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(54) **PUMP, AND CORRESPONDING CONTROL METHOD**

(57) A pump comprises means to suck in and deliver a fluid, and a coil (14) connectable to an electric power source (18) configured to feed an alternate electric voltage (VAC). The coil (14) is suitable to move the suction and delivery means in order to suck in and deliver the fluid as a function of a pulsed electric current (I) circulating therein. The pump also comprises a control device (20) configured to regulate the flow rate of the pump, comprising a convertor unit (22) configured to convert the alternate electric voltage (VAC) into a substantially continuous electric voltage (VDC), and a frequency setting unit (28), configured to selectively and periodically feed the continuous electric voltage (VDC) to the coil (14).

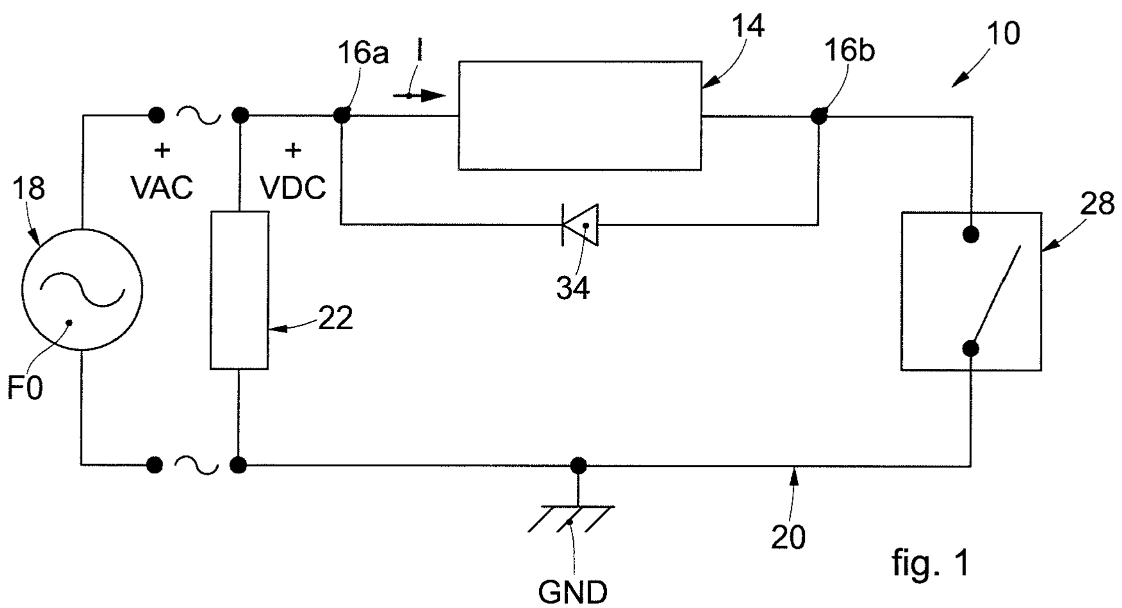

fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a pump, in particular a micropump, provided with means to regulate its flow rate according to specific requirements.

[0002] The invention also concerns a control method applicable to a pump in order to regulate its flow rate.

BACKGROUND OF THE INVENTION

[0003] It is known to use pumps, in particular micropumps, in different types of applications, for example steam irons or ovens, coffee machines, or similar devices, which require the delivery of water, or steam, with low flow rates but at relatively high pressures.

[0004] Such pumps generally comprise fluid suction and delivery means, moved by a drive member controlled by a control device of the electronic type.

[0005] Among these pumps are known in which the drive member comprises a coil in which an electric current circulates, and the suction and delivery means are moved by the electromagnetic force generated by the electric current circulating in the coil.

[0006] For example, pumps are known in the field defined as "vibration" pumps, in which the suction and delivery means comprise a piston, connected to elastic means, for example a diaphragm, or a membrane, in which the piston is moved in one direction by the electromagnetic force, and in the opposite direction by an elastic force exerted by the elastic means.

[0007] The electronic control device conditions the functioning of the pump by supplying an electric current in the coil with determinate intensity and frequency.

[0008] In solutions known in the prior art, such pumps are generally designed and produced according to their specific application, so that it is not then possible to modify their performances as a function of varying requirements that arise during use.

[0009] In particular, different pumps are available on the market depending on the flow of water and/or steam they have to manage, since this flow depends, among other things, on physical and construction parameters such as the sizes of the pipes and/or nozzles through which the fluid transits and/or is delivered.

