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(54) **ELECTRIC GEAR PUMP**

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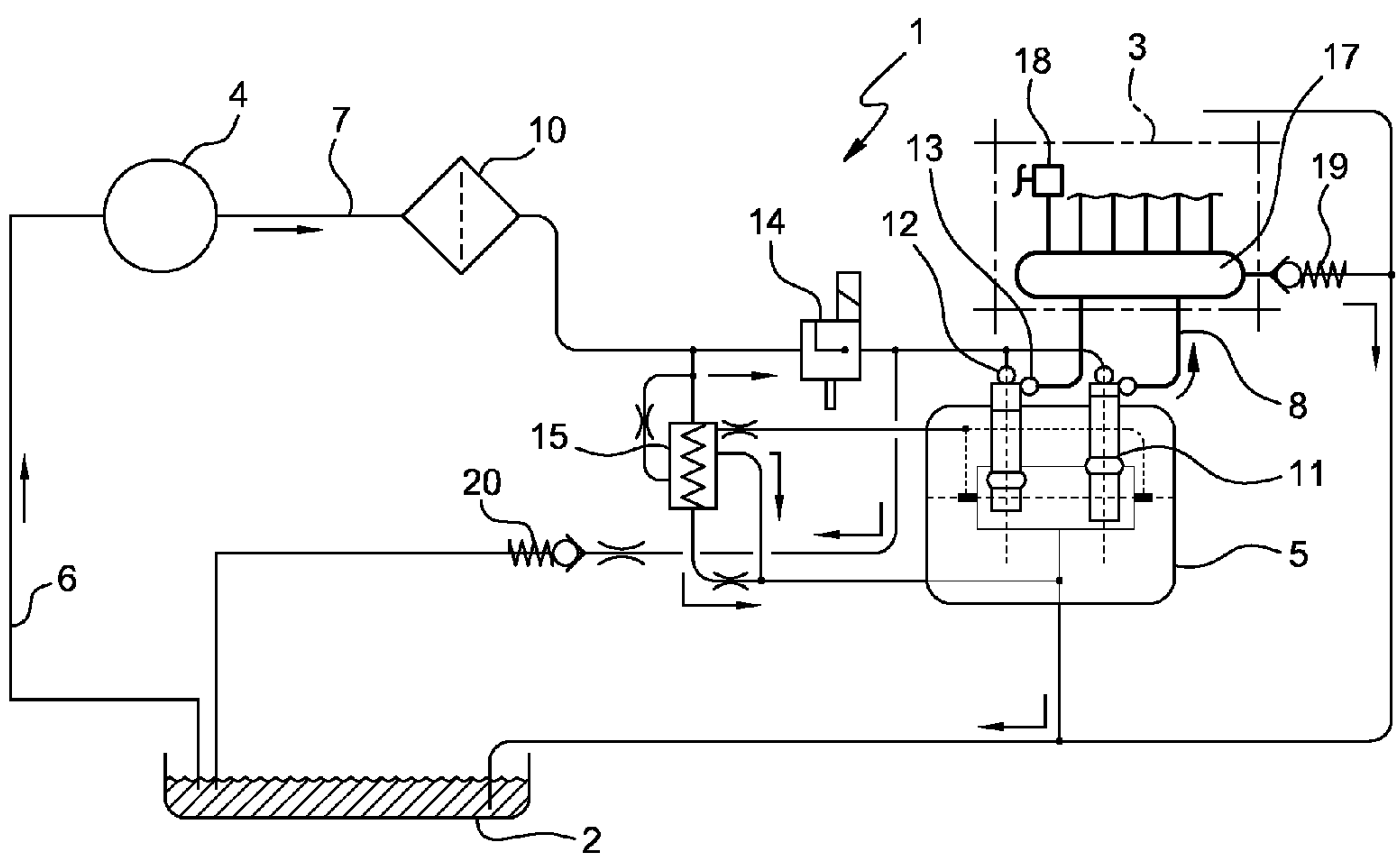
(57) **ABSTRACT**

An electric gear pump comprising a gerotor that may rotate about an axis of rotation A, comprising an external spur rotor and an internal spur rotor arranged outside the external spur rotor; a stator having electrical windings arranged outside the internal spur rotor; at least one magnet at least partially housed in the internal spur rotor in such a way as to cause the gerotor to rotate when the electrical windings of the stator are supplied with current; in which the internal spur rotor comprises a cylindrical external surface centred on the axis of rotation A; the magnet comprises an external surface separated from the external surface of the internal spur rotor; the external surface of the magnet is shaped in such a way as to define a constant radial distance d between the magnet and the corresponding portion of the external surface of the internal spur rotor.



