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(71) Applicant *(for all designated States except US)*: **HYDOR SRL** [IT/IT]; Via Voiron, 27, I-36061 Bassano del Grappa, Vicenza (IT).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **BRESOLIN, Valerio** [IT/IT]; Via Cornon, 9, I-36020 Pove del Grappa, Vicenza (IT).

(74) Agent: **LAZZAROTTO, Roberto**; Via Ca'Savorgnan, 9, I-30172 Mestre-Venezia (IT).

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(54) Title: SYNCHRONOUS ELECTRIC MOTOR FOR THE OPERATION OF A PUMP AND THE RELATED MOTOR PUMP

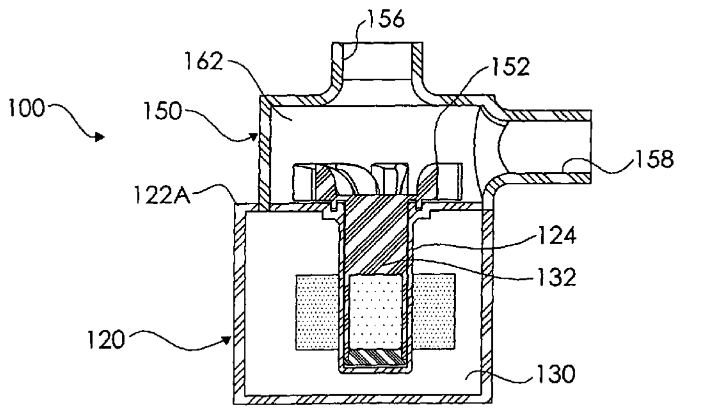

Fig. 2

(57) Abstract: In a synchronous electric motor (120) for operating a pump (150) comprising a motor body (122), a stator (140) and a rotor (132,232) coupled to an impeller (152) of said pump (150), said motor (120) also comprises a cylindrical element (124,224) which extends towards the inside of said motor body (122) from one of its outer walls (122A) so as to define a first cylindrical cavity (128) open to the outside to insert inside said rotor (132,232), said rotor (132,232) has a circular cross section essentially corresponding to the inner section of said cylindrical element (124,224) so that said rotor (132,232) is in contact with said cylindrical element (124,224) and then there is a friction between said rotor (132,232) and said cylindrical element (124,224) when said rotor (132,232) rotates, said rotor (132,232) being shaftless and axially and directly coupled to said impeller (152) of said pump (150).

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Synchronous electric motor for the operation of a pump and the related motor pump.

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The present invention relates to a synchronous electric motor for the operation of a pump.

The invention also relates to a motor pump comprising a synchronous electric motor coupled to a pump.

It is well known to use synchronous motors for the operation of pumps such as pumps for aquariums, pumps for household appliances as for example washing machines, dishwashers and more.

Synchronous motors comprise a motor body inside which a stator and a rotor are housed.

The stator comprises a statoric pack, usually a stack of magnetic laminations, on which one or more electrical windings are wound. The statoric pack has at least two pole pieces inside which a rotor is positioned. Then, the stator forms the inductor of the electric motor.

The rotor usually consists of a permanent magnet of cylindrical shape and constitutes the armature of the electric motor.

By feeding the electric windings, a magnetic flux is generated in the statoric pack and, therefore, magnetic poles are generated at the pole pieces which interact with the magnetic field of the rotor thus causing the rotation of the rotor.

The rotor usually is holed in the centre and inside a shaft is rigidly inserted and fixed. The shaft is supported at its two ends by respective bushes which are rigidly secured inside cavities formed in the motor body. The impeller of the pump is fixed to one of the two ends of the shaft.

In some motors of the prior art as shown in figure 1, a cylindrical element is used for insulating the statoric part from the rotoric part and thus preventing the electric windings of the stator from coming into contact with the liquid to be pumped. In this figure, a motor pump 10 of the prior art comprising a motor 20 coupled to a pump 50 is shown.

The motor 20 comprises a motor body 22 delimited by walls. By starting from an upper wall 22A of the motor body 22, a cylindrical element 24 extends towards the inside having two ends: a first end 24a facing the wall 22A and open towards the outside, and a second end 24b facing the inside of the motor body 22 and closed by a bottom 26. The cylindrical element 24 thus defines two cavities: a first cavity 28 inside the cylindrical element 24 and a second cavity 30 outside the cylindrical element 24 but contained inside the motor body 22.

A rotor 32 containing a magnet is housed in the first cavity 28, while the stator is housed in the second cavity 30 the pole pieces 34 thereof have been represented in figure 1.

The rotor 32 comprises a shaft 36 which is inserted and fixed inside a hole made in the centre of the rotor 32. The shaft 36 has two ends: a first end 36a on which the impeller 52 of the pump 50 is fixed, and a second end 36b housed inside a seat 26a formed on the bottom 26 of the cylindrical element 24.

A portion of the shaft 36 between the rotor 32 and the impeller 52 is inserted into a bush 38 wherein the shaft 36 is free to rotate. The bush 38 is fixed by a gasket 40, for example an O-ring, inside the cylindrical element 24.

The pump 50 comprises a pump body 54 mounted onto the motor body 22 inside which the impeller 52 is housed.

By feeding the electric windings of the stator, magnetic poles are generated at the pole pieces 34 which, by interacting with the magnetic field of the rotor magnet 32, put the rotor 32 in rotation and therefore also the impeller 52.