[0010] Drive devices are also known which allow to modify the functioning of a motor to regulate the capacity of the load connected to the motor, or to reduce energy consumption.

[0011] US-A-2008/0226464 describes a device to drive an electromagnet of a pump, in which the electromagnet comprises a primary coil and a piston which is attracted inside the primary coil when an energizing electric current flows therein. The device described in US-A-2008/0226464 provides to regulate the capacity of the electromagnetic pump by limiting the stroke of the piston, that is, by supplying an electric current in the primary coil only for a portion of a predefined current curve, thus providing a quantity of current less than that needed so that the piston can complete a full stroke.

[0012] US 2012/0235619 describes an alternating current motor piloted in frequency and duty cycle which provides to modify the functioning thereof according to the load applied, for example on the basis of a functioning or inactive condition of a pump, in order to reduce energy consumption when the pump is not functioning.

[0013] Document US-A-2004/005222 concerns a drive apparatus of a linear compressor. The solution described in US-A-2004/005222 provides to increase or decrease the electric current or voltage supplied to the linear compressor according to the capacity required by the load.

[0014] These solutions, however, do not allow to modify the flow rate of a pump in order to adapt it to applications that require different conditions of use, in particular in the case of micropumps for irons, coffee machines, steam ovens and suchlike.

[0015] Therefore, to modify the flow rate of fluid sucked in and delivered by a pump it is generally necessary to modify the overall sizes of the pump itself, including its mechanical sizes or the size of the coils.

[0016] This entails high costs for the design and construction of the various types of pumps, since it is necessary to produce specific components for different sizes.

[0017] Moreover, this condition entails a need for storage spaces, both in the warehouse and also in the final sales points, in order to have available types of pumps with different sizes and suitable on each occasion for the specific requirements.

[0018] One purpose of the present invention is therefore to provide a pump and a method to control a pump which are improvements in terms of versatility and flexibility of use compared with the solutions of the prior art.

[0019] Another purpose of the present invention is to provide a pump that allows to regulate its flow rate easily and quickly according to requirements, being thus able to adapt to different conditions of use.

[0020] Another purpose is to perfect a method to control a pump that allows to adapt its functioning to a specific application or requirement, by regulating its flow rate in a simple and economical manner.

[0021] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the prior art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0022] The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

[0023] Embodiments described here concern a pump comprising means to suck in and deliver a fluid between an entrance aperture and a sending aperture, and a coil suitable to move the suction and delivery means in order to suck in and deliver the fluid as a function of a pulsed electric current circulating in the coil.

[0024] The coil can be connected to an electric power source configured to feed an alternate electric voltage with a defined frequency.

[0025] The alternate electric voltage can be that generally supplied by a public or private power network.

[0026] According to some embodiments of the invention, the pump comprises a control device configured to control the functioning of the pump and regulate the flow rate of the latter. The control device, in particular, is configured to modify, in a desired manner, the frequency of the pulses of the electric current circulating in the coil in order to modify, as a consequence, the flow rate of the pump.

[0027] According to some embodiments, the control device can be configured to modify the frequency of the current pulses as a function of the size of the pipes and/or nozzles to which the fluid has to be supplied.

[0028] The control device allows to regulate the flow rate of the pump quickly and easily, according to needs, to adapt it on each occasion to different conditions of use.

[0029] Thanks to the control device, it is therefore possible to use the same pump for a plurality of different applications in which different supply flow rates are required, at least within a certain range of flow rates, without needing to make specific components for the different sizes, allowing to reduce both production costs and costs for the storage of the different components.

[0030] According to some embodiments, the control device comprises a convertor unit, connected to the coil and connectable to the electric supply source, and configured to convert the alternate electric voltage into a substantially continuous electric voltage, and a frequency setting unit, suitable to define a desired frequency for the electric current pulses.

[0031] The frequency setting unit is connected to the coil and the convertor unit, and is configured to allow or selectively and periodically prevent the supply of the continuous electric voltage in the coil, according to a desired set frequency, independent of the network frequency.

[0032] According to some embodiments, the frequency setting unit in particular is configured to close and open, with the set frequency, a circuit defined by the coil, by the convertor unit and by the ground, so as to make an electric current circulate in the coil with a pulse development correlated to the frequency set.

[0033] The frequency set is thus made independent from the defined network frequency defined by the power source, and, given the same intensity of the electric current, the different duration of the pulses allows to suitably regulate the flow rate of fluid directly, by varying the electric power supply, so as to adapt the pump to the specific applications and requirements on each occasion.

