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(54) Diaphragm pump for fluids

(57) Diaphragm pump for fluids including at least one chamber (1a, 2a) a wall of which is at least partially made up of a flexible membrane (1b, 2b) movable to and from a rigid opposite wall (1d, 2d) of the chamber by means of a working operative fluid acting on the back side of the membrane, with respect to said rigid wall, operated by a piston (9, 10, 28) that slides inside a relative cylinder connected to the back of the membrane and containing said operative fluid, said chamber (1a, 2a) being provided with a suction opening (A1, A2) and a delivery opening (M1, M2) each provided with respective valve means. The pump includes a linear electric motor with one stationery armature (19) and one mobile armature (18) sliding along a rectilinear trajectory. The piston (9, 10, 28) operating said membrane operative fluid is connected directly to the movable armature (18) of said linear electric motor. Furthermore, means (20) are provided for adjusting the speed of said movable armature of the motor, for adjusting the pump stroke and for inverting the movement direction.

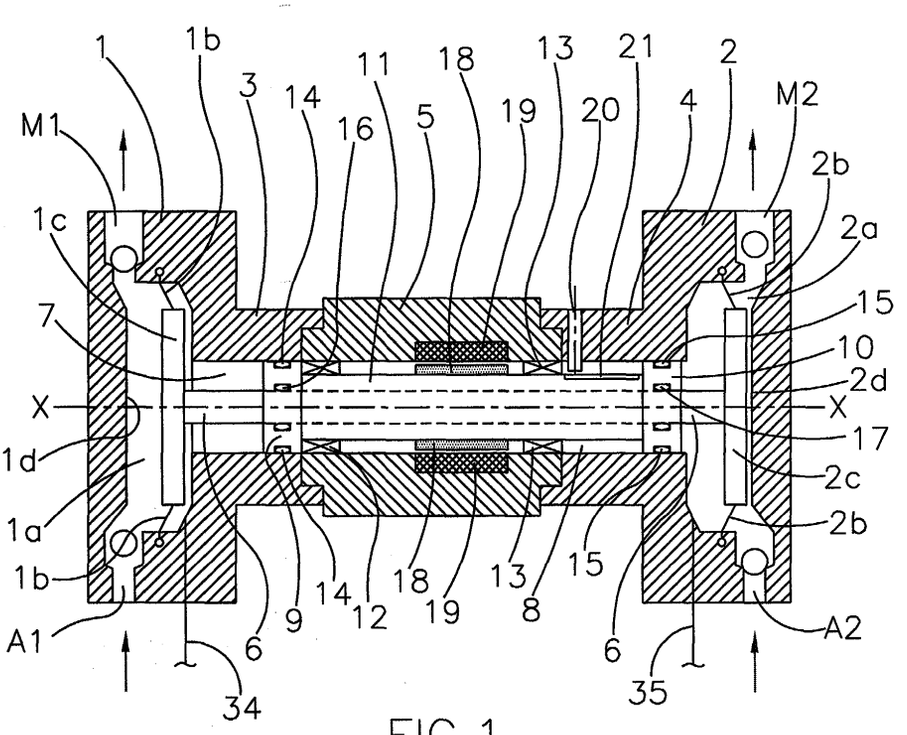

FIG. 1

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Description

[0001] This invention relates to a diaphragm pump for fluids including at least one chamber, a wall of which is at least partially made up from a flexible membrane that can be displaced towards and away from a rigid opposite chamber wall by means of a working operative fluid acting upon the back of the membrane, with respect to said rigid wall, pressed by a sliding piston on the interior of a relative cylinder connecting with the back of the membrane and containing said operative fluid, said chamber being provided with a suction opening and a discharge opening, each provided with respective valve means.

[0002] As already known, diaphragm pumps are used for pumping different types of fluids, including dense fluids, with many particles in suspension. In particular, they are used in the chemical industry for the pumping of varnishes, plasters, creams, jellies and other difficult-to-handle fluids containing chemical agents in general, in the ceramic industry for the pumping of ceramic water suspended clay, in the textile industry for the pumping of bonds, latex, inks, in the foodstuff industry for the pumping of fruit and vegetable pulps, sugar solutions, animal offal as well as in ecology for the pumping of lime, thick sludge and the like.