As can be seen, thanks to the cylindrical element 24, the second cavity 30 which houses the stator is completely closed and therefore the electrical windings are completely insulated.

However, this embodiment of the prior art just described has several drawbacks.

First of all, the embodiment is quite complex since it is necessary to construct a shaft for transmitting motion from the rotor to the impeller, a rotor with a hole inside where the shaft is inserted and fixed, a bush to support one end of the shaft and a housing seat for supporting the other end of the shaft. In addition, once constructed all these elements, it is necessary to mount them to each other. Then, both the production costs for obtaining the individual pieces and their assembly are high.

Then, with time and due to wear, it is inevitable that some components may fail and interrupt the correct operation of the motor pump and making also necessary a cost for the intervention of specialized personnel.

In particular, since the gasket 40 is in contact with the pump body, it is also in contact with the fluid to be pumped which in some cases is dirty or even aggressive. In fact, the water waste of a washing machine contains chemically aggressive detergents that easily attack and erode the gaskets therefore they must be frequently replaced causing evident inconveniences.

Moreover, spaces or air chambers are defined between the first cylindrical cavity 28 and the rotor 32, and more precisely a first air chamber between the rotor 32 and the bottom 26 of the cylindrical element 24 and a second air chamber between the rotor 32 and the bush 38.

Then, the two air chambers are in communication with each other through the space defined between the cylindrical element 24 and the rotor 32.

It was established by the applicant that these air chambers due to:

- the constant starting and stopping of the motor,
- the variation of the temperature of the liquid to be pumped (for example in case of a motor pump for washing machines or dishwashers the liquid can be either at room temperature or heated),

function as minipumps which suck the liquid contained in impeller body. But, despite the fact gasket 40 is used, these air chambers are able to suck the liquid contained in impeller body especially if, as indicated above, it has to be considered that the seals are worn and attacked by the liquid to be pumped.

Therefore, the impurities contained in the liquid, such as detergents, cleansing agents and various impurities in case of motor pumps for washing machines or dishwashers, penetrate inside the cavity which house the rotor and, with time, they accumulate and prevent the correct rotation of the rotor inside the cavity, thus causing jamming or irreparable damages to the rotor.

This causes issues due to the stop of the motor and then generating a high cost for maintenance or even replacement of the damaged motor pump.

The aim of the present invention is to obviate the drawbacks mentioned above with reference to the cited prior art and, in particular, to avoid a rapid wear of the various components that form the electric motor, but especially preventing the rotor function incorrectly or even jam or fail due to impurities that could penetrate into the cavity.

These aims are achieved by a motor pump according to claim 1.

In this way, the construction design of the motor is considerably simplified since, compared to the motors of the prior art, there is not a drive shaft, it is not necessary to drill the rotor in order to insert the shaft, and it is not necessary to construct the bushes or other supports inside which the ends of the shaft rotate.

It is simply necessary to realize only a rotor and coupled it axially and directly to the impeller.

In fact, bearing in mind that the rotor, for at least a portion of its length, has a section corresponding to the cylindrical cavity of the cylindrical element inside which it is housed, there is no need of any support as the rotor is directly supported by the cylindrical element inside which it is inserted.

In other words, the rotor itself operates as a shaft and the bushes are replaced by the cylindrical element inside which the rotor rotates.

Thanks to the simplicity of this construction, the production time of such a motor is considerably reduced and the manufacturing cost is significantly limited.

Moreover, the diameter of contact between the rotor and the cylindrical element is much higher than the diameter of contact between the drive shaft and the bushes of the prior art motors and therefore the contact surface is much wider.

Consequently, the contact pressures are very limited, so there is a significant reduction of the wear. In this way, the service life of the motor significantly extends.

Furthermore, due to the fact that there is a direct contact between the rotor and the cylindrical element for at least a portion of the length of the rotor, the fluid is not able to penetrate inside the cavity housing the rotor. Therefore, there is no risk that the rotor can be subject to malfunctions or jammings due to the impurities contained in the fluid to be pumped.

Preferably, the entire part of the rotor housed within said cylindrical element has a circular cross-section corresponding to the inner section of said cylindrical element, so that the whole part of the rotor housed inside said cylindrical element is in contact with said cylindrical element.

In particular, said rotor has a length equal or higher than the length of said cylindrical element so that the rotor substantially engages the entire inner cavity of said cylindrical element, so that between said cylindrical element and said rotor there are no spaces or voids and the friction contact between the rotor and the cylindrical element occurs for the entire length of said first inner cavity of said cylindrical element.

It is evident that if the rotor completely engages the cavity wherein it is housed, first of all the contact occurs on a very extensive surface increasing the benefits described previously, but above all there is no possibility that impurities penetrate inside the cavity.

This is due not only because the entire cavity is engaged by the rotor, but above all because there is no air chambers between the rotor and the cavity, and pump effect is no longer originated, as previously described, effect which could draw back the fluid with impurities to be pumped into the cavity. Since the fluid is no longer drawn back inside, there is no deposit of impurities between the rotor and the cavity which houses it.

The motor no longer gets damaged or no further malfunctions, and the service life is considerably extended.