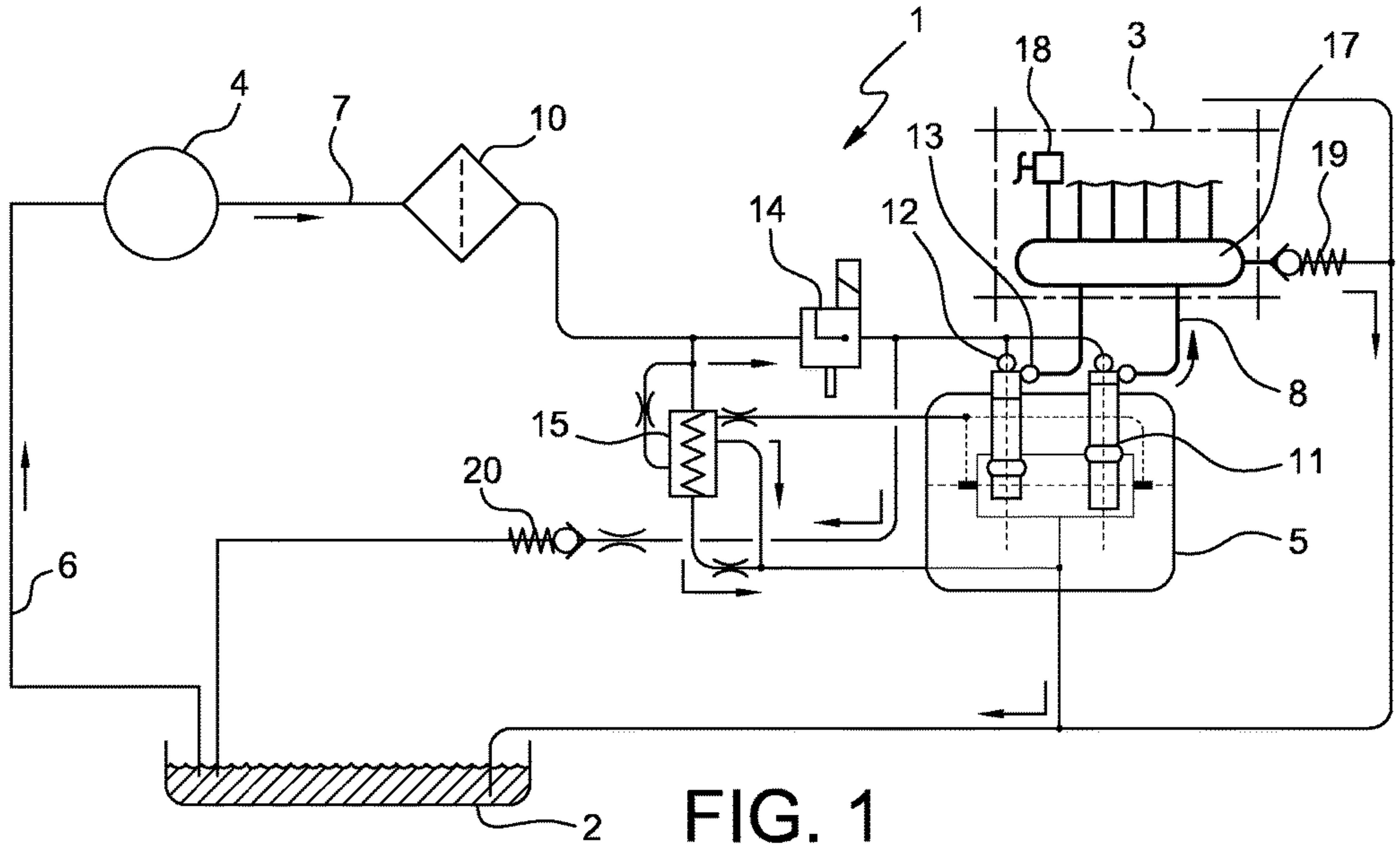


FIG. 1

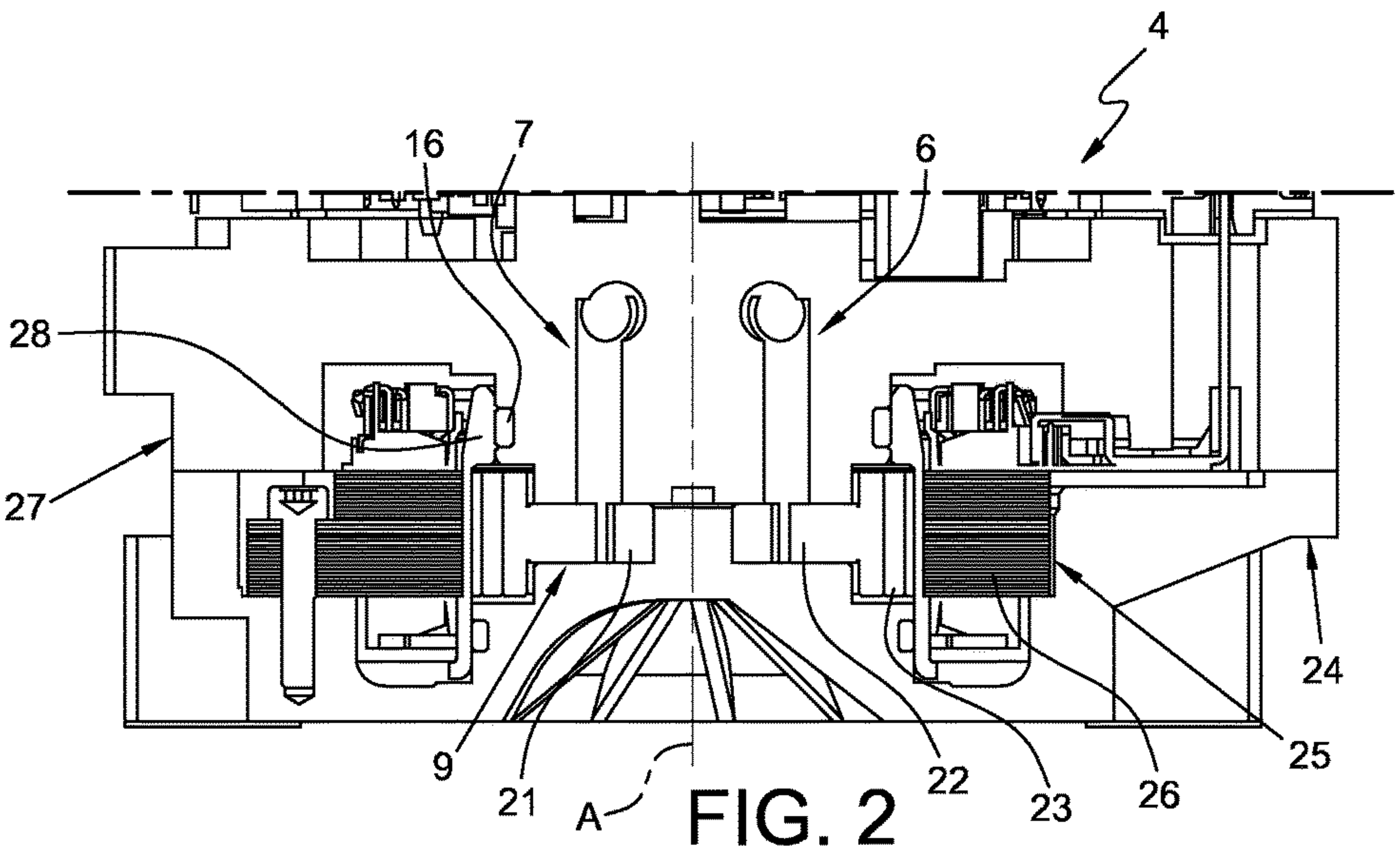


FIG. 2