[0003] A first type of known diaphragm pump uses compressed air that, by means of suitable exchange valves, alternately operates two opposing membranes.

[0004] This known type of diaphragm pump requires rather high powered air compressors for the supply of the compressed air with overall modest efficiency of the system. Moreover, this type of pump only allows heads compatible with the maximum air pressures available by means of the compressor to be obtained.

[0005] A second type of known diaphragm pump, for operating the opposing diaphragms, instead of air, uses a hydraulic fluid that is put under pressure by secondary cylinders whose pistons are activated by an electric rotary motor through a mechanism made up of a reducer and a crank system. Such pumps, resulting rather complex, expensive and rigid in operation, are only used when strictly necessary. Moreover, althrough allowing delivery heads greater than those of the known pumps already mentioned, they have the disadvantage of being constant flow pumps.

[0006] The object of the present invention is to overcome the drawbacks reported in relation to the above-mentioned known types of diaphragm pumps by proposing a diaphragm pump whose operating characteristics, particularly flow and delivery pressure, may be varied and also controlled according to a pre-established program.

[0007] The object is achieved with a diaphragm pump that is characterized in accordance with the appended claim 1.

[0008] The invention will now be described in more detail with respect to the included drawings, intended as non-limitative, in which:

- Figure 1 shows a schematic longitudinal cross-section view of a first embodiment of the diaphragm pump according to the invention;
- Figure 2 shows a longitudinal cross-section view of a second embodiment of the diaphragm pump according to the invention;
- Figure 3 shows a longitudinal cross-section view of a third embodiment of the invention;
- Figure 4 shows a schematic longitudinal cross-section view of a fourth embodiment of the invention.

[0009] With reference to Figure 1, the diaphragm pump comprises two opposing hollow bodies 1 and 2 each including a flange portion 3 and 4 through which said bodies are connected to an intermediate tubular body 5. Each hollow body includes a respective chamber 1a and 2a, in which the relative diaphragms 1b and 2b operate, provided with a rigid central part 1c and 2c respectively. The chambers are equipped with suction and delivery openings indicated as A1, M1 and as A2 and M2 respectively, each of these is equipped with a respective conventional type unidirectional valve.

[0010] The membranes are connected to each other by a rigid rectilinear rod 6 fixed to their rigid part 1c and 2c respectively and can be moved to and from a rigid wall 1d and 2d of the chambers 1a and 2a.

[0011] The rod 6 extends along the longitudinal axis X-X of the pump and axially crosses the flange parts 3 and 4 as well as the intermediate tubular body 5.

[0012] The above-mentioned flange parts 3 and 4 define respective inner cylindrical chambers 7 and 8 in which respective pistons 9 and 10 are placed, connected to each other by means of a tubular rod 11 housed in the intermediate tubular body 5 with the interposition of bearings 12 and 13. Pistons 9 and 10 are equipped with a respective axial opening through which the rigid rod 6 that connects the membranes passes.

[0013] Furthermore, pistons 9 and 10 are provided with respective sealing elements 14 and 15 with respect to the wall of the cylindrical chambers 7 and 8 and with further sealing elements 16 and 17 with respect to the rigid rod 6.

[0014] According to the invention, the tubular rod 11 is directly connected to the movable armature 18 of a linear electric motor or actuator, known *per se*, whose stationary armature 19 is housed in the inner wall of the intermediate tubular body 5.

[0015] On the intermediate tubular body 5 a movement sensor is also provided, schematically indicated by 20 and 21, by means of which and by means of a connected not shown electronic apparatus, the displacement speed of the movable armature 18 of the linear actuator, the pump stroke as well as the running inversion are controlled and operated conventionally.

[0016] An operative liquid, which is preferably water with a small percentage of additives such as glycol, for

example, is placed in of the cylindrical chambers 7 and 8 which are in direct connection with the back side of the membranes 1b and 2b, respectively.

[0017] The operation of the pump occurs by means of the axial motion of the movable armature 18 of the linear motor that is directly transmitted, without intermediate mechanisms, to the tubular rod 11 that controls the axial movement of pistons 9 and 10.