[0034] This allows both to optimize the use and functioning of the pump, adapting it to different types of application, and also to reduce the overall energy consumption of the latter.

[0035] According to some embodiments, the convertor unit comprises a straightener configured to straighten the alternate electric voltage, obtaining downstream thereof an electric voltage with a development that comprises only values greater than or equal to zero.

[0036] According to other solutions, a capacitor is provided connected in parallel to the straightener and having the function of leveling the voltage at exit from the latter, obtaining a continuous electric voltage leveled around a mean value.

[0037] According to other embodiments, the frequency setting unit comprises a switch device and a controller configured to generate a square wave signal, periodic with the desired set frequency, suitable to pilot the switch device in order to selectively and periodically activate and de-activate it.

[0038] According to some embodiments, the switch device is connected between the second terminal end of the coil and the ground, and, as a function of the signal generated by the controller, can switch between an inactive state, in which it behaves as an open circuit, and an active state, in which it behaves as a closed circuit allowing the circulation of the electric current in the circuit.

[0039] Embodiments described here also concern a method to control a pump, which comprises means to suck and deliver a fluid between an entrance aperture and a sending aperture, and a coil connectable to an electric power source, and suitable to move the suction and delivery means to suck and deliver the fluid as a function of a pulsed electrical current circulating between a first terminal end and a second terminal end of the coil.

[0040] The method according to the invention provides to regulate the flow rate of the pump by modifying the frequency of pulses of the electric power circulating in the coil. In particular the method provides:

- to convert the alternate electric voltage into a substantially continuous electric voltage by means of a convertor unit connected between the first terminal end of the coil and the electric power source; and
- to selectively and periodically feed the continuous electric voltage to the coil with a desired set frequency, independent of the defined network frequency, so as to generate, in the coil, the electric current, able to supply the desired flow rate, with a pulsed development correlated to the set frequency.

[0041] According to other embodiments, in order to selectively and periodically close and open the circuit, the method provides to generate a square wave signal with the set frequency by means of a controller, and to pilot, with the square wave signal, a switch device connected between the second terminal end of the coil and the ground, making it pass selectively and periodically from a non-active state, in which the switch device behaves as an open circuit, to an active state, in which it behaves as a closed circuit, allowing the circulation of the electric current.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] These and other characteristics of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a schematic view of a pump according to an embodiment described here;
- fig. 2 is a schematic view of the circuit blocks of a control device of a pump according to embodiments described here.

[0043] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can conveniently be incorporated into other embodiments without further clarifications.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0044] Embodiments described here concern a pump 10, in particular a micropump, of the type that can be used in irons, or steam ovens, coffee machines, or similar devices, to supply steam respectively to steam outlet nozzles and/or inside a cooking chamber.

[0045] According to some embodiments, the pump 10 can operate with a low electric power, for example of the range of a few tens of Watts, or even less than 10 Watts.

[0046] The pump 10 can comprise suction and delivery means, not shown, configured to suck the fluid through an entrance aperture and deliver the fluid through a sending aperture, and drive members suitable to drive the suction and delivery means.

[0047] In the embodiment shown, the drive members comprise a coil 14 suitable to move the suction and delivery means as a function of a pulsed electric current circulating therein between a first terminal end 16a and a second terminal end 16b.

[0048] According to some embodiments, the pump 10 can be a "vibration" volumetric pump, in which the suction and delivery means comprise a diaphragm, or a membrane, connected to a piston drive member, which is disposed inside the coil 14. The diaphragm, or membrane, defines a fluid accumulation chamber, which is provided with respective entrance and sending apertures.

[0049] The diaphragm, or membrane, is driven when the coil 14 is fed by unidirectional pulses created by the passage of an electric current I through it.

[0050] The electric current I circulating in the coil 14 generates an electromagnetic force which moves the piston, and consequently the diaphragm, so as to increase the volume of the accumulation chamber and promote the accumulation of fluid therein through the entrance aperture. At the end of the electric current impulse, the diaphragm moves toward its original position thanks to its elastic properties and return spring, thus reducing the volume of the accumulation chamber and promoting the delivery of the fluid through the sending aperture.

[0051] According to possible variants, not shown, instead of the diaphragm or membrane, elastic means can be provided, for example other springs, or other kind, configured to exert on a piston an elastic return force that acts in the opposite direction to that of the electromagnetic force.