These and other advantageous characteristics of the present invention will become more apparent from the following description of an embodiment provided only by the way of example with no limitation and which refer to the following drawings wherein:

- figure 2 is a cross section of a motor pump according to the present invention;
- figures 3, 4 and 5 are cross sections showing in an exploded view the motor pump of figure 2 and, in particular, respectively illustrate the pump body, the rotor with impeller housed inside a cylindrical element and the motor body;
- figures 6 and 7 are cross sections showing details of figure 4, i.e. the rotor with impeller and the cylindrical element able to contain the rotor;
- figure 8 is a perspective view of the rotor with impeller housed in the stator of the motor pump of figure 2;
- figures 9, 10 and 11 are perspective views which illustrate in an exploded view what contained in figure 8, in particular respectively the rotor with the impeller, the cylindrical element and the stator;
- figure 12 is a perspective view illustrating a variant of the invention relating to the cylindrical element and the rotor contained therein;
- figures 13 and 14 are perspective views of the cylindrical element of figure 12 respectively shown in full and partially sectioned;
- figures 15 and 16 are perspective views of the rotor of figure 12 respectively shown in full and partially sectioned.

In figure 2, generally indicated with 100 is a motor pump comprising a synchronous electric motor 120 coupled to a pump 150, such as a pump for aquariums or a pump for household appliances such as washing machines and dishwashers.

The motor 120 comprises a motor body 122 which, as better illustrated in figure 5, is delimited by walls, in particular an upper wall 122A where a circular opening 123 is formed.

Figures 7 and 10 show in details a cylindrical element 124 inserted inside the motor body 122, the cylindrical element is formed by a tubular element 125 having two opposite ends: a first open end 125a and a second end 125b closed by a bottom 126.

A collar 127 is mounted on the first end 125a of the tubular element 125 with dimensions corresponding to the circular opening 123 made in the upper wall 122A, so by inserting the cylindrical element 124 into the motor body 122, the collar 127 closes the circular opening 123. A circumferential recess 129 is made on the collar 127 whose function will be described below.

The cylindrical element 124, inside the pump body 122, thus defines two cavities: a first cavity 128 inside the cylindrical element 124 and a second cavity 130 outside the cylindrical element 124 but inside the motor body 122.

The rotor 132 is housed inside the first cavity 128 (see fig.4), while a stator 140 is housed in the second cavity 130 (see fig.8).

The rotor 132, as better illustrated in figures 4 and 6, has a shape corresponding to that of the cylindrical element 124 so that it is possible to insert the rotor 132 inside the cylindrical element 124, completely filling the first cavity 128. Thus, the rotor 132 is supported during its rotation along its entire outer cylindrical surface by the cylindrical element 124.

The rotor 132 contains a magnet 134 and it is coupled at its one end 132a directly and axially to the impeller 152 of the pump 150. At the end 132a coupled to the impeller 152, the rotor 132 has a circumferential projection 136 of dimensions corresponding to that of the circumferential recess 129 formed on the cylindrical element 124. By inserting the rotor 132 within the cylindrical element 124, the circumferential projection 136 enters into the circumferential recess 129 which therefore acts as a guide for the relative rotation between the rotor 132 and the cylindrical element 124.

The stator 140, as shown in figure 11, comprises a statoric pack 142 of ferromagnetic material having two pole pieces 142A, 142B and an electric winding 144 wound.

The pump 150 comprises a pump body 154 inside which the impeller 152 is housed. As can be seen more clearly in figure 3, the pump body 154 includes an inlet or a suction intake 156 through which the liquid to be pumped is sucked and an outlet 158 through which the pumped liquid comes out.

The pump body 154 also includes a circular opening 160 having dimensions corresponding of the collar 127 of the cylindrical element 124 so by mounting the pump body 154 onto the motor body 122 the circular opening 160 is closed by the collar 127.

Inside the pump body 154, when the impeller 152 is inserted inside, a passage 162 (see fig. 2) of the liquid is defined which connects the suction intake 156 to the outlet 158 and which has dimensions equal or higher than the dimensions of the suction intake 156 and the outlet 158. This way, any foreign body that may penetrate inside the pump body 154 through the suction intake 156 is able to cross the passage 162 and comes out from the outlet 158.

For the assembling of the motor pump is sufficient:

- insert the stator 140 into the motor body 122;
- insert the cylindrical element 124 into the motor body 122 so that the collar 127 closes the circular opening 123 of the motor body 122;
- insert the rotor 132 with the impeller 152 inside the cylindrical element 124 so that the circumferential projection 136 is inserted inside the circumferential recess 129;
- mount the pump body 154 onto the motor body 122 so that the circular opening 160 of the pump body 154 is closed by the collar 127 of the cylindrical element 124.

As can be noted, the stator 140 with the electric winding 144 is housed inside the second cavity 130 of the motor body 122 which is completely insulated, so that there is no possibility that liquid can penetrate and come into contact with the electric winding 144.

By feeding the electric winding 144 of the stator 140, magnetic poles are generated at the pole pieces 142A, 142B which interacts with the magnetic field of the magnet 134 of the rotor 132 putting the rotor 132 in rotation and therefore the impeller 152.

The rotor 132 rotates inside the cylindrical element 124 which acts as a plain bearing.

The cylindrical element 124 is preferable made with self-lubricating and anti-wear material, such as a polymeric material.

The construction of such a motor is very simple due to the reduced number of components necessary for its realization. The time and the cost of construction are therefore considerably reduced.

It can be noted that the rotor 132 fully engages the first cavity 128 of the cylindrical element 124 whereby the contact surface between the rotor 132 and the cylindrical element 124 is remarkable, and then the rotor is suitably supported inside the cylindrical element 124. Thanks to this feature, the operation of the rotor is more regular and also wear is reduced.