[0018] These compress the operative fluid present in the cylindrical chambers 7 and 8 which, in turn, acts on the membranes 1b and 2b that move in the respective chambers 1a and 2a, against the rigid walls 1d and 2d, pumping alternately, in a conventional way, the fluid sucked at the openings A1 and A2.

[0019] It can be observed that the cross section of pistons 9 and 10 is indicated with smaller size than that of the membranes while the stroke of the pistons is proportionally greater than that of the membranes. This is provided in order to obtain a ratio between the operative areas most favourable to the force exerted by the linear motor 18, 19.

[0020] With reference to the embodiment shown in figure 2, it is observed, having regard to the hollow bodies 1 and 2, to the respective membranes 1a and 2a, to the connecting rigid rod 6 as well as to the suction and delivery openings, that it corresponds to the previously described embodiment of figure 1.

[0021] The hollow bodies 1 and 2 have instead flange parts 22 and 23 that extend within the axial cavity 24 of the intermediate tubular body, indicated by 25, where they are positioned with the respective ends 22b and 23b frontally opposed and spaced apart.

[0022] The sleeve-like ends 26 and 27 of a piston 28 movably mounted between the ends 22b and 23b of the flange parts 22 and 23, and placed coaxially to the rigid rod 6 connecting the membranes, are mounted on the flange parts 22 and 23,.

[0023] The piston 28 consequently forms two chambers, 29a and 29b, that are in fluid connection with the back side of the respective membranes 1b and 2b of the bodies 1 and 2.

[0024] The movable armature 18 of the linear motor or actuator is directly fixed to the piston 28 while the stationary part 19 is fixed to the intermediate tubular body 25.

[0025] Conventional toroidal sealing gaskets 30 and 31 are placed between the sleeve-like parts 26 and 27 and the coaxial flange parts 22 and 23 of bodies 1 and 2.

[0026] An additional sealing gasket 32 is placed between the rod 6 connecting the membranes and the piston 28 that is axially crossed by said rod 6.

[0027] The membrane operative fluid, which in this embodiment is also water with the addition of a small percentage of glycol, is placed in the chambers 29a and 29b. The operative fluid is preferibly contained in a tank 33 which is connected to the areas at the back side of the membranes 1b and 2b by conduits 34 and 35 equipped with conventional unidirectional valve means, as a whole indicated by 36.

[0028] The operation of the pump occurs by means of the linear motor whose movable armature 18 is connected directly to the piston 28 to which a to-and-fro movement is given, whose speed and stroke is controlled by a conventional electronic control apparatus, not shown, set by means of a movement sensor indicated by 20, which is completely equivalent to that of the embodiment of figure 1.

[0029] The piston 28 alternately puts under pressure the operative liquid in the cylinders 29a and 29b that determine the alternate movement of the membranes and therefore the pumping action.

[0030] With respect to the embodiment shown in Figure 3 it is observed that this differs from the embodiment of Figure 1 in that the linear motor 18, 19 and pistons 9 and 10 are housed within a first tubular body 37 placed in a parallel position and no longer coaxial to the connecting rod 6 of the membranes 1b and 2b. The said rod is housed in a second tubular body 38 that connects the opposite hollow bodies 1 and 2.

[0031] The pistons 9 and 10 that are connected to each other by means of a rectilinear rigid rod 11a, act in respective cylindrical cavities 39 and 40 that are in connection with the back side of the membranes 1b and 2b by means of ducts 41 and 42.

[0032] With reference to the embodiment shown in Figure 4, it is observed that the structure for pressurizing the operative fluid including the piston 28 of the embodiment of Figure 2 is housed within a second tubular body 43 placed parallel to the connecting rod 6 of the membranes 1b and 2b as in the embodiment of Figure 3.

[0033] The cylindrical chambers 29c and 29d are in connection with the back side of the membranes 1b and 2b by means of ducts 44 and 45.

[0034] The other structural parts correspond to those described in relation to the Figures 1 and 2.