[0052] The terminal ends 16a, 16b of the coil 14, during use, are connected to an electric power source 18 and to a ground GND.

[0053] The electric supply source 18 can be, for example, the public electric supply network, or another source of current supply and alternating electric voltage VAC.

[0054] According to some embodiments, the electric supply source 18 can supply, for example, an alternating electric voltage VAC with an effective value of about 230V, and a defined network frequency F0 of about 50 Hz.

[0055] According to some embodiments of the present invention, the pump 10 is provided with a control device 20 configured to control the functioning of the pump 10, and in particular to regulate the flow rate of the pump 10 in order to adapt it on each occasion according to specific applications and needs.

[0056] According to some embodiments, the control device 20 is made integrally in the pump 10.

[0057] According to possible variant embodiments, the control device 20 can be made as a separate component which can be connected, according to needs, to a pump of the type provided with delivery and suction means moved by drive members comprising a coil 14.

[0058] In particular, the control device 20 is configured to modulate the pulses of the electric current I circulating in the coil 14 according to a set frequency FSET in such a way as to modify the flow rate of the pump 10 consistently.

[0059] The duration of the pulses of the electric current I, in fact, given the same amplitude thereof, conditions the duration of the action of moving the suction and delivery means, and therefore the quantity of fluid that can be sucked in and delivered in a given interval of time.

[0060] According to some embodiments, the control device 20 comprises a convertor unit 22, connected on one side to the electric supply source 18, and on the other side to a first terminal end 16a of the coil 14, and configured to convert the alternating electric voltage VAC supplied by the electric supply source 18 into a substantially continuous voltage VDC.

[0061] According to some embodiments, the convertor unit 22 comprises a straightener 24 configured to straighten the alternating electric voltage VAC and to supply an electric voltage at exit, the development of which comprises only values greater than or equal to zero.

[0062] According to some embodiments, the straightener 24 is a full wave straightener in which the negative half-wave is inverted in the quadrant of the positive values, in a symmetrical position with respect to the axis of the times shown on the abscissa.

[0063] According to possible embodiments, the straightener 24 is a diode bridge.

[0064] According to other embodiments, the convertor unit 22 comprises, connected in parallel to the output of the straightener 24, a capacitor 26 having the function of leveling the voltage exiting from the straightener 24.

[0065] The capacitor 26, in particular, is configured to obtain a voltage with a leveled development around a mean value, that is, a continuous electric voltage VDC.

[0066] According to these embodiments, downstream of the capacitor 26 the electric voltage can have a mean value equal to the effective value of the voltage value of the electric supply source 18.

[0067] In the case of an alternating voltage VAC of 230V, for example, downstream of the capacitor 26, the continuous voltage VDC can have a mean value of about 325V.

[0068] The control device 20 also comprises a frequency setting unit 28 connected to the coil 14 and configured to selectively and periodically allow the supply of the continuous electric voltage VDC to the coil 14.

[0069] In particular, the supply of the continuous electric voltage is selectively allowed, or prevented, at defined periodic intervals, according to a desired set frequency FSET.

[0070] According to some embodiments, the frequency setting unit 28 is connected between the second terminal end 16b of the coil 14 and the ground GND.

[0071] The frequency setting unit 28 is configured to selectively and periodically close and open the circuit defined between the coil 14, the convertor unit 22, and the ground GND, so as to generate an electric current I in the circuit having a pulsed development with the desired set frequency FSET.

[0072] According to possible solutions, the frequency setting unit 28 comprises a switch device 30, and a controller 32, or microprocessor, configured to generate a square wave signal, having the set frequency FSET and suitable to activate/deactivate the switch 30.

[0073] According to some embodiments, the controller 32 can be a computer, a microprocessor, a microcontroller, or a similar or comparable device.

[0074] Preferably, the controller 32 is a microcontroller, or microprocessor, that is, made in a single integrated circuit.

[0075] According to some embodiments, the switch device 30 can be, or comprise, a semiconductor device.

[0076] According to variant embodiments, the switch device 30 can be made with a MOSFET (Metal Oxide Semiconductor Field-Effect Transistor), suitably piloted by the controller 32.

[0077] Using a MOSFET 30 and a controller 32 allows to modulate in the desired manner the frequency of the pulses of the electric current I, and therefore to regulate the flow rate of the pump 10, being able to adapt it to different applications simply and economically.

[0078] The MOSFET 30 in particular is connected with the source terminal S to the ground GND and with the drain terminal D to the second terminal end 16b, while the gate terminal G is connected to and piloted by the controller 32.