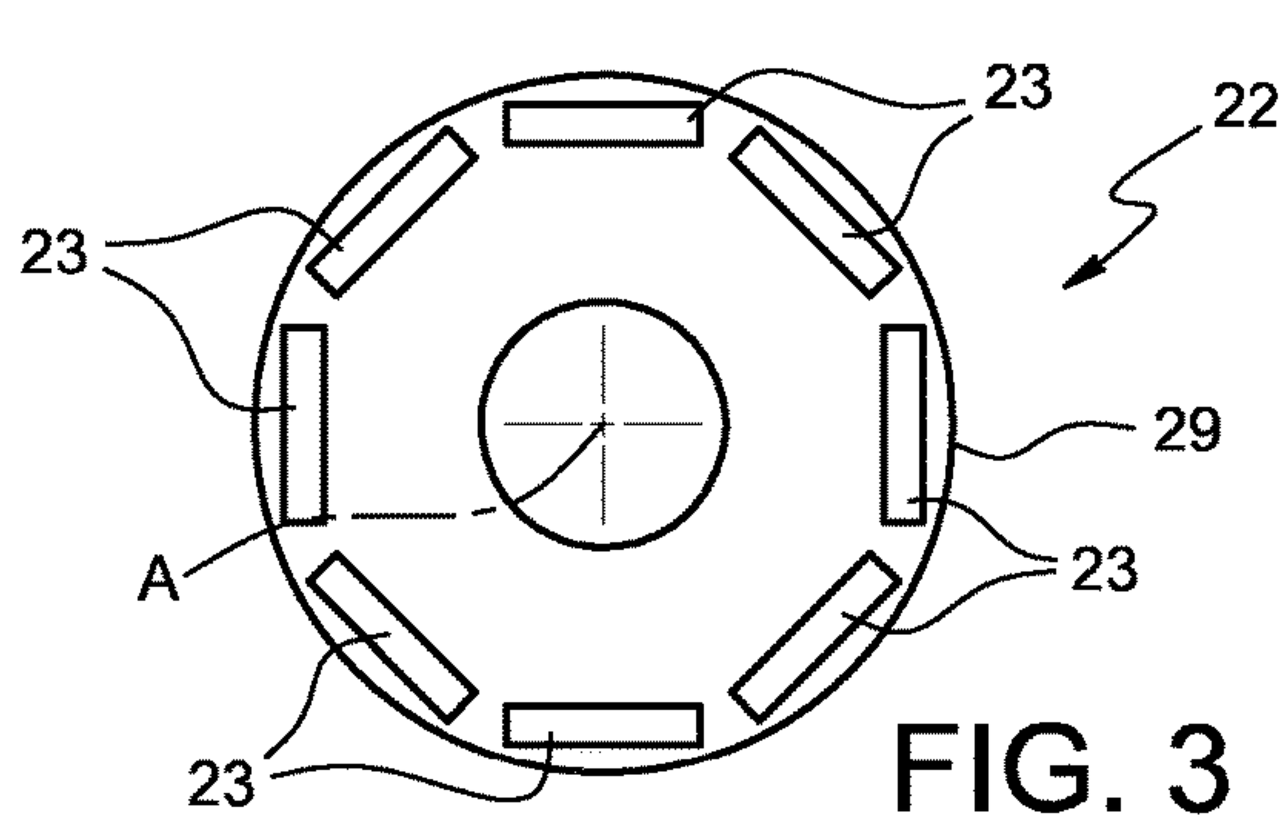


FIG. 3

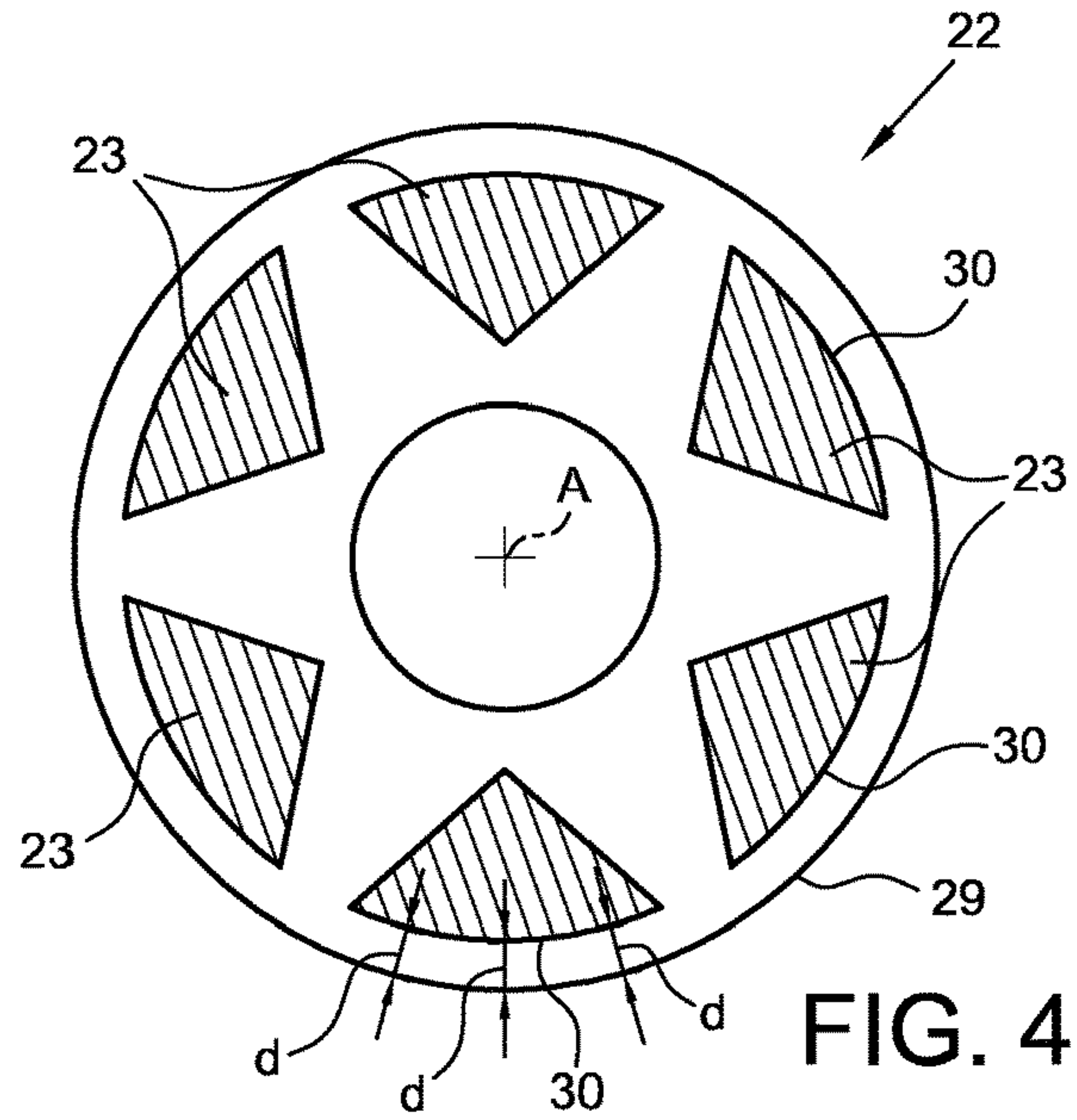


FIG. 4

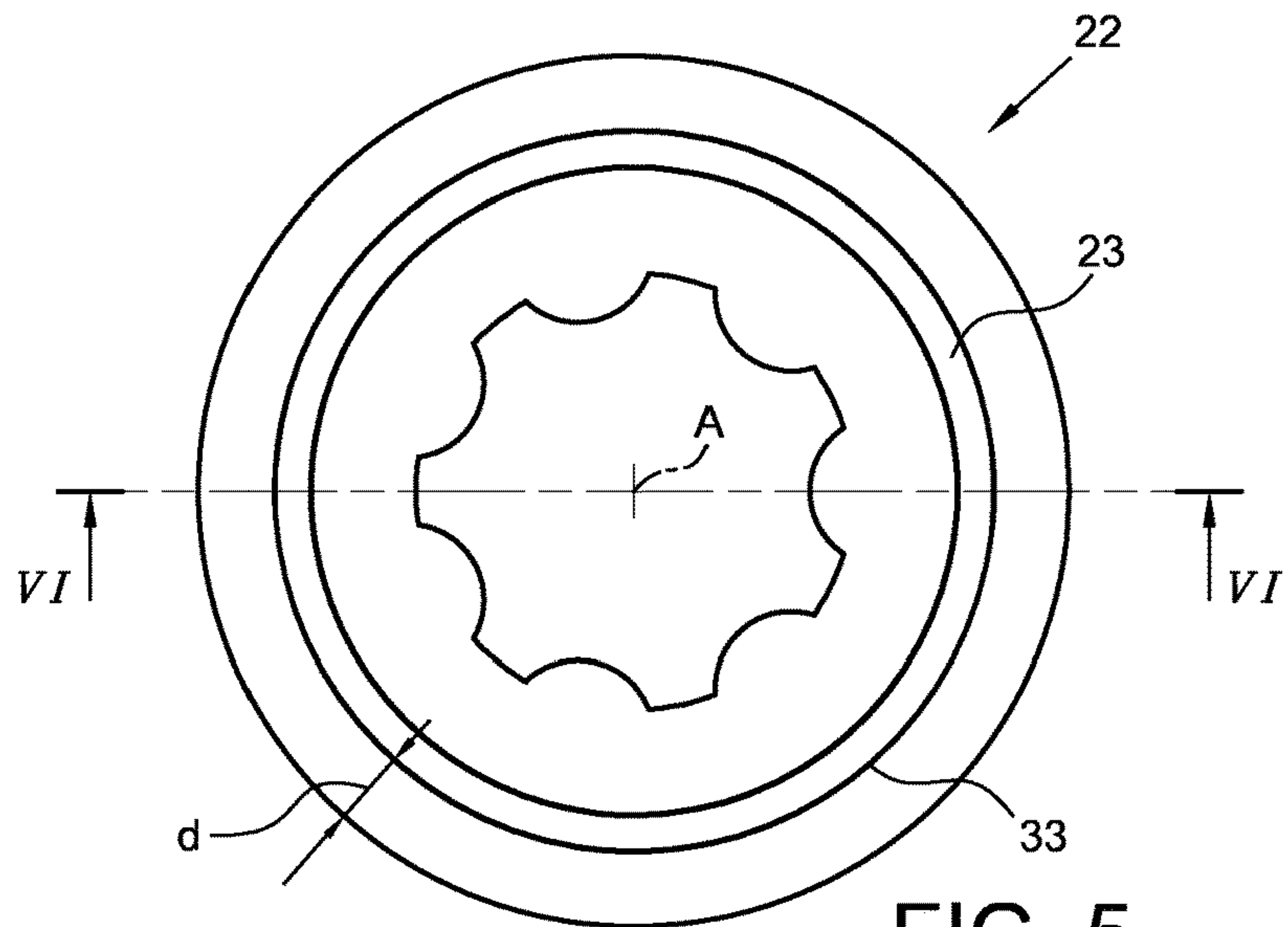


