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(54) Household appliance for treating soft goods with displacement sensor

(57) The present invention relates to a household appliance for treating soft goods, in particular a laundry washing machine, comprising a swinging assembly elastically constrained to a frame by means of a suspension system comprising a pair of elements telescopically coupled together through two respective ends, wherein the first of said two ends comprises ferromagnetic material and the second end comprises a coil (9). The household appliance also comprises an electronic detection module (6) comprising an oscillator circuit (12), the oscillation frequency of which depends on the impedance of the coil (9), and processing means operationally connected to the oscillator circuit (12) and adapted to measure the oscillation frequency and to determine, as a function of said oscillation frequency, at least one piece of information which can be associated with said relative displacement.

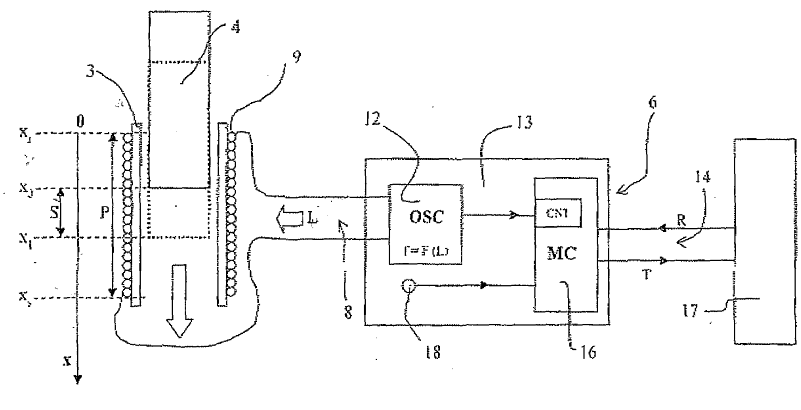

FIG. 3

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Description

DESCRIPTION

[0001] The present invention relates to a household appliance for treating soft goods according to the preamble of claim 1.

[0002] In particular, the invention relates to household laundry washing machines.

[0003] The term "laundry washing machine" is used herein to designate a machine suited to carrying out at least one wash treatment on soft goods. A laundry washing machine may be a so-called "washing machine" (intended for washing only) or a so-called "washing/drying machine", which can also carry out a drying treatment on soft goods (in particular by means of hot air blown into the wash tub by a blower assembly).

[0004] Known household appliances for treating soft goods include a swinging assembly into which the items to be treated are loaded. The swinging assembly is elastically constrained to a frame by means of a suspension system.

[0005] In laundry washing machines, the swinging assembly comprises a tub in which soft goods are washed.

[0006] Soft goods can be loaded from the front side, through an opening obtained in the front wall of the machine, or from the top, through an opening obtained in the top wall of the machine.

[0007] Several typologies of sensing devices are available for the household appliances currently available on the market to measure the relative displacement of the swinging assembly with respect to the appliance frame, in order to detect, for example, the mass or weight of the laundry being present inside the appliance and/or the value of any load imbalance during the operation of the appliance and/or the quantity of wash water supplied into the tub.

[0008] Said sensing devices are often built in one of the mechanical components of the household appliance.

[0009] If the household appliance is a laundry washing machine, the sensing devices used for measuring the relative displacement of the swinging assembly with respect to the appliance frame may suitably be mounted to one of the dampers comprised in the suspension system of the appliance. In such a case, the relative displacement between the piston and the cylinder of the damper is used to detect the relative displacement of the swinging assembly with respect to the frame. It should be reminded that the commonly used terms "cylinder" and "piston" respectively refer to the outer and inner elements of a damper, which are adapted to move telescopically.

[0010] Patent DE4319614 describes a front-loading laundry washing machine with a swinging assembly suspended on two springs and connected to the frame through two dampers. In one of the two dampers, a Hall-effect sensing device is installed on the piston and a permanent magnet is installed on the cylinder. The relative displacement between the cylinder and the piston thus translates into a corresponding relative displacement between the magnet and the Hall sensor, so that the output of the latter is a voltage value which is proportional to said relative displacement.

[0011] This solution suffers from the drawback that an accurate displacement reading requires the use of very expensive permanent magnets (rare-earth type). Also, such sensors do not allow to obtain a very accurate detection, since small relative movements between piston and cylinder translate into imperceptible variations in the amplitude of the voltage signal. The detection of such movements would require very expensive electronics, which is seldom available in household appliances for treating soft goods.

[0012] Patents EP1220961 and EP1094239 disclose a damper for a laundry washing machine wherein a coil is applied to one of the two movable elements (cylinder and piston), while a ferromagnetic element is applied to the other element which can affect the inductance value of the coil depending on its position in the latter. When applying alternating current having a predetermined amplitude to the coil, the voltage amplitude across the latter is proportional to the relative displacement between the cylinder and the piston of the damper. By reading the voltage amplitude across the coil it is therefore possible to obtain the relative displacement value.