[0079] The MOSFET 30 is selectively activated and deactivated on the basis of the development of the signal supplied by the controller 32 which periodically modifies with frequency FSET the electric voltage applied between the gate terminal G and source S.

[0080] According to some embodiments, the MOSFET 30 closes the circuit when the signal corresponds to the high value of the square wave, that is, the voltage applied between gate G and source S exceeds a determinate limit threshold value, and opens the circuit when the signal corresponds to the low value of the square wave.

[0081] In this way, an electric current I circulates in the coil 14, having a pulse development correlated to the set frequency FSET and independent of the defined network frequency F0.

[0082] According to some embodiments, the controller 32 can be programmed on each occasion, for each application, to set the desired set frequency FSET of the square wave signal.

[0083] According to possible variant embodiments, the controller 32 can be programmed during the production phase by memorizing two or more set working frequencies in a memory unit 36, and selection means 38 can be provided, for example on a user interface, by means of which an operator can select the desired frequency on each occasion from those memorized.

[0084] According to some embodiments, the frequency setting unit 28 can also comprise a first resistor R1 connected in series between the controller 32 and the gate terminal G of the MOSFET 30.

[0085] The first resistor R1 is configured to prevent unwanted oscillations of the square wave signal supplied to the gate terminal G of the MOSFET 30, which could result in consequent unwanted oscillations in the voltage between the gate terminal G and source terminal S and therefore in the electric current I circulating in the coil 14.

[0086] According to some embodiments, the frequency setting unit 28 can also comprise a second resistor R2, connected in parallel to the MOSFET 30.

[0087] The second resistor R2 is configured to ensure that the MOSFET 30 is normally open, that is, it is in the non-active state and therefore prevents the circulation of current in the coil 14.

[0088] According to other embodiments, the control device 20 also comprises a diode 34 connected in parallel to the coil 14 between the first terminal end 16a and the second terminal end 16b.

[0089] The diode 34 is configured to prevent voltage surges occurring between the terminal ends 16a, 16b of the coil 14 during the switching of the frequency setting unit 28, which could damage the coil 14 and/or the MOSFET 30.

[0090] The present invention also concerns a method to control the pump 10, and in particular to regulate its flow rate.

[0091] The method according to the invention provides to regulate the flow rate of the pump 10 by modifying the frequency of the electric current I circulating in the coil 14 between the first terminal end 16a and the second terminal end 16b.

[0092] According to some embodiments, the method provides to convert, by means of a convertor unit 22, the alternating electric voltage VAC supplied by the supply source 18 into a continuous electric voltage VDC to be supplied to a first terminal end 16a of the coil 14.

[0093] According to some embodiments, the method provides to open and close, selectively and periodically according to a set frequency FSET, the circuit defined between the convertor unit 22, the coil 14, and the ground GND, by means of a frequency setting unit 28, so as to define in the circuit an electric current I with pulses with the set frequency FSET.

[0094] The method according to the invention provides to modify the set frequency FSET of the pump 10 according to the flow rate required on each occasion by the specific application.

[0095] According to some embodiments, the method according to the invention provides to independently vary the amplitude and frequency of the electric current I circulating in the coil 14.

[0096] According to some embodiments, to open and close the circuit, the method provides to generate a square wave signal with the set frequency FSET by means of a controller 32, and to pilot a switch device 30 with the square wave signal.

[0097] In particular, the method provides to make the switch device 30 pass selectively between an inactive state, in which it behaves as an open circuit, and an active state in which it behaves as a closed circuit, allowing the electric current I to circulate, and vice versa.

[0098] According to other embodiments, the method provides to use as a switch device 30 a MOSFET connected with the source terminal S to the ground GND, with the drain terminal D to the second terminal end 16b of the coil 14 and with the gate terminal G to the controller 32, and to periodically modify, with frequency FSET, the electric voltage applied between the gate terminal G and source terminal S as a function of the square wave signal generated by the controller 32.

[0099] It is clear that modifications and/or additions of parts can be made to the pump 10, the device 20 and the control method thereof as described heretofore, without departing from the field and scope of the present invention.