FIG. 5

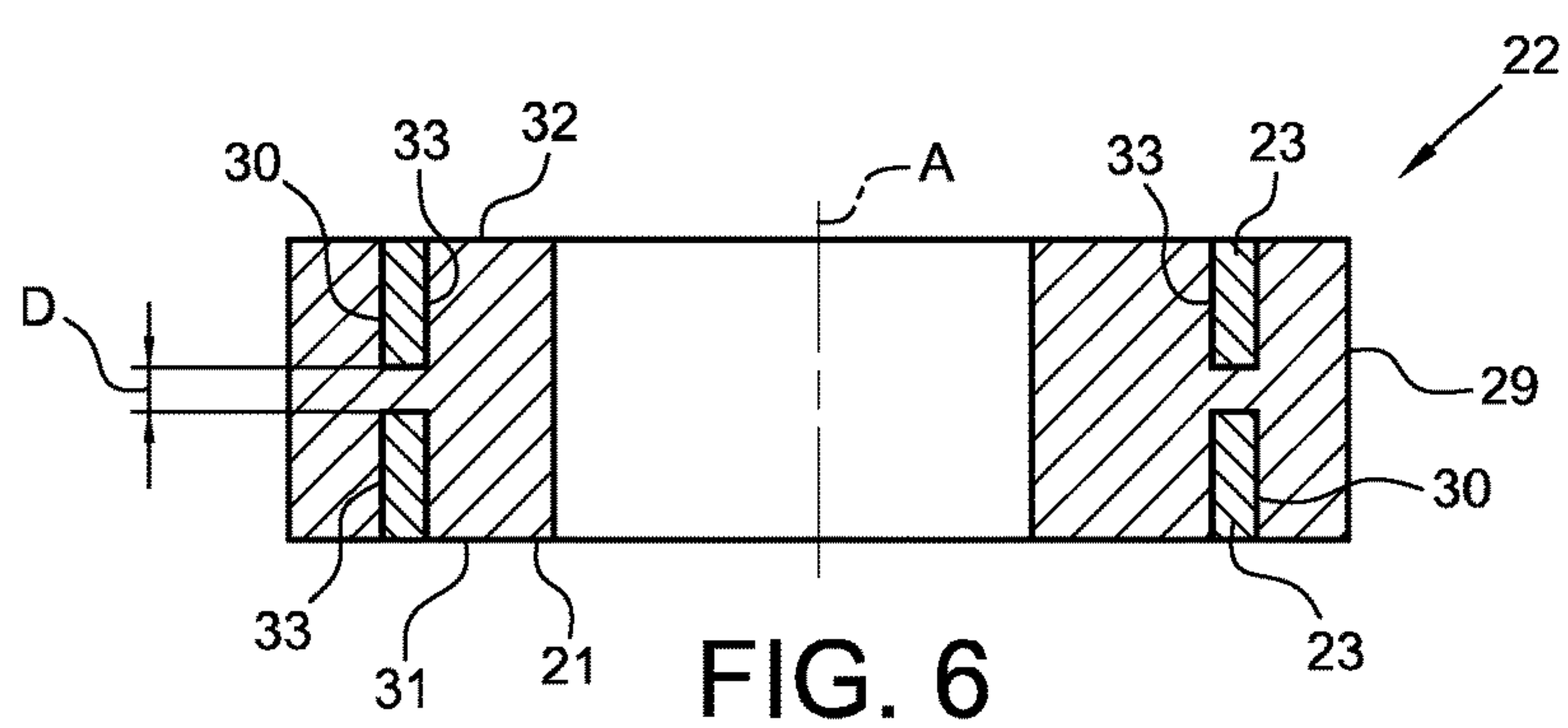


FIG. 6

ELECTRIC GEAR PUMP

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an electric gear pump. In particular, the present invention relates to a gerotor electric gear pump.