Moreover, the following very important characteristic has to be noted: between the cylindrical element 124 and the rotor 132 there is no space or air chambers so that the above said pump effect is not created thus avoiding that impurities contained in the liquid to be pumped, which as already explained is a source of malfunctionings and failure, can penetrate into the cylindrical element 124.

Thanks to the simplicity of construction, the large contact surface between the rotor and the cylindrical element and because there is no air chambers in the cavity which houses the rotor, the motor is extremely reliable and its service life is considerably increased with respect to the motors of prior art.

It should also be considered that due to the contact between the rotor 132 and the cylindrical element 124, the air gap existing between the stator 140 and the rotor 132 is reduced to the minimum possible and in such condition the magnetic field of the stator 140 and that of the rotor 132 are closely linked. Consequently, between the voltage that feeds the electric winding of the stator 140 and the electric current passing through there is a very little phase angle φ which is very close to zero and then the so-called power factor Cos φ is essentially equal to 1. This way, the electric current in the winding 144 is the minimum possible and, therefore, the electrical losses due to the Joule effect are reduced to a minimum. In so doing, the efficiency of the electric motor is high and, with the same electric power of known motors, it is able to operate a pump which absorbs more power.

Figure 12 shows a variant of the invention and in particular a rotor 232 inserted inside a cylindrical element 224.

As better seen from figures 13 and 14, the cylindrical element 224 is similar to the cylindrical element 124, i.e. it has a tubular element 225 provided with a collar 227.

A tubular duct 22 is placed beside the tubular element 225 and it has the same length but of smaller section. A longitudinal slot 228 is formed in the area of contact between the tubular element 225 and the duct 229 for the entire length of the two elements which puts in contact the inside of the tubular element 225 with the inside of the duct 229.

As will be seen from figures 12, 15 and 16, the rotor 232 is provided with a central pin 233 on which a magnet 234 is mounted, while the impeller 152 is mounted at the free end 233A of the pin 233. The pin 233 has an axial through hole 237.

As noted in figure 12, the length of the rotor 232 is less than the length of the tubular element 225 and, therefore, the rotor 232 is spaced apart from the bottom 226 of the tubular element 225.

In figure 12, a stator 240 is represented which externally surrounds the cylindrical element 224.

When the pump is operated, the rotor 232 rotates inside the tubular element 225, the impeller 152 coupled to the rotor 232 thrust the liquid to be pumped into the duct 229 and, thanks to the longitudinal slot 228, the liquid comes into contact with the rotor 232 enabling both the cooling and lubrication of the contact area between the rotor 232 and the tubular element 225.

Since the rotor 232 is spaced apart from the bottom of the tubular element 225, the liquid through the slot 228 goes inside the tubular element 225 in the area below the rotor 232 and then goes up along the through hole 237 of the rotor 232 and, finally, comes out from the free end 233A of the pin 233. This way, a forced circulation of liquid is created which considerably increases the amount of liquid that enters into the longitudinal slot 228 and, then, in the contact area between the rotor 232 and the tubular element 225. This effectively cools and lubricates the area where there is friction between the rotor and the tubular element.

Finally, it is evident that any variation or modification functionally or conceptually equivalent fall under the scope of the present invention.

For example, it is possible to have a stator with a different number of pole pieces, or having more electric windings or a stator packs with a different shape.