[0035] As previously described, it can be observed that, according to the invention, the absence of mechanisms in the pump for moving the pistons that pressurize the operative fluid of the membranes allows for much more compact and well proportioned sizes for the flow rate of the pump, the reduction of pump manufacturing and operation costs, the elimination of mechanical performance losses of the mechanism and the considerable reduction of wear and of maintenance needs.

[0036] The control of the operating characteristics of the pump carried out by means of the electronic control of the linear actuator 18, 19 and the simplicity of the structure provide a high adaptation flexibility of the system to different use requirements. For example, it is possible to enhance the pump head simply by varying the section of the operative fluid feeding cylinder to the membrane and programming the strokes in a corresponding way so as to maintain constant the set power.

[0037] The pump according to the invention can, moreover, work with a closed type service fluid circuit for the movement of the membranes without thus requir-

ing complex feeding and discharge systems that are necessary in crank mechanism pumps.

[0038] Finally, the pump, according to the invention, can attain the electronic automatic adjustment of the flow rate and of the pump head as a function of the input-output demand of the apparatus with the advantage of not undergoing any damage due to possible unforeseen limitations regarding pump delivery.

[0039] Obviously, numerous embodiment variations and modifications can be made to the previously described pump, allincluded anyhow in the scope defined by the following claims.

Claims

1. Diaphragm pump for fluids including at least one chamber (1a, 2a) a wall of which is at least partially made up of a flexible membrane (1b, 2b) movable to and from a rigid opposite wall (1d, 2d) of the chamber by means of a working operative fluid acting on the back side of the membrane, with respect to said rigid wall, operated by a piston (9, 10, 28) that slides inside a relative cylinder connected to the back of the flexible membrane and containing said operative fluid, said chamber (1a, 2a) being provided with a suction opening (A1, A2) and a delivery opening (M1, M2) each provided with respective valve means, **characterised in that** it is provided with a linear electric motor with a stationery armature (19) and a mobile armature (18) sliding along a rectilinear trajectory and **in that** said piston (9, 10, 28) actuating said operative fluid is directly connected to the movable armature (18) of said linear electric motor, means (20, 21) being provided for adjusting the speed of said movable armature (18) of the motor, for regulating the entity of its stroke and for inverting the movement direction.

2. Diaphragm pump according to claim 1, **characterised in that** it includes two chambers (1a, 2a) with a relative membrane (1b, 2b), the chambers being obtained in respective opposite hollow bodies (1, 2) connected to each other by means of an intermediate tubular body (5, 25, 38).

3. Diaphragm pump according to claim 2, **characterised in that** the membranes (1b, 2b) of said chambers (1a, 2a) are connected to each other by means of a rectilinear rigid rod (6) that passes through the inside of said intermediate tubular body (5, 25, 38).

4. Diaphragm pump according to claims 1 to 3, **characterised in that** said pistons (9, 10) operating said working operative fluid acting on the back side of the respective flexible membrane (1b, 2b) are connected to each other by means of a rigid rectilinear tubular rod (11) positioned concentrically to said rod (6) connecting the flexible membranes (1b, 2b) and housed inside said intermediate tubular body (5).

5. Diaphragm pump according to claims 1 to 3, **characterised in that** said pistons (9,10) operating said working operative fluid acting on the back side of the respective membrane (1b, 2b) are connected to each other by means of a rigid rectilinear rod (11a) positioned parallel to said rod (6) connecting the flexible membranes (1b, 2b) and housed in an auxiliary tubular body (37) placed in a position parallel to the membrane connecting rod (6).

6. Diaphragm pump according to claims 1 to 5, **characterised in that** the stationary part (19) of said linear electric motor is fixed to said intermediate tubular body (5), while the movable armature (18) of said motor is fixed directly to the said tubular rod (11) connecting the pistons operating on the operative fluid of the flexible membranes (1b, 2b).

7. Diaphragm pump according to claims 1 to 5 **characterised in that** the stationary part (19) of said linear electric motor is fixed to said first auxiliary tubular body (37) while the movable armature (18) of said motor is fixed directly to said rigid rectilinear rod (11a) parallel to said rod (6) connecting the membranes.

8. Diaphragm pump according to claims 1 to 5, **characterised in that** the stationary part (19) of said linear electric motor is fixed to said second auxiliary tubular body (43) while the movable armature (18) of said motor is directly fixed to said piston (28).