[0013] Though to a lesser extent than the solution using a Hall sensor, this solution also has some limitations affecting the displacement detection, which are related to the capability of the electronics to detect small voltage variations.

[0014] According to both of the above-described solutions, in fact, the measurement of the relative displacement between the piston and the cylinder of the damper is translated into a direct voltage obtained by processing, through a suitable electronic circuit, the signal generated by the associated sensor, the latter being a Hall-effect sensor or a coil, respectively.

[0015] The worst drawback of such an approach is that the electronic circuit used for processing the signal generated by the displacement sensor is of the analog type, and thus it is characterized by the typical limitations of that technology, which derive both from the tolerances and thermal drifts of its components and from a low immunity to electric noise. Consequently, this solution turns out to be very costly, in that it implies that it is necessary to use higher quality components characterized by very strict tolerances and low thermal drift.

[0016] The solutions known in the art, wherein an analog signal is transmitted, also require the presence of appropriate electromagnetic shielding systems in order to prevent the readings from being affected by electromagnetic noise.

[0017] An analog electric circuit which can be used for processing the signal generated by a displacement sensor based on a coil and a ferromagnetic element, respectively located on two movable elements of a damper for a laundry washing machine, is described, for example, in patent EP654140.

[0018] It is the object of the present invention to overcome the above-mentioned limitations of the prior art.

[0019] In particular, it is an object of the present invention to provide a solution, preferably a low-cost one, for accurately measuring the relative displacement between two telescopically coupled elements (in particular the cylinder and the piston of a damper) of a suspension system of a household appliance for treating soft goods.

[0020] These and other objects of the present invention are achieved through a household appliance incorporating the features set out in the appended claims, which are intended as an integral part of the present description.

[0021] The invention is based on the general idea of providing an electronic module comprising an oscillator circuit, the oscillation frequency of which depends on the impedance of a coil located on one of the two telescopically coupled elements.

[0022] The relative displacement between the two elements (coinciding with the relative displacement between the swinging assembly and the appliance frame) is thus determined by an electronic detection module as a function of the oscillation frequency of said oscillator circuit, which is measured, for example, by a microcontroller included in said electronic module. The relative displacement S is therefore measured by exploiting the fact that the value of the inductance L of the coil depends on the axial penetration x of one of the two elements within the volume of the coil itself. As a result, the frequency value f of the signal, preferably a square-wave signal, generated by the oscillator circuit (which incorporates the coil) depends on said inductance value L, and is therefore related to said relative displacement S.

[0023] Advantageously, in addition to measuring the relative displacement S of the two movable elements, the present invention also provides for assessing one or more quantities associated with said relative displacement S (such as, for example, the weight of the soft goods contained in the drum of the washing machine and/or the quantity of water supplied into the tub and/or the imbalance of the laundry load) by measuring a value of frequency instead of a value of voltage amplitude as in the prior art. Advantageously, a microcontroller included in the electronic module according to the present invention processes locally the signal output by the oscillator circuit in order to obtain, based on its frequency f, the value of the relative displacement S between the two elements and/or of any other physical quantities associated with said relative displacement S (such as the weight of the laundry placed in the drum of the washing or washing/drying machine): in this embodiment, the microcontroller sends the result of said processing to the electronic control system of the household appliance over a suitable digital communication line. According to an advantageous embodiment of the present invention, which is aimed at ensuring higher measurement accuracy and reliability over time, said local processing may take into account one or more external interference factors adversely affecting the quality of the relative displacement reading S.

[0024] The household appliance according to the present invention will become apparent, together with its further advantages, from the following detailed description and from the annexed drawings, which are supplied by way of non-limiting example, wherein:

Fig. 1 is a sectional view of a damper of a household appliance according to a first embodiment of the present invention;

Fig. 2a is a block diagram of an electronic detection module known in the art, used for detecting the relative displacement between the cylinder and the piston of a damper for a laundry washing machine by measuring the voltage amplitude variation across a coil located on the damper cylinder;

Fig. 2b is a block diagram of an electronic detection module according to the invention, which is adapted to detect the relative displacement between the cylinder and the piston of a damper for a laundry washing machine through frequency measurements;

Fig. 3 is a global view of a damper, an electronic detection module and an electronic control system of a household appliance according to the present invention;

Fig. 4 is a sectional view of a damper of a household appliance according to a second embodiment of the present invention.

[0025] In the following description, reference will be made to a laundry washing machine as a preferred but non-limiting example of application of the present invention.

[0026] Fig. 1 shows a damper 1 included in the suspension system of a laundry washing machine according to the present invention.

[0027] Said laundry washing machine, which may be a washing or washing/drying machine, comprises a frame and a swinging assembly, the latter comprising in turn a drum adapted to house soft goods to be treated and to be rotated about its axis by means of a motor device, and a tub adapted to contain water and/or wash liquid used for performing the treatment. A suspension system connects the swinging assembly to the frame while keeping it elastically suspended. Said household appliance also comprises an electronic control system with a central controller, and possibly an interface device adapted to provide information to the user of the household appliance. Said interface device may be a luminous device, e.g. an electronic display or a LED array, or else an acoustic device, e.g. a buzzer or a voice synthesizer.

