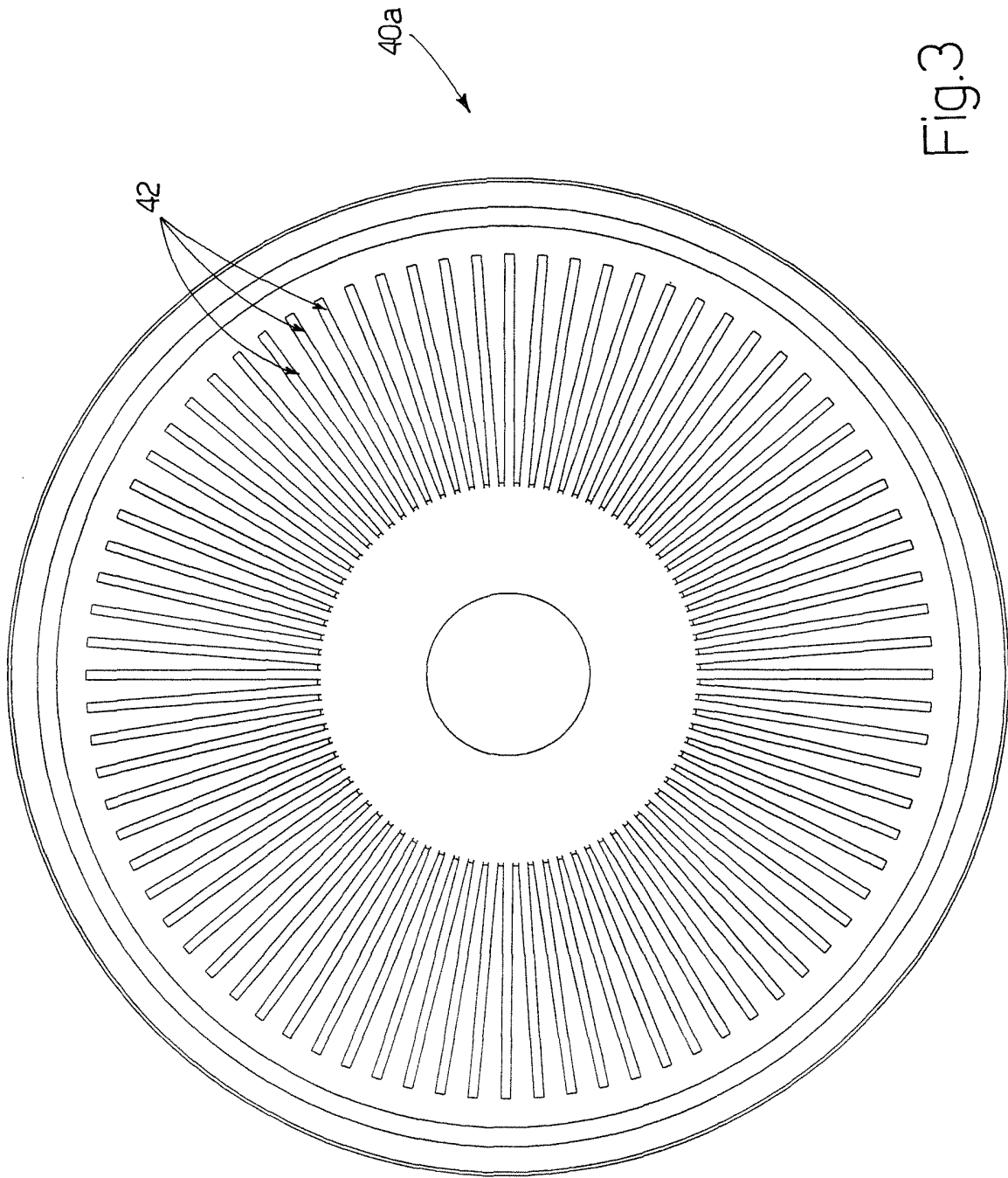


Fig.2





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 04 10 5725

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Place of search The Hague		Date of completion of the search 4 February 2005	Examiner Kolby, L
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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