9. Diaphragm pump according to claims 1 to 5, **characterised in that** said cylinders (7, 8) containing the working operative fluid acting on the back side of the membranes (1b, 2b) are obtained axially on the exterior of said intermediate tubular body (5) and each cylinder (7, 8) is positioned adjacent to the hollow body (1, 2) of the respective membrane (1b, 2b).

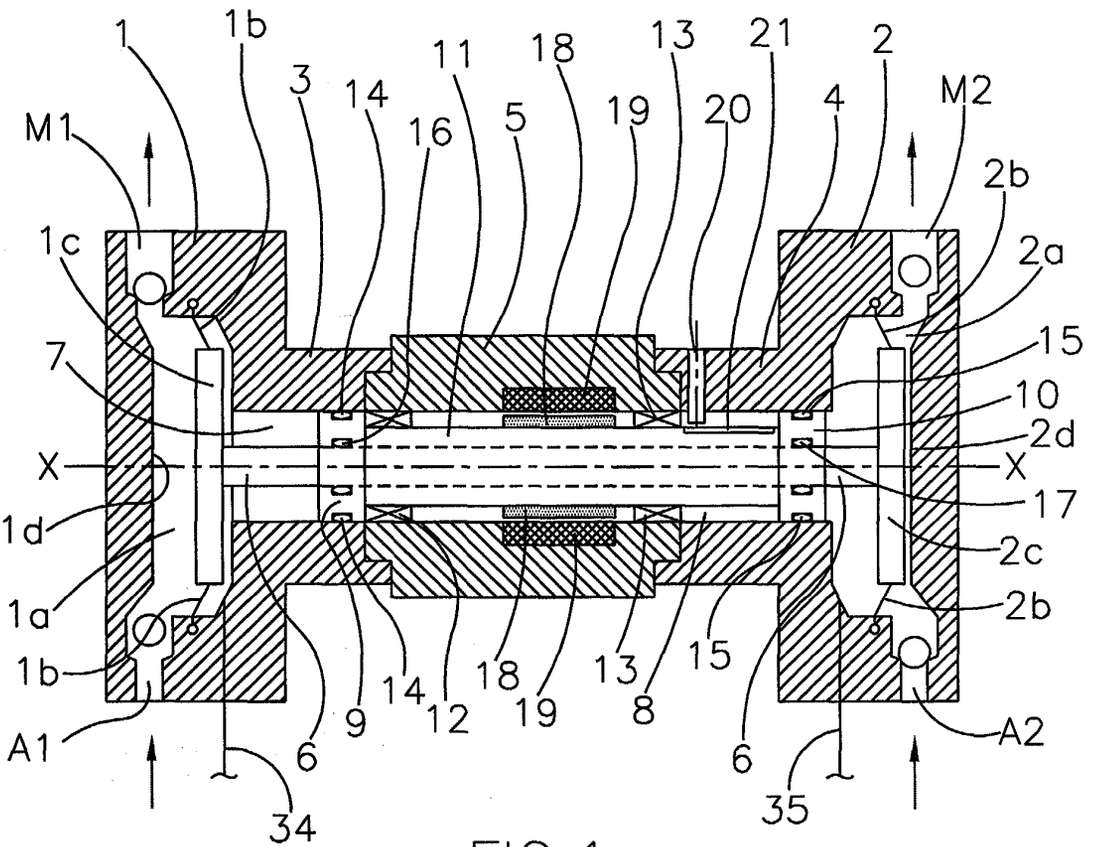
10. Diaphragm pump according to claims 1 to 5, **characterised in that** said cylinders (29a, 29b) containing the working operative fluid acting on the back side of the membranes (1b, 2b) are obtained axially on the interior of said intermediate tubular body (25) and each cylinder is positioned adjacent to the hollow body (1, 2) of the respective flexible membrane (1b, 2b).

11. Diaphragm pump according to claim 10, **characterised in that** said cylinders (29c and 29d) are obtained in a tubular body placed in a position parallel to said rod (6) connecting said membranes.