[0028] In order to improve the operation of the laundry washing machine, it is useful to measure the relative displacement between the swinging assembly and the frame. In fact, said measurement allows, in static conditions, to know certain characteristics of the load being present in the household appliance, whereas in dynamic conditions it allows to quantify the imbalance of the load inside the drum and/or the vibration of the swinging assembly, or to determine the maximum admissible spin speed. Particularly interesting is the possibility of using the relative displacement of the swinging assembly with respect to the frame in static conditions to obtain the mass or weight of the laundry contained in the drum, preferably the mass or weight of the laundry loaded in the drum by the user before starting a wash treatment.

[0029] A laundry washing machine, which is the subject of the present invention, comprises, in its suspension system, dampers connected to the swinging assembly (i.e. to the tub assembly) through an upper fixing and to the frame through a bottom fixing hinged to a pin. The dampers provide the very important function of damping the oscillations of the swinging assembly, mostly during the spin phases. Said dampers comprise a cylinder, i.e. a cylindrical tubular element, within which a piston, which typically is also a cylindrical tubular element, slides and is braked by a braking element capable of generating adequate friction between the outer surface of the piston and the inner surface of the cylinder.

[0030] The damper 1 shown in Fig. 1, which is adapted to be installed in a household appliance according to the present invention, comprises two elements (piston 4 and cylinder 3) telescopically coupled together through two ends. Said elements are adapted to move reciprocally, in particular the first element being adapted to slide relative to the second element in an essentially straight direction. Both the piston 4 and the cylinder 3 have preferably an axially symmetrical shape, in particular a cylindrical shape, and are both preferably hollow.

[0031] A braking element 5, preferably made of a material having a high friction coefficient, is constrained to one of the two elements of the damper 1 (e.g. the cylinder 3), so as to come into contact with the other element (e.g. the piston 4), thus countering the relative sliding motion between the two elements.

[0032] Seats 10A and 10B are obtained at the ends of the damper 1 for the top and bottom fixings of the damper 1.

[0033] A coil 9, consisting of a wire made of an electrically conductive material, is wound coaxially around the cylinder 3 for a length P, so that one end of the piston 4, at least partly made of ferromagnetic material and sliding axially within the cylinder 3 under the effect, for example, of the weight of the laundry loaded in the drum of the washing machine, alters the flow of the magnetic field generated by the coil 9 when alternating current flows therethrough, thus changing the inductance value L of the coil 9 as a function of the penetration x of the piston 4 in the cylinder 3, the correlation between inductance L and penetration x being expressed by a linear or non-linear mathematical expression.

[0034] An electronic detection module 6, electrically connected to the coil 9 by means of the wiring 8, is constrained to the cylinder 3 through a header 13 fixed on the cylinder 3 with screws 7A and 7B. The electronic detection module 6 is electrically connected to the central controller of the household appliance by means of the wiring 14 (which may also act as a digital communication line). In the preferred embodiment, the electronic detection module is powered through the central controller. The wiring 14 may have its wires welded to the electronic module 6 or else, according to a technically equivalent solution, it may use a suitable connector on the electronic module 6, which allows to connect the electric wires that connect the electronic module 6 to the central controller. Fig. 2a shows a schematic diagram of an analog electric circuit, known in the art because described in detail, for example, in patent EP654140, through which it is possible to obtain the value of the relative displacement between the two movable elements (cylinder and piston) of a damper of a laundry washing machine, by appropriately processing the voltage signal detected across the impedance coil Z3, the inductance L of which depends on the relative displacement between cylinder and piston. For this purpose, the coil is supplied, by means of a generator G, with a sinusoidal alternating voltage Vac having fixed frequency f_0 through two impedances Z1 and Z2 in series, which for simplicity are supposed herein to be purely of the resistive type, so that current Iac=Vac/(Z1+Z2+Z3) flows through the coil. As the inductance value L of the coil changes, the impedance Z3 thereof changes as well in accordance with the known relationship $Z3=R+j\omega_0 L$ (where $\omega_0=2\pi f_0$), and so does the voltage drop V3 across its terminals. The sinusoidal signal V3, having fixed frequency f_0, is read by a special analog detection module AM which, through suitable analog AC-DC conversion, filtering and scaling steps performed on the output signal, transforms the latter into a direct signal Vdc, the value of which is dependent on the coil inductance value L and therefore also on the relative position of the two movable elements of the damper, on which said inductance L depends. In summary, the known method usually adopted for measuring variations in the coil inductance L is characterized by the following three steps:

application of a sinusoidal voltage Vac, having known amplitude and frequency f_0, to an electric circuit consisting of a series of impedances, among which the impedance Z3 of the coil with inductance L, which changes depending on the relative displacement of the two movable elements of the damper;

measurement of the voltage drop V3 across the coil terminals;

analog processing of the sinusoidal signal V3 and generation of the direct-voltage output signal Vdc, which is representative of the relative displacement of said two movable elements of the damper.