[0002] The present invention also relates to a pump assembly comprising, in series:

- **[0003]** a low-pressure pump (the abovementioned gerotor electric gear pump) for drawing fuel, preferably diesel, and for initial compression of the fuel; and
- **[0004]** a high-pressure pump, preferably with pumping pistons, for further compression of the fuel and for supplying the fuel at high pressure to an internal combustion engine.

[0005] The use of systems for supplying fuel, in particular diesel, to an internal combustion engine, which comprise a high-pressure pump for supplying the internal combustion engine, and a low-pressure pump for supplying fuel to the high-pressure pump, is already known. The high-pressure pump comprises at least one pumping piston moved by a shaft and housed in a cylinder supplied with fuel at low pressure. At least two different types of low-pressure pump for such systems currently exist.

[0006] The first type comprises a gear pump which is driven by the same shaft as drives the pistons of the high-pressure pump. In particular, this gear pump may be a “gerotor” pump. As is known, the gerotor pump comprises an external spur rotor rotated by the shaft and housed inside an internal spur rotor. During rotation, the spurs of the external spur rotor engage with the spurs of the internal spur rotor, which has one more spur than the external spur rotor. The two rotors, rotating either absolutely or relatively, or relative to one another, pump fuel from an inlet, connected to the tank, to an outlet, connected to the high-pressure pump.

[0007] The second type of gear pump comprises gear pumps not driven by the shaft for driving the pumping pistons, but pumps driven electrically or electromagnetically. With this type of pump, in current gerotor pumps, at least one out of the internal spur rotor and the external spur rotor has magnetic or ferromagnetic modules, such as bundles of little plaques made of iron, which engage electromagnetically with a stator which is arranged outside of the internal spur rotor and comprises electrical windings. In particular, it is currently common to house the magnetic modules, which usually have a parallelepiped structure, embedded directly in the internal spur rotor near the external surface thereof, or near the windings of the stator placed outside the internal spur rotor.

[0008] By supplying current to said windings, electromagnetic conditions are created such that the gerotor starts to rotate, pumping the fuel between the tank and the high-pressure pump.

[0009] In this type of gerotor electric gear pump, the stator with electrical windings, which may also be defined as an “electric motor” since it causes the gerotor to move, is placed at the same level as said gerotor so as to increase the electromagnetic interaction. This concentric arrangement of gerotor and stator currently requires the presence of a bearing placed between the external wall of the internal spur rotor of the gerotor and the stator. A high degree of precision in terms of mechanical machining regarding the geometric circularity of the external surface of the internal spur rotor coupled to said bearing is thus necessary.

[0010] Although gerotor electric gear pumps are widely used, the current versions of these pumps have a number of drawbacks.

[0011] In particular, placing the magnets inside the internal spur rotor as described above is a difficult, expensive process.

[0012] Moreover, owing to the current structure of the magnets used, mechanical machining of the external surface of the rotor does not always attain the circularity tolerance required, but on the contrary, produces a multi-lobed external profile.

SUMMARY OF THE INVENTION

[0013] In light of the known prior art, it is an aim of the present invention to produce an alternative gear pump, preferably an alternative gerotor electric gear pump.

[0014] In particular, it is an aim of the present invention to produce a gerotor electric gear pump which makes it possible to improve the corresponding prior art pumps described above, simply and economically, both from the functional viewpoint and from the structural viewpoint.

[0015] In accordance with these aims, the present invention relates to an electric gear pump comprising:

- **[0016]** a gerotor that may rotate about an axis of rotation A, comprising an external spur rotor and an internal spur rotor arranged outside the external spur rotor;
- **[0017]** a stator having electrical windings arranged outside the internal spur rotor;
- **[0018]** at least one magnet at least partially housed in the internal spur rotor in such a way as to cause the gerotor to rotate when the electrical windings of the stator are supplied with current.

[0019] The term “magnet” means either a magnet per se or a magnetic/ferromagnetic structure. Furthermore, the terms “internal” and “external” refer to the axis of rotation A of the gerotor.

[0020] According to the invention, the internal spur rotor comprises an external surface centred on the axis of rotation A, which is usually cylindrical with a circular cross section centred on the axis A. The magnet in turn comprises an external surface which, once the magnet has been coupled to the internal spur rotor, is in a position separated or distanced from the external surface of the internal spur rotor, which is substantially cylindrical with a circular cross section centred on the axis A. In particular, with this configuration according to the invention, the external surface of the magnet is shaped in such a way as to define a constant distance d, measured radially from the axis A, between the magnet and the corresponding portion of the external surface of the internal spur rotor.

[0021] Advantageously, even at the magnets there is thus ensured a homogeneous distribution of the material for mechanical machining of the external surface of the internal spur rotor, with a consequent improvement in the circularity obtainable.

[0022] Preferably, the pump comprises a support base for the gerotor and a closure cover. Therefore, the internal spur rotor comprises a lower surface for coupling with the base and an upper surface for coupling with the cover. According to this embodiment, the internal spur rotor comprises at least one seat, for example in the form of a surface channel, for housing the magnet on the lower surface or the upper surface.

[0023] Advantageously, in this way, production of the magnet, for example by moulding, production of the housings for the magnets and coupling of the magnets to the seats, for example by adhesive bonding, are simple, inexpensive operations.