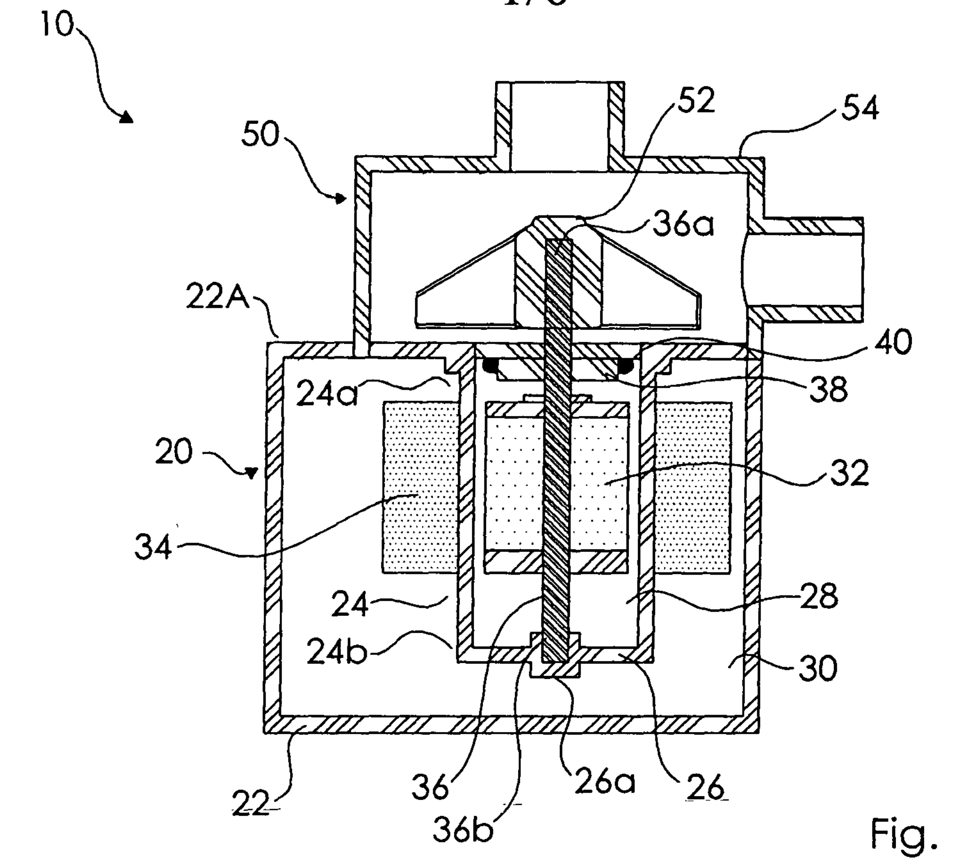
CLAIMS

1. Motor pump (100) comprising an electric motor (120) coupled to a pump (150), said electric motor (120) including a motor body (122), a stator (140) and a rotor (132,232) coupled to an impeller (152) of said pump (150), said motor (120) further comprising a cylindrical element (124,224) which extends towards the inside of said motor body (122) from one of its outer walls (122A) so as to divide the inside of said motor body (122) in two cavities, a first cylindrical cavity (128) inside said cylindrical element (124,224) able to house said rotor (132,232) and a second cavity (130) outside said cylindrical element (124,224) able to house said stator (140), said cylindrical element (124,224) having a first open end (125a), opposite to a second end (125b), positioned at said outer wall (122A) of said motor body (122) so that said first cylindrical cavity (128) is open to the outside so as to insert said rotor (132,232) inside said cylindrical element (124,224), characterized in that said rotor (132,232), for at least part of its length, has a circular cross section essentially corresponding to the inner section of said cylindrical element (124,224) so that said rotor (132,232) is in contact with said cylindrical element (124,224) and then there is a friction between said rotor (132,232) and said cylindrical element (124,224) when said rotor (132,232) rotates, said rotor (132,232) being shaftless and axially and directly coupled to said impeller (152) of said pump (150).
2. Motor pump according to claim 1, characterized in that the entire portion of the rotor (132,232) housed inside said cylindrical element (124,224) has a circular cross section corresponding to the inner section of said cylindrical element (124,224), so that all the portion of the rotor housed inside said cylindrical element (124,224) is in contact with said cylindrical element (124,224).
3. Motor pump according to claim 2, characterized in that said rotor (132,232) has a length equal or higher than the length of said cylindrical element (124,224), so that the rotor essentially fills the entire first cavity (128) inside said cylindrical element (124,224), so that between said cylindrical element (124,224) and said rotor (132,232) there is no space or gap and the frictional contact between the rotor (132,232) and the cylindrical element (124,224) occurs for the entire length of the first cavity (128) of said cylindrical element (124,224).
4. Motor pump according to any of the previous claims, characterized in that said

cylindrical element (124,224) is made of self-lubricating and wear-resistant material.

5. Motor pump according to claim 4, characterized in that said self-lubricating and wear-resistant material is a polymeric material.
6. Motor pump according to any of the previous claims, characterized in that said cylindrical element (124,224) comprises a collar (127) at its first end, said motor body (122) having an opening (123) with the shape and dimensions corresponding to that of said collar (127), so that by inserting said cylindrical element (124,224) inside said motor body (122) said collar (127) closes said opening (123) of said motor body (122).
7. Motor pump according to any of the previous claims, characterized in that said rotor (132,232) comprises at least one permanent magnet (134).
8. Motor pump according to any of the previous claims, characterized in that said stator (140) comprises at least one statoric pack (142) defining at least two pole pieces (142A, 142B) faced to said cylindrical element (124,224) and at least one electric winding (144) to generate a magnetic field and then at least two magnetic poles at said at least two pole pieces (142A, 142B).
9. Motor pump according to any of the previous claims, characterized in that it comprises a duct (229) placed on the side of said cylindrical element (224) and defining a longitudinal slot (228) of communication between said cylindrical element (224) and said duct (229), said duct (229) being in communication with said pump (150) so that the fluid pumped by said pump (150) can enter into said duct (229) and lubricate and/or cool the contact area between said rotor (232) and said cylindrical element (224).
10. Motor pump according to any of the previous claims, characterized in that said duct (229) also communicates with the area interposed between said rotor (232) and the bottom (226) of said cylindrical element (224), said rotor (232) is also provided with a through hole (237) so that the fluid that arrives between the bottom (226) of the cylindrical element (224) and the rotor (232) can pass through the rotor (232) and then comes out.
11. Motor pump according to any of the previous claims, characterized in that said pump (150) comprises a pump body (154) inside which the impeller (152) of said pump (150) is housed, said pump body (154) being provided with a suction