[0100] It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve many other equivalent forms of pump 10, device 20 and control method, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

Claims

1. Pump comprising fluid suction and delivery means, and a coil (14) connectable to an electric power source (18) configured to feed an alternate electric voltage (VAC) at a defined frequency (F0), and configured to move said suction and delivery means in order to suck in and deliver said fluid as a function of a pulsed electric current (I) circulating in said coil (14), **characterized in that** said pump comprises a control device (20) configured to regulate the flow rate of said pump, said control device (20) comprising a convertor unit (22), connected to a first terminal end (16a) of the coil (14) configured to convert said alternate electric voltage (VAC) into a substantially continuous electric voltage (VDC), and a frequency setting unit (28), connected to said coil (14) and configured to feed, selectively and periodically, said continuous electric voltage (VDC) to said coil (14) with a desired set frequency (FSET), independent of said defined network frequency (F0), so as to generate, in said coil (14), said electric current (I) with a pulsed development correlated to said set frequency (FSET).

2. Pump as in claim 1, **characterized in that** said convertor unit (22) comprises a straightener (24) configured to straighten said alternate electric voltage (VAC) and to obtain an electric voltage with a development that comprises only values greater than or equal to zero, and a capacitor (26), connected in parallel to said straightener (24), and having the function of leveling the voltage at exit from said straightener (24) in order to obtain said continuous electric voltage (VDC).

3. Pump as in any claim hereinbefore, **characterized in that** said frequency setting unit (28) comprises a switch device (30), connected between a terminal end (16b) of the coil (14) and a ground (GND), and able to pass from a non-active state, in which it behaves as an open circuit, to an active state, in which it behaves as a closed circuit, allowing said electric current (I) to circulate, and vice versa, and a controller (32), configured to generate a square wave signal, periodic with said set frequency (FSET), suitable to pilot said switch device (30) in order to selectively and periodically activate and de-activate it.

4. Pump as in claim 3, **characterized in that** said switch device (30) is made with a MOSFET in which the source terminal (S) is connected to the ground

(GND), the drain terminal (D) is connected to said coil (14) and the gate terminal (G) is connected to said controller (32) and receives said square wave signal.

5. Pump as in claim 4, **characterized in that** said frequency setting unit (28) comprises at least one of either a resistor (R1) connected in series between said controller (32) and the gate terminal (G) of the MOSFET (30) and a resistor (R2) connected in parallel to the MOSFET (30).

6. Pump as in any claim hereinbefore, **characterized in that** said control device (20) comprises a diode (34) connected in parallel to said coil (14) between a first terminal end (16a) and a second terminal end (16b) of the coil and configured to prevent the occurrence of voltage peaks between said terminal ends (16a, 16b) of said coil (14) during the opening/closing of said circuit.

7. Control method to regulate the flow rate of a pump (10), wherein said pump comprises fluid suction and delivery means to suck in and deliver a fluid between an entrance aperture and a sending aperture, and a coil (14) connectable to an electric power source (18) configured to power an alternate electric voltage (VAC) with a defined frequency (F0), and configured to move said suction and delivery means in order to suck in and deliver said fluid as a function of a pulsed electric current (I) circulating in said coil (14), said method being **characterized in that** it provides to regulate the flow rate of said pump, modifying the frequency of the impulses of said electric current (I), wherein said method provides:

   - to convert said alternate electric voltage (VAC) into a substantially continuous electric voltage (VDC) by means of a convertor unit (22) connected between said electric power source (18) and said coil (14);
   - to selectively and periodically feed said continuous electric voltage (VDC) to said coil (14) with a desired set frequency (FSET), independent of said defined network frequency (F0), so as to generate, in said coil (14), said electric current (I) with a pulsed development correlated to said set frequency (FSET).

8. Method as in claim 7, **characterized in that** in order to close and open said circuit periodically, it provides to generate a square wave signal with said set frequency (FSET) with a controller (32), and to pilot, with said square wave signal, a switch device (30) connected between said coil (14) and a ground (GND), making it pass selectively and periodically from a non-active state, in which said switch device (30) behaves as an open circuit, to an active state, in which it behaves as a closed circuit, allowing said electric current (I) to circulate, and vice versa.

9. Method as in claim 8, **characterized in that** it provides to use, as a switch device (30), a MOSFET connected with a source terminal (S) to the ground (GND), with a drain terminal (D) to said coil (14) and with a gate terminal (G) to said controller (32), and to periodically modify, with said frequency (FSET), the electric voltage applied between said gate (G) and source (S) terminals, as a function of said square wave signal generated by said controller (32).