12. Diaphragm pump according to claims 1 to 11, **char-**

acterised in that it comprises a storage container (33) for the operative liquid of the flexible membranes (1b, 2b), said container being connected to said cylinders and with the back side of the membranes (1b, 2b) by means of respective ducts (34, 35) provided with unidirectional valve means (36).

13. Diaphragm pump according to claims 1 to 12, **characterised in that** each flexible membrane (1b, 2b) is circular and includes a central rigid part (1c, 2c) that constitutes the connecting area with the respective end of the rigid rectilinear rod (6) connecting the membranes (1b, 2b).


1
1b
3
14
11
18
13
21
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M1
16
5
19
20
4
M2
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7
15
10
2d
X
X
17
1d
2c
1a
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19
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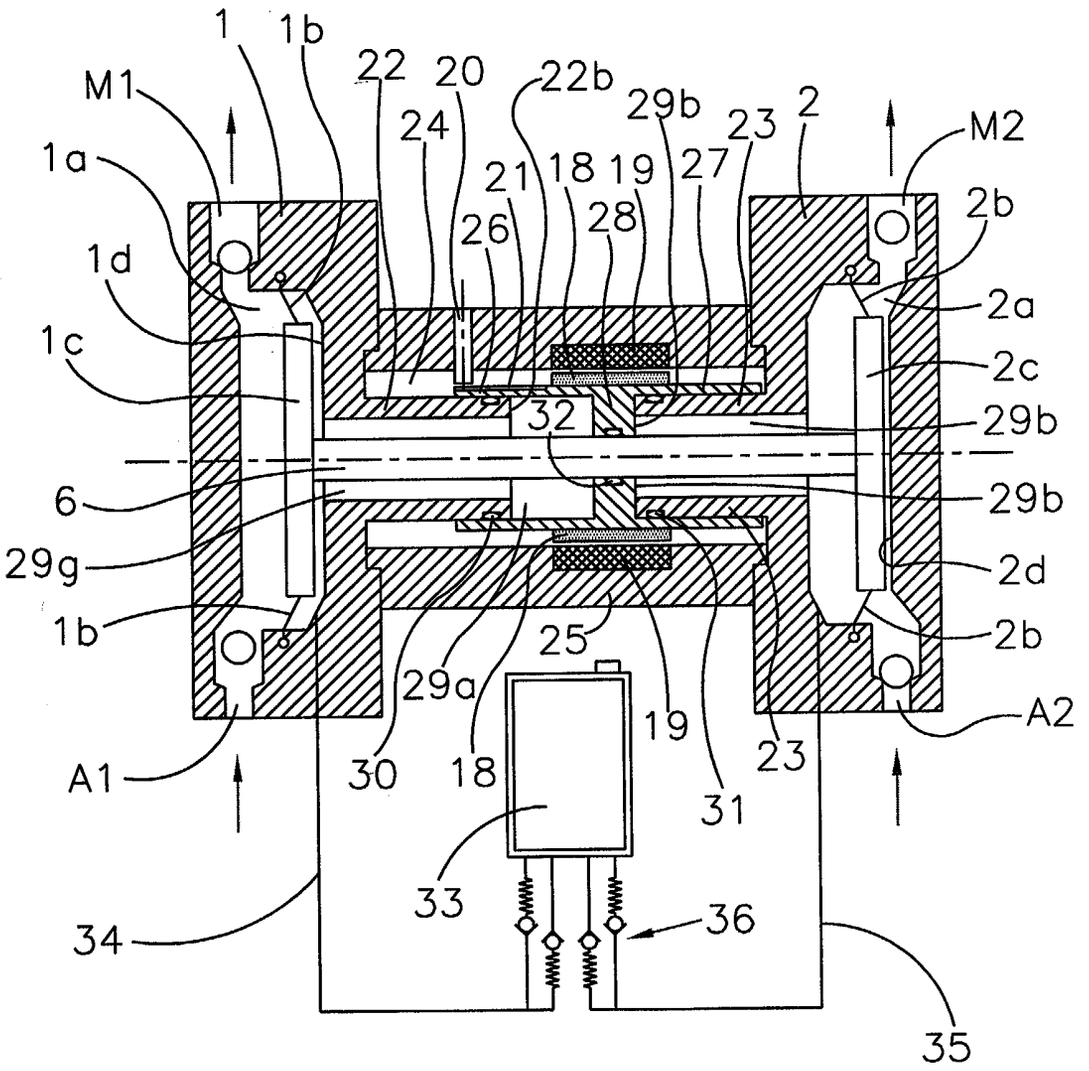
8
15
6
35
A2
34