Fig. 2b shows a schematic diagram of an electric circuit according to the present invention, through which it is possible to obtain the value of the relative displacement S between the cylinder 3 and the piston 4 of the damper 1 for a laundry washing machine.

[0035] The circuit diagram of Fig. 2b is based on a new method for detecting the displacement S provided as an alternative to the one known in the art and characterized by the following steps:

use of an oscillator circuit, preferably of the square-wave type (e.g. a "non stable multivibrator"), the oscillation frequency f of which depends on the coil inductance value L;
determination of the oscillation frequency of said oscillator circuit;
determination of the relative displacement S of the two movable elements as a function of said oscillation frequency.

[0036] By using a non stable multivibrator or an equivalent oscillator circuit, the determination of the displacement takes place in a fully digital manner through the following steps:

digital measurement of the frequency f of the square-wave signal generated by said oscillator circuit, carried out by means of a suitable input CNT of a microcontroller MC;
digital processing of the frequency value f read by the microcontroller MC, and
generation of a digital datum being representative of the relative displacement S of the two movable elements of the damper.

[0037] Of course, the measurement of the oscillation frequency also allows to determine any other physical quantity related to the relative displacement S.

[0038] In the method known in the art (Fig. 2a), a sinusoidal signal having constant frequency f_0 is forced through the voltage generator G and the voltage drop V3 is measured across the coil terminals; the method according to the invention (Fig. 2b), on the contrary, does not employ a voltage generator with fixed-frequency, but a non stable oscillator OSC with square-wave signal and variable frequency f, the frequency f being dependent on the coil inductance value L, and the frequency f is measured digitally.

[0039] It follows that these two methods, although referring to the same damper architecture intended for use in a washing or washing/drying machine, such as the one shown in Fig. 1, detect the value of the relative displacement between the two movable elements of the damper by measuring two completely different quantities: a sinusoidal voltage V3 in the former case and a frequency f in the latter case.

[0040] Moreover, if we take into consideration the preferred embodiment of the present invention, which uses a non stable multivibrator, the measured quantity is processed in a purely analog manner in the former case, whereas it its processed in a fully digital manner in the latter case. The use of digital processing techniques allows to cut down the cost of the solution according to the invention: all measurement, calibration and data processing operations can be carried out by using a low-cost microcontroller MC (e.g. an 8-pin commercial microcontroller, typically costing around $0.4-0.5).

[0041] A further advantage of the solution according to the present invention is that the electronic detection module 6 can provide the central controller of the household appliance, directly and in digital format (e.g. over a serial channel), with the value of the quantity (e.g. the weight of the laundry loaded in the drum of the washing machine) associated with the relative displacement S of the two movable elements of the damper. Instead, the datum output by the analog detection module AM in known solutions (Fig. 2a) cannot be used directly by the microcontroller: the output variable, consisting of the direct voltage Vdc, must be subsequently converted into digital format and processed by the control system of the appliance for the purpose of obtaining the value of the desired quantity (e.g. the weight of the laundry loaded in the drum of the appliance).

[0042] A more detailed analysis of the invention will now be provided with reference to Fig. 3, which diagrammatically shows the following:

a possible embodiment of the electronic detection module 6 according to the present invention,
the coil 9, located in the damper 1 of the household appliance and used for measuring the relative displacement S between the cylinder 3 and the piston 4 of the damper 1, and the serial connection, schematically represented by the wiring 14, to the electronic control system, in particular to the central controller 17 of the household appliance.

[0043] The piston 4 is drawn with a continuous line in a first position and with a dotted line in a second position, said first position being the position of the piston 4 before a relative displacement S occurs with respect to the cylinder 3 (and therefore with respect to the coil 9, which is integral with the cylinder 3), and said second position being the position of the piston 4 after a relative displacement S has occurred.

[0044] The value of the relative displacement S between the piston 4 and the cylinder 3 is given by the difference between the initial value x_0 of the axial penetration of the piston 4 in the inner volume of the coil 9 and the final value x_1 of the axial penetration of the piston 4 in the inner volume of the coil 9. x_s and x_i designate the upper and lower filling limits, respectively, of the inner volume of the coil 9, where x_s-x_i=P.