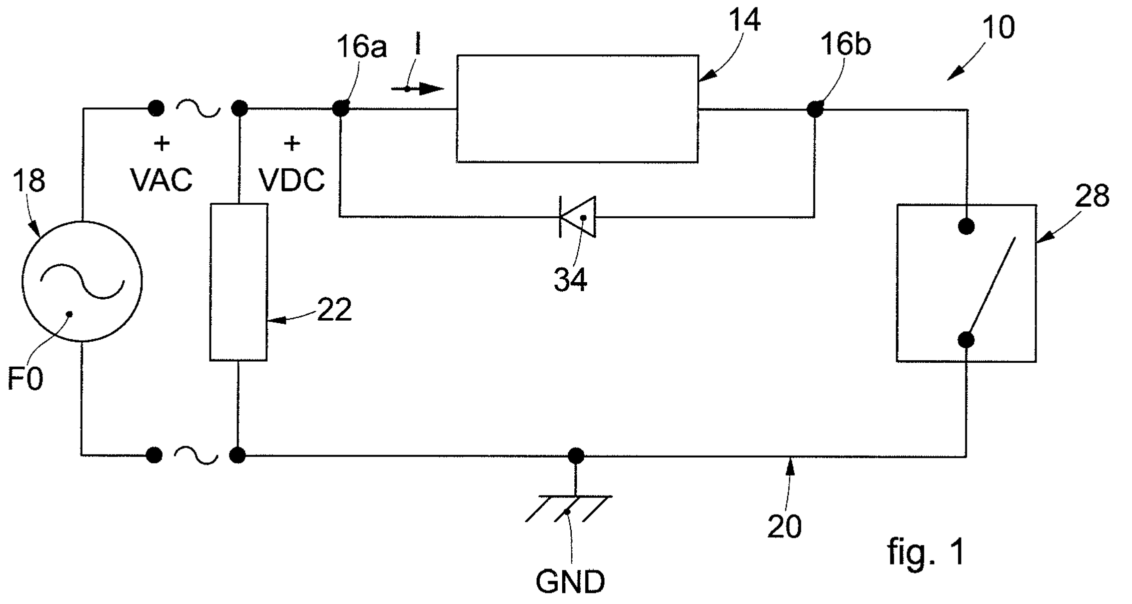
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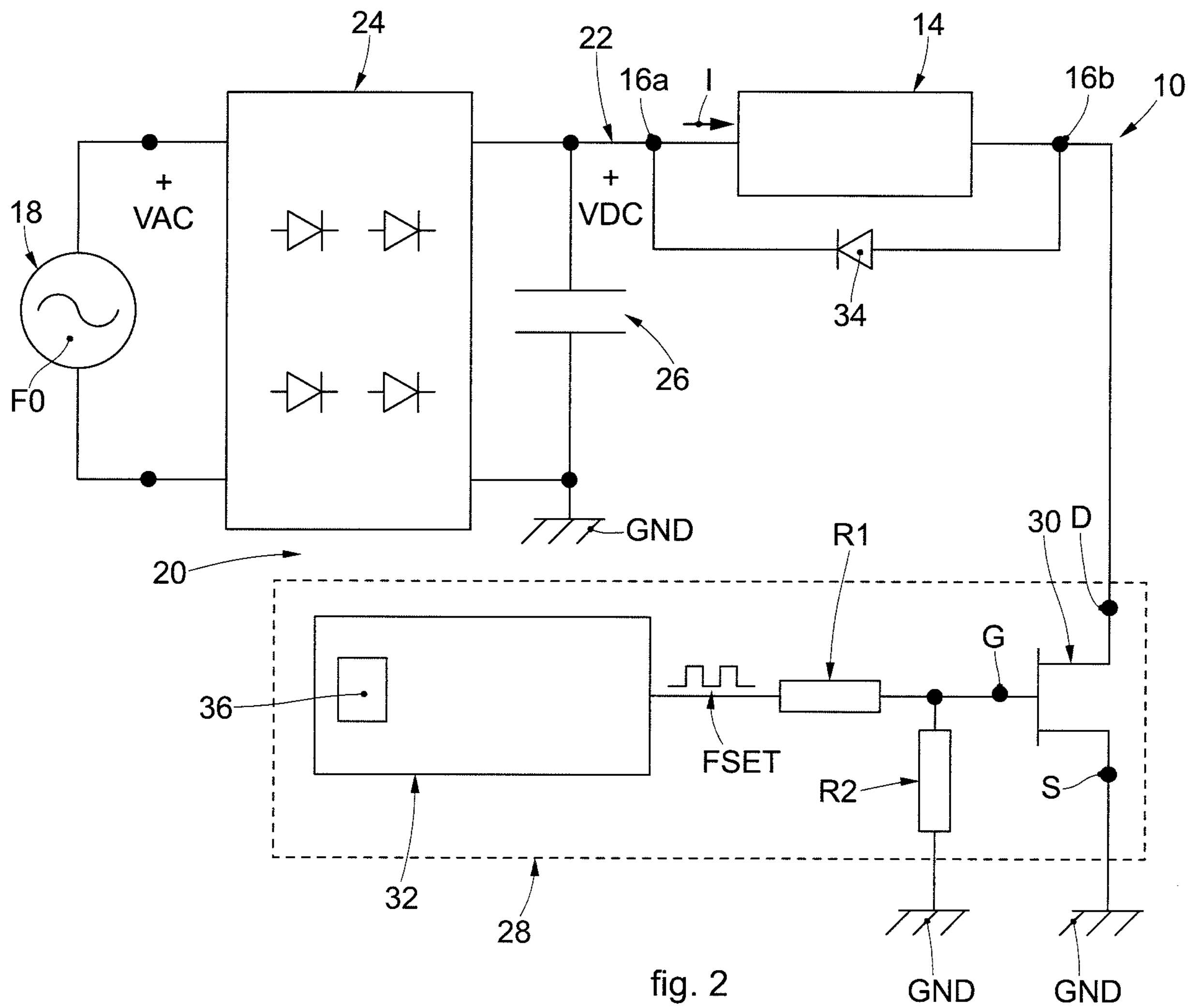
fig. 1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GND
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fig. 2