[0024] Preferably, the magnet is designed in such a way that when inserted in the associated seat, the lower or upper face thereof is flush with the relative lower or upper surface of the internal spur rotor.

[0025] Advantageously, in this way the magnets do not interfere with the other static components present in the base or in the cover of the gear pump.

[0026] Preferably, the pump comprises at least two magnets and the internal spur rotor comprises at least one lower seat on the lower surface and at least one upper seat on the upper surface. Even more preferably, according to this embodiment, the lower and upper seats are aligned along an axis parallel to the axis of rotation A and separated from one another by a distance D which is less than the thickness of the magnet measured along an axis parallel to the axis of rotation A.

[0027] Advantageously, the electromagnetic field which moves the gerotor is optimized, minimizing loss of flow between the magnets.

[0028] According to a preferred embodiment of the invention, the magnet is made in the form of one or more rings centred with respect to the axis of rotation A, and thus concentric, and with respect to the external surface of the internal spur rotor.

[0029] Advantageously, according to this embodiment, positioning the magnet is simple and quick since they lie along the whole periphery of the internal spur rotor. Moreover, according to this embodiment, there is a constant distance d along the whole periphery of the internal spur rotor between the external surface of the rotor and the external surface of the ring magnet, with a consequent improvement in the circularity obtainable by mechanical machining.

[0030] Preferably, the magnet in the form of a ring may be made as a single piece or as a plurality of adjacent parts.

[0031] Naturally, the present invention can be used both for a pump assembly for supplying fuel from a tank to an internal combustion engine which comprises, in series, an electric gear pump as described above and a high-pressure pump, and for just the internal spur rotor as a possible spare part that may be used to improve the pumps currently used.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] Further features and advantages of the present invention will become clearer from the description below of two non-limiting embodiments thereof, with reference to the figures in the attached drawings, in which:

[0033] FIG. **1** is a schematic view of an embodiment of a pump assembly for supplying fuel, preferably diesel, from a tank to an internal combustion engine, which comprises, in series, a low-pressure gear pump and a high-pressure pump with pumping pistons;

[0034] FIG. **2** is a schematic view of a low-pressure gerotor gear pump according to the prior art;

[0035] FIG. **3** is a schematic view of the internal spur rotor of FIG. **2** according to the prior art;

[0036] FIG. **4** is a schematic view of a first embodiment of an internal spur rotor according to the present invention for a low-pressure gerotor electric gear pump;

[0037] FIG. **5** is a schematic view of a second embodiment of an internal spur rotor according to the present invention for a low-pressure gerotor electric gear pump;

[0038] FIG. **6** is a view in section of the internal spur rotor of FIG. **5** along the section line VI-VI;

DETAILED DESCRIPTION

[0039] FIG. **1** is a schematic view of an embodiment of a pump assembly for supplying fuel, preferably diesel, from a tank to an internal combustion engine, which comprises, in series, a low-pressure pump and a high-pressure pump. In particular, FIG. **1** shows a pump assembly **1** comprising:

- **[0040]** a low-pressure electric gear pump **4**;
- **[0041]** a high-pressure pump **5**;
- **[0042]** a low-pressure suction pipe **6** for supplying the fuel from the tank **2** to the electric gear pump **4**;
- **[0043]** a low-pressure delivery pipe **7** for supplying the fuel from the electric gear pump **4** to the high-pressure pump **5**;
- **[0044]** high-pressure delivery pipe **8** for supplying the fuel from the high-pressure pump **5** to the internal combustion engine **3**.

[0045] In this example, the internal combustion engine **3** is shown only schematically and comprises a common manifold **17** fed by the high-pressure delivery pipes **8** and a plurality of injectors **18** (not shown) designed to spray and inject the fuel at high pressure into the cylinders of the internal combustion engine **3**. In FIG. **1**, the high-pressure pump **5** is shown only schematically and comprises two pumping pistons **11** supplied with fuel at low pressure at supply valves **12** and connected to delivery valves **13** for supplying the fuel at high pressure to the engine **3**. FIG. **1** also shows a filter **10** arranged downstream of the low-pressure pump **4**, a fuel measuring device **14** downstream of the filter **10**, a relief valve **15** between the filter **10** and the fuel measuring device **14**, a pressure limiting valve **19** connected to the manifold **17** and a valve **20** for delivering to the tank **2**. The arrows shown in FIG. **1** indicate the path of the fuel through the pump assembly **1**.

[0046] FIG. **2** shows a gerotor electric gear pump **4** according to the prior art. Said electric gear pump **4** comprises:

- **[0047]** a gerotor **9** that may rotate about an axis of rotation A, comprising an external spur rotor **21** and an internal spur rotor **22** arranged outside the external spur rotor **21**;
- **[0048]** a stator **25** with electrical windings **26**, arranged outside and at the same level as the gerotor **9**;
- **[0049]** a support base **24** for the gerotor **9**;
- **[0050]** a cover **27** that may be coupled to the base **24** in which the supply **6** and delivery **7** pipes are made at least partially;
- **[0051]** a bearing **28**, with associated seals **16**, between the stator and the gerotor **9**, in particular the external surface of the internal spur rotor **22**.

[0052] As can be seen in FIG. **2**, the internal spur rotor **22** has magnets **23** arranged near the bearing **28** so as to maximize the electromagnetic interaction with the windings **26** of the stator **25**.