[0045] As shown in Fig. 3, the coil 9 is electrically connected (by means of the wiring 8) to an oscillator circuit 12 and determines, based on its inductance value L, the oscillation frequency f of the alternating signal generated by said oscillator circuit 12. The value of said frequency f can therefore be expressed by means of a mathematical function such as f=F(L), wherein the inductance L is an independent variable. In the example of Fig. 3, the alternating signal generated by the oscillator circuit 12 consists of a square wave having a voltage swinging between a low voltage level (associated with logic level 0) and a high voltage level (associated with logic level 1). The signal generated by the oscillator circuit is sent to a digital input of the microcontroller 16 which, through a suitable digital counter CNT, measures the number of oscillations per second of the signal, i.e. it determines the oscillation frequency f of the oscillator circuit 12. Based on the reading of the frequency value f, the microcontroller 16 calculates the relative displacement S of the piston 4 with respect to the cylinder 3 of the damper 1, and thus also, for example, the weight of the contents of the drum of the washing machine. The relationship between the oscillator frequency value and the weight of the laundry being present in the drum of the washing machine is determined experimentally and can be expressed through a mathematical algorithm or data tables managed by the control program of the microcontroller 16.

[0046] The household appliance for treating soft goods, in particular the laundry washing machine, according to the present invention, is of the electronically controlled type and includes a central controller 17 adapted to control the household appliance by adjusting and controlling the various laundry treatment phases based on instructions received from the user and on data detected by sensor means, among which the data supplied by the electronic detection module 6.

[0047] As previously mentioned, the household appliance comprises a frame and a swinging assembly. The swinging assembly is connected to the frame by means of a suspension system, which comprises a pair of elements telescopically coupled to each other through two respective ends, wherein a first of said two ends comprises ferromagnetic material and a second of said two ends comprises a coil 9.

[0048] According to the invention, the household appliance comprises an electronic detection module 6 adapted to detect a relative displacement S of said two ends. Said electronic detection module 6 comprises an oscillator circuit 12 having an oscillation frequency f which depends on the impedance L of the coil 9, and processing means, operationally connected to said oscillator 12 and adapted to detect said oscillation frequency f and to determine, as a function of said oscillation frequency f, at least one piece of information which can be associated with the relative displacement S. Said piece of information may also be associated, in particular in static conditions, wherein no relative displacement S has occurred between the cylinder 3 and the piston 4, with the absolute position of the swinging assembly with respect to the frame, which can be deduced from the absolute value of the axial penetration x of the end of the piston 4, made of ferromagnetic material, in the inner volume of the coil 9.

[0049] According to the embodiment of Fig. 1, the coil 9 is located on the cylinder 3 of the damper, whereas the piston 4 includes at least a portion made of ferromagnetic material which travels in the cylinder 3, thereby changing the inductance of the coil 9.

[0050] Said embodiment can be modified, without departing from the scope of the present invention, according to a fully technically equivalent alternative configuration, by associating the coil 9 with the piston 4 and by manufacturing the cylinder 3 from ferromagnetic material, as shown in Fig. 4.

[0051] Fig. 4 uses the same reference number as Fig. 1 to designate means which are identical or equivalent to those already shown in Fig. 1.

[0052] According to this embodiment, the piston 4 has one end 41 telescopically coupled to one end of the cylinder 3. The end 41 is hollow and is wound with a coil 9 connected to the electronic detection module 6 by means of a wiring 8.

[0053] In its turn, the cylinder 3 has one end 31 at least partly made of ferromagnetic material, which is inserted telescopically in the cavity of the end 41 of the piston 4.

[0054] The relative displacement of the end 31 with respect to the end 41 causes a variation in the inductance of the coil 9. This variation, as described previously, determines a variation in the oscillation frequency f of an oscillator 12 comprised in the electronic detection module 6.

[0055] Said electronic detection module 6 comprises a microcontroller 16 which, being fitted with a suitable counter CNT, measures the oscillation frequency f of the oscillator circuit 12 and determines the relative displacement between the cylinder 3 and the piston 4. The counter CNT is operationally connected to the oscillator circuit 12 and is adapted to count the phase transitions of the output signal generated by the oscillator circuit 12. According to the present invention, the microcontroller 16 is adapted to transmit to the central controller 17, over a digital communication line, a piece of information which can be associated with the relative displacement S of the swinging assembly with respect to the frame.

[0056] The digital communication line between the microcontroller 16 and the central controller 17 includes appropriate transmission means, typically of the electric type, and the transmission of suitable digital signals is managed through appropriate communication protocols.

[0057] Based on said piece of information which can be associated with the relative displacement S, the central controller 17 can therefore exert at least one control action on the household appliance.

[0058] In particular, said information may be a measurement of the mass or weight of the contents of the swinging assembly or of a portion of the contents of the swinging assembly.

[0059] More in particular, said piece of information is the value of the mass or weight of the soft goods loaded in the swinging assembly before a wash treatment is started: the central controller 17 can use this measurement of the mass or weight of the soft goods loaded in the swinging assembly for calculating at least one parameter related to a subsequent wash treatment, said parameter being preferably the appropriate quantity of water or the appropriate quantity of washing agents. As an alternative, said piece of information which can be associated with the relative displacement S of the swinging assembly with respect to the frame may be the measurement of the mass or weight of the water or wash liquid in the swinging assembly during the operation of the household appliance.