intake (156) through which the liquid to be pumped is sucked and an outlet (158) through which the pumped liquid goes out, inside said pump body (154) being defined a passage (162) which connects said suction intake (156) to said outlet (158) has a dimension equal or greater than the dimension of said suction intake (156) and of said outlet (158), so that any foreign body that penetrates inside said pump body (154) through said suction intake (156) can pass through said passage (162) and go out from said outlet (158).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52
54
36a
22A
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24
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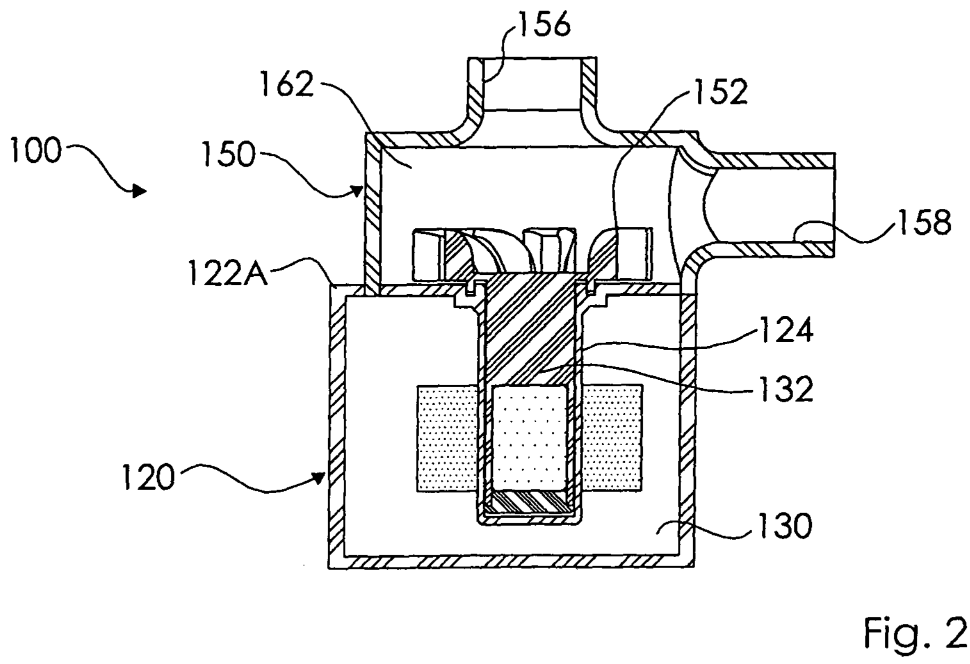
36b

Fig. 1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162
152
100
150
158
122A
124
132
120
130