FIG. 1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M1
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20
22b
29b
23
2
M2
24
21
18
19
27
1a
26
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2b
1d
2a
1c
2c
32
29b
6
29b
29g
2d
1b
25
2b
29a
19
A2
A1
30
18
23
31
33
36
34
35

FIG.2

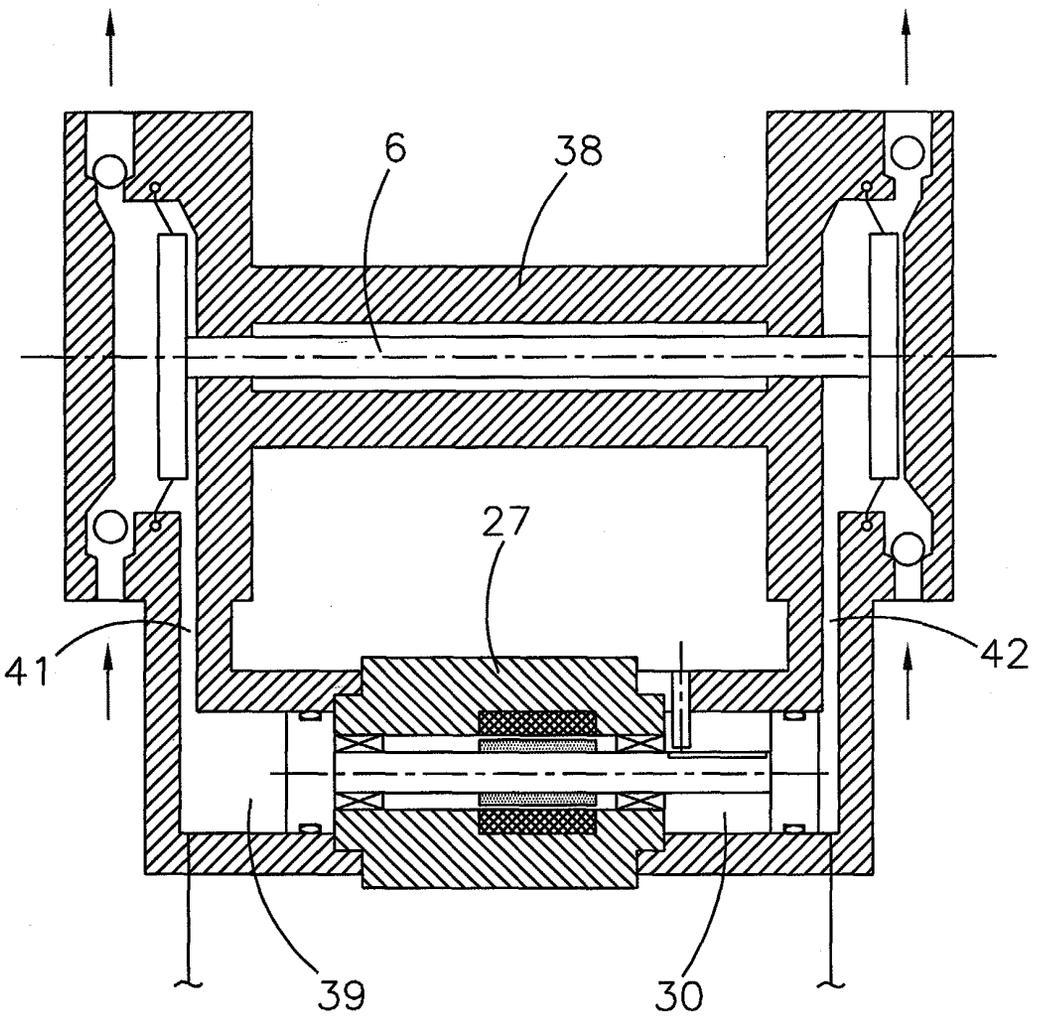