Europäisches Patentamt
European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 4452

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2008/226464 A1 (LIVOTI STEFANO [IT]) 18 September 2008 (2008-09-18) * figures 1, 7 * * paragraph [0062] - paragraph [0071] *	1-9	INV. F04B17/04 F04B43/04 F04B49/06
Y A	US 6 713 901 B2 (BOEING CO [US]) 30 March 2004 (2004-03-30) * figure 3 * * column 3, line 58 - column 4, line 55 *	1,2,7 3-6,8,9	
Y A	US 2012/235619 A1 (YUN HONG MIN [KR]) 20 September 2012 (2012-09-20) * figure 2 * * paragraph [0035] - paragraph [0045] *	1,2,7 3-6,8,9	
A	US 2004/005222 A1 (YOSHIDA MAKOTO [JP] ET AL) 8 January 2004 (2004-01-08) * paragraph [0058] - paragraph [0069]; figure 1 *	1-9	
A	JP H07 103147 A (TECHNO TAKATSUKI KK) 18 April 1995 (1995-04-18) * figure 1 * * machine translation; paragraph [0017] - paragraph [0021] *	1-9	TECHNICAL FIELDS SEARCHED (IPC) F04B
A	WO 00/22298 A2 (LIQUID METRONICS INC [US]) 20 April 2000 (2000-04-20) * figures 5,9,13 * * page 5, line 15 - page 7, line 25 *	1-9	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	11 January 2019	Ricci, Saverio

CATEGORY OF CITED DOCUMENTS

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008226464 A1	18-09-2008	AT 446447 T	15-11-2009
		CA 2614325 A1	18-01-2007
		CN 101228353 A	23-07-2008
		DK 1904745 T3	08-03-2010
		EP 1904745 A1	02-04-2008
		ES 2335528 T3	29-03-2010
		US 2008226464 A1	18-09-2008
		WO 2007007365 A1	18-01-2007
US 6713901 B2	30-03-2004	NONE	
US 2012235619 A1	20-09-2012	CN 102678504 A	19-09-2012
		JP 2012197788 A	18-10-2012
		KR 20120106447 A	26-09-2012
		US 2012235619 A1	20-09-2012
US 2004005222 A1	08-01-2004	CN 1459921 A	03-12-2003
		JP 2003339188 A	28-11-2003
		KR 20030091716 A	03-12-2003
		US 2004005222 A1	08-01-2004
JP H07103147 A	18-04-1995	NONE	
WO 0022298 A2	20-04-2000	EP 1121529 A2	08-08-2001
		JP 2002527669 A	27-08-2002
		US 6174136 B1	16-01-2001
		WO 0022298 A2	20-04-2000

EPO FORM P0459

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Patent documents cited in the description

- US 20080226464 A **[0011]**
- US 20120235619 A **[0012]**
- US 2004005222 A **[0013]**