Fig. 2

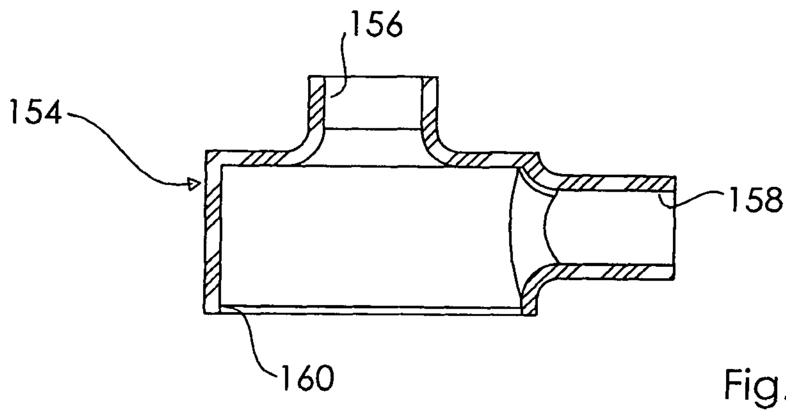

Fig. 3

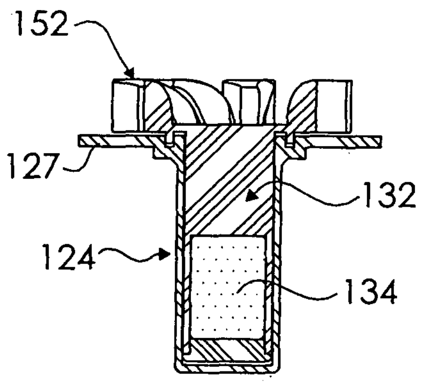

Fig. 4

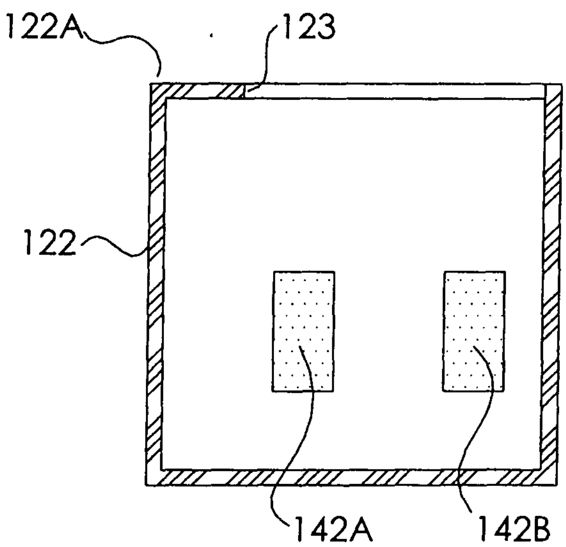

Fig. 5

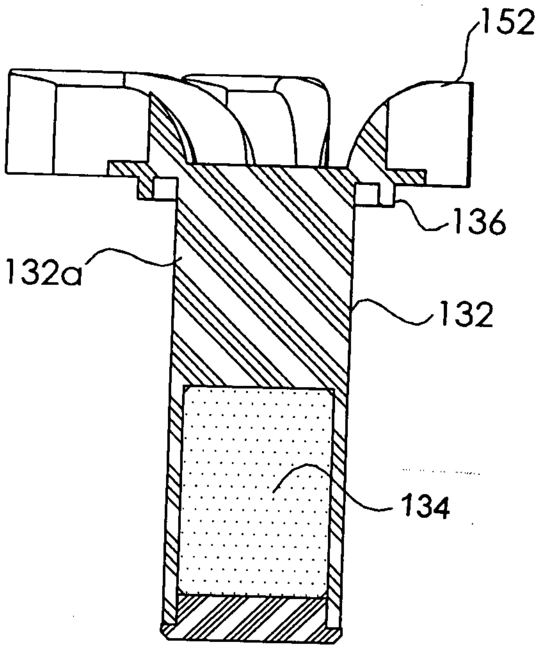

Fig. 6

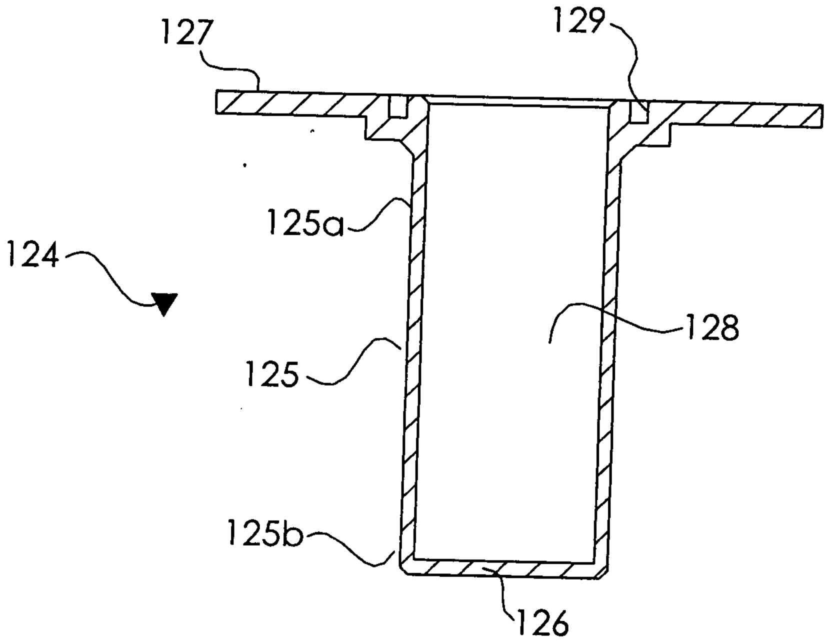

Fig. 7

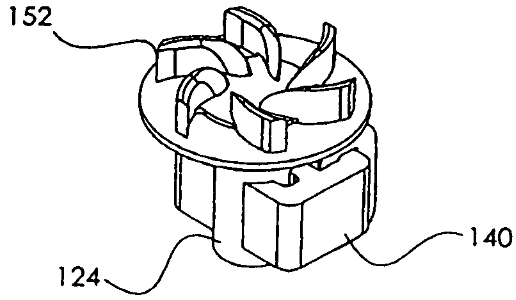

Fig. 8

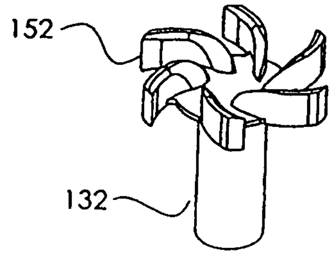

Fig. 9