FIG.3

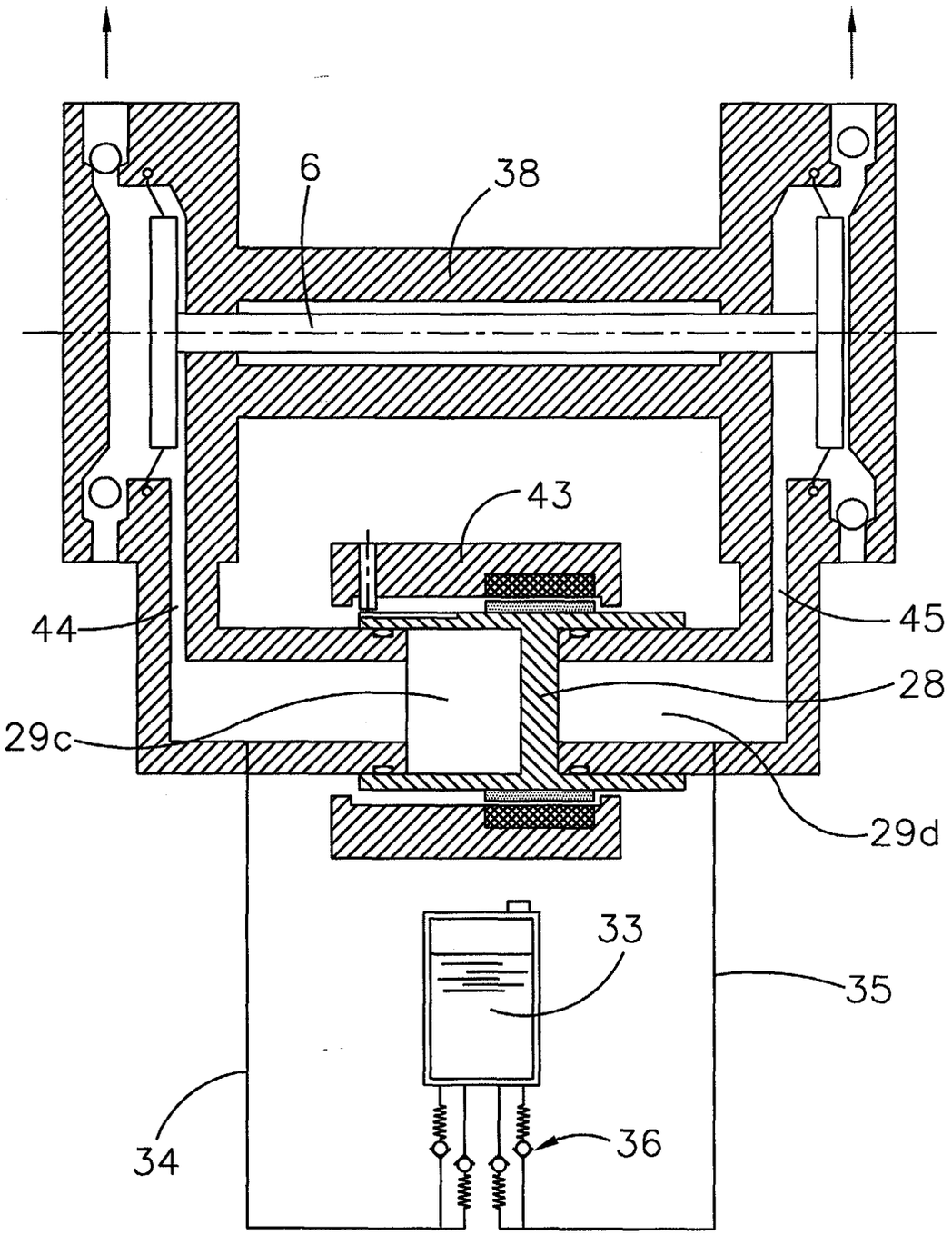

FIG.4

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EUROPEAN SEARCH REPORT

Application Number
EP 03 42 5591

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	4 February 2004	Fistas, N

CATEGORY OF CITED DOCUMENTS

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