[0060] According to a preferred embodiment, the microcontroller 16 is a slave unit of the central controller 17, whereto it is connected by means of the wiring 14, and the microcontroller 16 can receive instructions from the central controller 17.

[0061] It is apparent that the microcontroller 16 may be positioned without distinction either on the same PCB board housing the oscillator circuit or at a distance from said circuit.

[0062] In the preferred embodiment, the entire electronic module 6 is located near the coil 9 in order to minimize the length of the connections between microcontroller 16, oscillator circuit 12 and coil 9, thus ensuring the utmost immunity to electromagnetic noise. Advantageously, a calibration step may be performed, e.g. during the final testing of the household appliance, for making the microcontroller 16 capable of associating any possible reading of the frequency f of the square-wave signal generated by the oscillator 12 with a digital signal which is interpreted by the central controller 17 as being representative of a particular value of the relative displacement of the swinging assembly with respect to the frame and/or of a particular value of one or more physical quantities related to said relative displacement (such as the mass or weight of the soft goods contained in the drum).

[0063] The microcontroller 16 transmits a digital signal to the central controller 17 over the communication line consisting of the wiring 14.

[0064] It should be underlined that the digital transmission from the microcontroller 16 to the central controller 17 is much more robust than a simple analog connection between the analog module AM (shown in Fig. 2a) and the central controller 17, since it is essentially immune from noise and does not require any special shielding for the wiring 14 connecting the electronic module 6 to the central controller 17. This ensures high reliability and accuracy of the measurements carried out by using the value of the frequency f of the square-wave signal generated by the oscillator 12, corresponding to the measurement of the relative displacement of the swinging assembly with respect to the frame and to the measurements of the mass or weight of the contents of the swinging assembly.

[0065] The microcontroller 16, which is adapted to generate, through the measurement of the frequency f of the alternating voltage signal generated by the oscillator circuit 12, a digital signal being representative of the relative displacement S of the swinging assembly with respect to the frame and/or of any other physical quantities related to said relative displacement S (among which, for example, the mass or weight of the soft goods contained in the drum), is also adapted to process the measured value of the frequency f of the square-wave voltage signal generated by the oscillator circuit 12 in order to compensate for any errors caused by external interference. For instance, the microcontroller 16 subjects the measured value of the frequency f to a digital processing step in order to compensate for any errors due to external environmental factors (e.g. temperature) or to wear of mechanical components of the suspension system of the household appliance.

[0066] Said compensation may take place on the basis of signals sent by sensor means adapted to detect operating parameters of the appliance (e.g. according to the output signal of a temperature sensor 18 located on the header 13 for detecting the temperature near the damper 1, said header being suitably secured thereto), or else on the basis of algorithms taking into account the variation over time of the elasticity and/or damping characteristics of the suspension system of the household appliance. More in detail, said algorithms consist of software code portions created on the basis of data acquired experimentally and adapted to counter the loss of accuracy and reliability over time of both the measurement of the relative displacement of the swinging assembly with respect to the appliance frame and the measurement of any other physical quantity which can be obtained from said relative displacement.

[0067] According to a particularly advantageous embodiment of the present invention, the laundry washing machine comprises sensor means operationally connected to the microcontroller 16 and adapted to detect operating parameters of the household appliance, wherein at least one of said sensor means may be incorporated into the electronic module 6. The electronic module 6 shown in Fig. 3 also comprises a temperature sensor 18, which is preferably an NTC type sensor, used for determining the value of the temperature in the area of the header 13. The temperature sensor 18 may be suitably interfaced with an analog channel of the microcontroller 16 or incorporated into the microcontroller 16 (since low-cost microcontrollers having a built-in temperature sensor are currently available on the market). During the operation of the household appliance, said area is in fact subject to the action of the nearby braking element 5, which dissipates a portion of the kinetic energy of the swinging assembly as heat: in particular, said action of the braking element 5 of the damper 1 is perceived as a temperature value being higher than room temperature, which may cause drifts altering the measurement of the relative displacement of the swinging assembly with respect to the appliance frame.

[0068] Moreover, this temperature variation can affect the friction in the damper, thus changing the laws that regulate the relationship between displacement and other associated quantities, such as the weight of the soft goods loaded in a washing machine.

[0069] The temperature sensor 18 generates an auxiliary electric signal being representative of the temperature in the area of the header 13, and then sends it to the microcontroller 16. The microcontroller 16 takes into account the auxiliary electric signal received from the temperature sensor 18 for generating the information to be sent to the central controller 17 over a digital communication line.

[0070] The microcontroller 16 compensates the measured value of the relative displacement of the swinging assembly with respect to the appliance frame (or of any other physical quantity related to said displacement) based on the temperature value detected by the temperature sensor 18, considering how the electric characteristics of the coil 9 and of the oscillator circuit 12 change as a function of temperature.

[0071] In the example of Fig. 3, the temperature sensor 18 is included in the architecture of the electronic module 6.