[0053] FIG. **3** is a schematic view in section of the internal spur rotor **22** of the prior art of FIG. **2**; As shown, according to the prior art, the magnets **23** are produced in the form of parallelepiped structures and are arranged along the periphery of the internal spur rotor **22**. According to this embodiment, there is no homogeneous distribution of material, or constant distance, between the magnets **23** and the corresponding portions of the external surface **29** of the internal spur rotor **22**.

[0054] FIG. **4** is a schematic view of a first embodiment of an internal spur rotor **22** according to the invention in which homogeneous distribution of material, or a constant distance d measured radially, is guaranteed between the magnets **23** and the corresponding portions of the external surface **29** of the internal spur rotor **22**. This technical effect is achieved in the embodiment of FIG. **4** by virtue of a plurality of magnets **23** arranged along the circular periphery of the internal spur rotor **22** in which said magnets have an external surface **30** which, viewed from a plane orthogonal to the axis A, coincides with an arc of a circle centred on said axis A.

[0055] Such magnets may be provided embedded in the internal spur rotor **22** or inserted in special seats made on the lower and/or upper surface of the internal spur rotor **22**. For the sake of clarity in FIG. **4**, the internal spurs of the rotor **22** have not been shown.

[0056] FIG. **5** is a schematic view of a second embodiment of an internal spur rotor **22** according to the invention in which homogeneous distribution of material, or a constant radial distance d, is guaranteed between the magnets **23** and the external surface **29** of the internal spur rotor **22**. According to this embodiment, the magnets **23** are made in the form of a ring concentric with the axis A so as to guarantee along the internal periphery of the internal spur rotor **22** a homogeneous distribution of material, or a constant radial distance d, between the magnets **23** and the external surface **29** of the rotor.

[0057] FIG. **6** is a view in section of the internal spur rotor of FIG. **5** along the section line VI-VI. As can be seen, according to this embodiment, the internal spur rotor **22** comprises a first annular seat **33** made on the upper surface **32** and a first annular seat **33** made on the lower surface **31**, in which said seats **33** are aligned in the axial direction A.

[0058] The distance between the seats in the axial direction A, indicated in FIG. **6** with the reference sign D, is less than the thickness of the individual magnets **23** also measured in said axial direction A.

[0059] According to this embodiment, the ring magnets **23**, when inserted in the relative seats **33** and held in position for example by adhesive bonding, are flush with the lower surface **31** and the upper surface of the internal spur rotor **22**.

[0060] Lastly, it is clear that amendments and variations may be made to the invention described herein without exceeding the scope of the attached claims.

1. An electric gear pump (**4**) comprising:

a gerotor (**9**) configured to rotate about an axis of rotation (A), the gerotor comprising an external spur rotor (**21**) and an internal spur rotor (**22**) arranged outside the external spur rotor (**21**);

a stator (**25**) having electrical windings (**26**) arranged outside the internal spur rotor (**22**);

at least one magnet (**23**) at least partially housed in the internal spur rotor (**22**) in such a way as to cause the gerotor (**9**) to rotate when the electrical windings (**26**) of the stator (**25**) are supplied with current;

wherein:

the internal spur rotor (**22**) comprises a cylindrical external surface (**29**) centered on the axis of rotation (A);

the magnet (**23**) comprises an external surface (**30**) separated from the external surface of the internal spur rotor (**22**); and

the external surface (**30**) of the magnet (**23**) is shaped in such a way as to define a constant radial distance (d) between the magnet (**23**) and the corresponding portion of the external surface (**29**) of the internal spur rotor (**22**).

2. A pump as claimed in claim **1**, wherein the pump (**4**) comprises a support base (**24**) for the gerotor (**9**) and a closure cover (**27**); wherein the internal spur rotor (**22**) comprises a lower surface (**31**) for coupling with the base (**24**) and an upper surface (**32**) for coupling with the cover (**27**), and wherein the internal spur rotor (**22**) comprises at least one seat (**33**) for housing the magnet (**23**) on the lower surface (**31**) or on the upper surface (**32**).

3. The pump as claimed in claim **2**, wherein the seat (**33**) is a channel with a shape corresponding to the magnet (**23**).

4. The pump as claimed in claim **2**, wherein, when inserted in the seat (**33**), the magnet (**23**) is flush with the lower surface (**31**) or the upper surface (**32**) of the internal spur rotor (**22**).

5. The pump as claimed in claim **4**, wherein the pump comprises at least two magnets (**23**) and the internal spur rotor (**22**) comprises at least one lower seat (**33**) on the lower surface (**31**) and at least one upper seat (**33**) on the upper surface (**32**).

6. The pump as claimed in claim **5**, wherein the lower and upper seats (**33**) are aligned along an axis parallel to the axis of rotation A.

7. The pump as claimed in claim **5**, wherein a distance between the lower and upper seats (**33**) is less than a thickness of the magnet (**23**) measured along an axis parallel to the axis of rotation A.

8. The pump as claimed in claim **1**, wherein the magnet (**23**) is in the form of a ring.

9. The pump as claimed in claim **8**, in which wherein the magnet (**23**) in the form of a ring is made as a single piece.

10. A pump assembly for supplying fuel from a tank (**2**) to an internal combustion engine (**3**); the pump assembly (**1**) comprising, in series, a low-pressure electric gear pump (**4**) and a high-pressure pump (**5**); wherein the low-pressure electric gear pump (**4**) is configured according to claim **1**.

11. The pump as claimed in claim **8**, wherein the magnet (**23**) in the form of a ring is made as a plurality of adjacent parts.

* * * * *