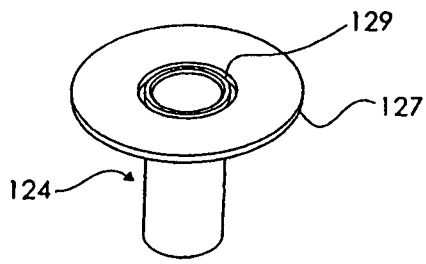

Fig. 10

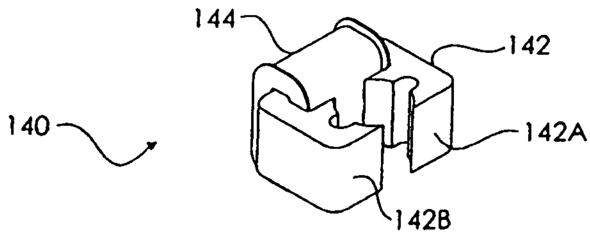

Fig. 11

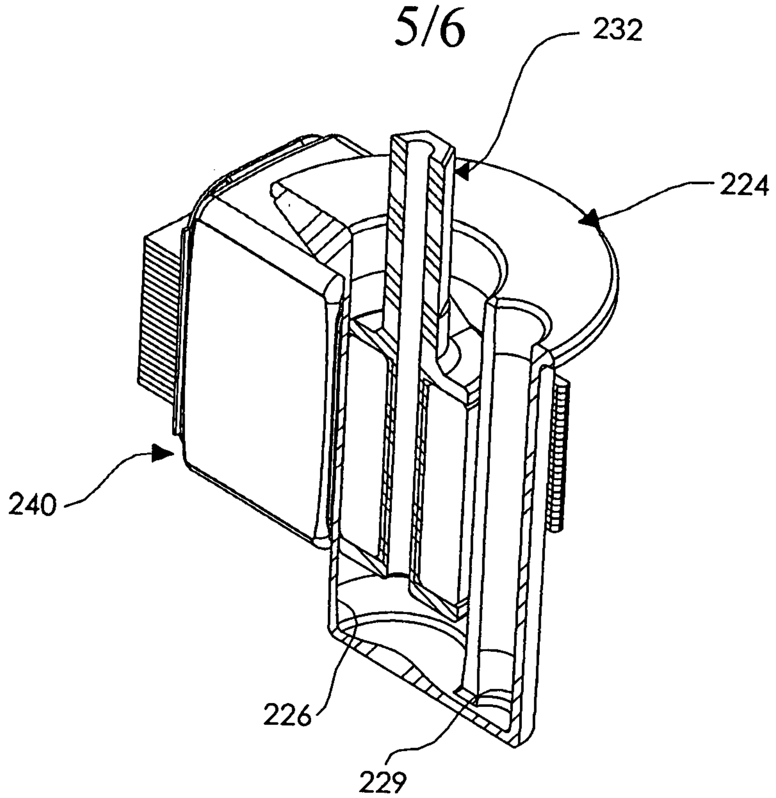

Fig. 12

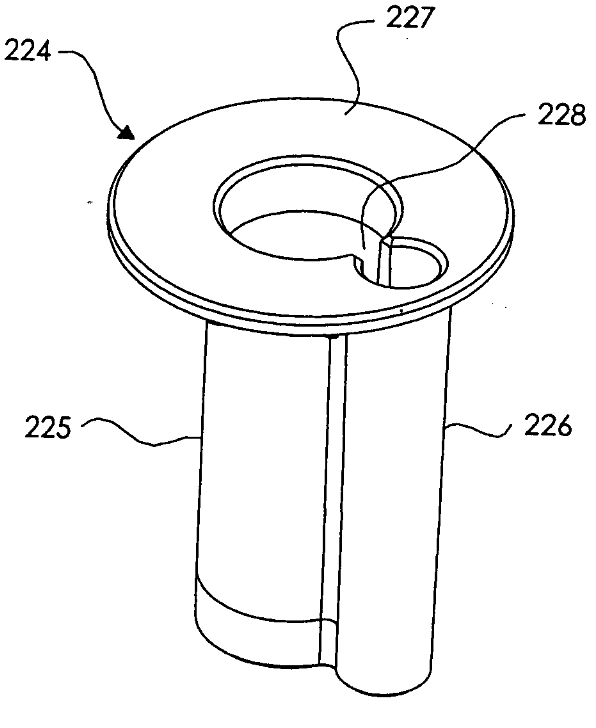

Fig. 13

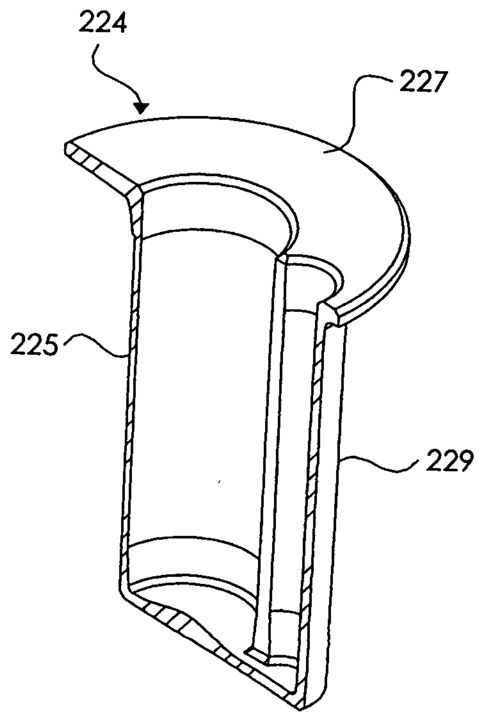

Fig. 11

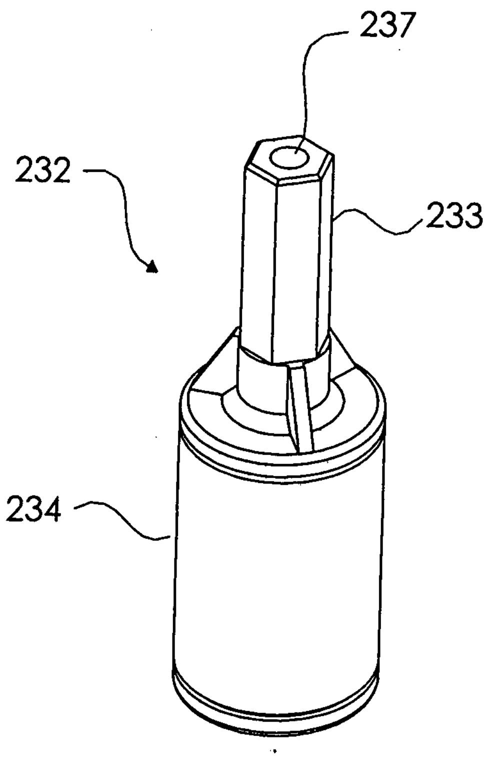

Fig. 15

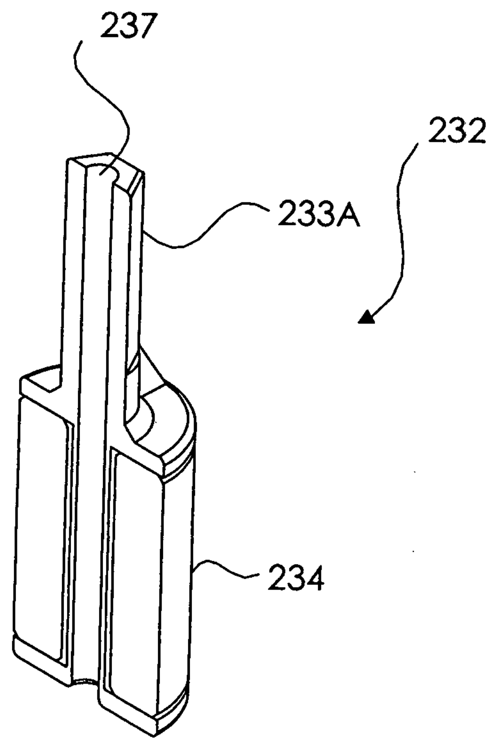

Fig. 16