[0072] Advantageously, different sensor means may be conveniently associated with the electronic module 6 in order to detect different physical quantities: for example, a (relative or absolute) humidity sensor adapted to detect the humidity in the air surrounding the electronic module 6 and to prevent said electronic module 6 from suffering any damage due to excessive humidity, or a microphone adapted to detect the noise produced by the laundry washing machine in order to provide a warning in the event that there is a risk of impending failure of the damper 1 or of any other components of the laundry washing machine according to the present invention. Preferably, the microcontroller 16 may also be adapted to counter the effects caused by wear of the household appliance, which translates into variations over time in the elasticity and damping characteristics of the suspension system of the laundry washing machine and therefore in the frequency of the signal generated by the oscillator 12.

[0073] Said variations in the elasticity and/or damping characteristics are detected as the number of operation cycles of the appliance increases, and are due to wear occurring over time. For example, if the electronic module 6 according to the present invention is to be used for detecting the mass or weight of the contents of the swinging assembly of the laundry washing machine, it should be taken into consideration that, as time goes by, a different relative displacement of the swinging assembly may occur, the mass or weight of the contents of the swinging assembly being equal.

[0074] In this case, the microcontroller 16 may be made capable of compensating for the effect exerted by variations over time in the elasticity and/or damping characteristics of the suspension system of the laundry washing machine on the detection of the mass or weight of the contents of the swinging assembly. To this end, the microcontroller 16 may, by way of non-limiting example, count the number of operation cycles carried out by the machine and then, based on said number, associate the value of the frequency f of the signal generated by the oscillator 12 with one of several experimentally obtained corrective factors, stored in the internal memory of the microcontroller 16. Thus, the microcontroller 16 performs a compensation action which allows to obtain a sufficiently accurate and reliable measurement of the mass or weight of the contents of the swinging assembly over time.

[0075] More preferably, the information relating to the treatment cycles carried out by the household appliance, just like any other information pertaining to the wear suffered by the household appliance, can be transmitted to the microcontroller 16 by the central controller 17.

[0076] In comparison with the measurement system according to the prior art, the present invention offers the additional advantage of significantly reducing the workload of the electronic control system of the household appliance, in particular of the central controller 17.

[0077] In fact, the information sent by the microcontroller 16 of the electronic module 6 can be used by the central controller 17 directly, without requiring any further processing, since said processing has already been carried out upstream of the central controller 17. The latter simply has to decode the digital signal sent by the microcontroller 16 to have the information contained therein available for controlling the household appliance.

[0078] The transmission of the above information from the microcontroller 16 to the central controller 17 may be provided by using well-known communication techniques.

[0079] The communication between the microcontroller 16 and the central controller 17 by means of the wiring 14 may be a unidirectional communication (e.g. according to the PWM technique, wherein the information is coded by acting on the duty cycle of the digital signal, which therefore consists of a series of pulses having constant amplitude and frequency and variable width), or preferably a bidirectional communication (by way of non-limiting example, one may use a UART-type asynchronous serial bidirectional communication).

[0080] Over the transmission line T, the microcontroller 16 transmits to the central controller 17, in the form of a digital signal, a piece of information which can be associated with the relative displacement of the swinging assembly with respect to the appliance frame (i.e. the relative displacement reading o any other physical quantity related to said relative displacement) and which is suitably compensated for temperature and wear of the mechanical components of the appliance.

[0081] Over the reception line R, the microcontroller 16 receives from the central controller 17 data which is useful for the microcontroller 16. For example, the central controller 17 may transmit to the microcontroller 16 the value of the rotational speed of the drum of the laundry washing machine, so that the microcontroller 16 can take it into account when assessing the variation over time in the elasticity and/or damping characteristics of the suspension system. Or, still by way of example, the central controller 17 may send to the microcontroller 16 information relating to the dynamic state of the system, so that the microcontroller 16 can more easily discern whether the ongoing measurement is a static measurement (such as a measurement of the mass or weight of the laundry contained in the drum before the wash treatment is started) or a dynamic measurement (such as a measurement of load imbalance during the operation of the household appliance).

[0082] The information indicating the value of the mass or weight of the laundry may be used by the machine for treating soft goods for the purpose of both providing useful information to the user through its own interface device (e.g. the laundry washing machine may warn the user when the maximum laundry load which can be treated by the household appliance has been reached, depending on the type of fabric, or it may suggest the appropriate quantity of washing agents to be used for a certain quantity of laundry loaded in the drum, or it may give advice as to the most appropriate wash program) and of automatically adapting the characteristic parameters of the treatment, in particular of the wash treatment, to the quantity of laundry loaded in the drum by the user, so as to optimize the consumption of the household appliance (if the laundry washing machine is fitted with a high-capacity washing agent dispensing device, knowing the value of the mass or weight of the laundry loaded in the drum will allow for an optimal metering of the washing agents).

[0083] In order to allow the electronic detection module 6 according to the present invention to carry out accurate and reliable measurements of the mass or weight of the contents of the swinging assembly or of a portion thereof, the central controller 17 transmits to the microcontroller 16 (assuming the existence of a bidirectional communication line between the two) at least one datum which can be used by the microcontroller 16 as a synchronism signal.

[0084] If the measurement concerns the mass or weight of the laundry loaded in the drum of the laundry washing machine, it is useful to adopt a synchronism signal indicating an empty condition inside the swinging assembly of the household appliance, which allows the microcontroller 16 to associate the offset detected when receiving the synchronism signal with the tare value.

[0085] Said synchronism signal transforms the measurements of the mass or weight of the contents of the swinging assembly of the laundry washing machine into differential measurements, the value of the mass or weight of the laundry loaded in the drum being therefore calculated by the microcontroller 16 as a difference between the mass or weight value corresponding to the frequency value instantaneously associated with the square-wave signal generated by the oscillator circuit 12 and the mass or weight value corresponding to the frequency value associated with the square-wave signal generated when the synchronism signal is sent.

[0086] In the most advantageous embodiment of the present invention, wherein the communication between the central controller 17 and the microcontroller 16 is bidirectional, the synchronism signal may be provided by the signal indicating that the door of the laundry washing machine has been opened, which is sent to the microcontroller 16 by the central controller 17 after having received it from the door locking device.

[0087] As an alternative, a dedicated calibration push-button may be provided inside the interface device, i.e. a push-button available to the user to notify the empty condition inside the swinging assembly to the central controller 17: in this case, the synchronism signal may be provided by a signal indicating that said push-button has been pressed. By performing differential measurements, the electronic detection module 6 according to the present invention can also operate as a water or wash liquid quantity sensor. In fact, by using the start signal of the laundry washing machine as a synchronism signal once the laundry has been loaded in the drum, it is possible to measure the mass or weight of the water or wash liquid inside the swinging assembly. In fact, the mass and weight of the water or wash liquid can be calculated by the microcontroller 16 as a difference between the mass or weight value obtained instantaneously during the operation of the laundry washing machine and the mass or weight value obtained when the synchronism signal is sent, i.e. when the laundry washing machine is started.

[0088] By working as a water or wash liquid quantity sensor, the electronic detection module 6 allows the central controller 17 to control the water intake and/or drain means of the laundry washing machine (determining the opening and closing times thereof) solely as a function of the information relating to the mass or weight of the water or wash liquid being present inside the swinging assembly.

[0089] If the household appliance according to the present invention is a washing/drying machine, the electronic detection module 6 may also be used for controlling the drying treatment.

[0090] During the drying treatment, the microcontroller 16 can transmit to the central controller 17, instant by instant, the information relating to the mass or weight of the swinging assembly, and the central controller 17 can use said information to control the drying treatment. Likewise, the microcontroller 16 can determine the quantity of water progressively removed from the laundry by calculating it based on the reduction in the mass or weight of the contents of the swinging assembly, and the central controller 17 can stop the drying treatment when the quantity of water removed from the laundry reaches a predetermined percentage of the quantity of water contained inside the swinging assembly at the end of the wash treatment.

[0091] It is apparent from the present description that the household appliance according to the present invention, besides overcoming the above-mentioned inherent drawbacks of the prior art, also offers the additional advantage of allowing to use the electronic module 6 for controlling many operational phases of the household appliance without increasing the workload of the central controller 17.

[0092] The present invention has been described with particular reference to some specific embodiment examples, but it is clear that many changes may be made thereto by those skilled in the art without departing from the scope defined by the appended claims.

[0093] For example, the detection of the relative displacement of the swinging assembly with respect to the frame may be provided by using a pair of telescopically coupled elements not necessarily consisting of the piston and cylinder of a damper. These two elements may be a pair of elements specifically conceived for said detection, but nonetheless having no function as a damper.

Claims

1. Household appliance for treating soft goods, in particular a laundry washing machine, comprising:

- a swinging assembly elastically constrained to a frame by means of a suspension system comprising a pair of elements telescopically coupled to each other through two respective ends, wherein a first of said two ends comprises ferromagnetic material and a second of said two ends comprises a coil (9), and
- an electronic detection module (6) adapted to detect a relative displacement of said two ends,

characterized in that said electronic module (6) comprises an oscillator circuit (12), the oscillation frequency of which depends on the impedance of said coil (9), and processing means operationally connected to said oscillator and adapted to measure said oscillation frequency and to determine, as a function of said oscillation frequency, at least one piece of information which can be associated with said relative displacement.

2. Household appliance for treating soft goods, in particular a laundry washing machine, comprising:

- a swinging assembly elastically constrained to a frame by means of a suspension system comprising a pair of elements telescopically coupled to each other through two respective ends, wherein a first of said two ends comprises ferromagnetic material and a second of said two ends comprises a coil (9), and
- an electronic detection module (6) adapted to detect a relative displacement of said two ends,

characterized in that said electronic module (6) is located on one of said two elements and comprises an oscillator circuit (12), the oscillation frequency of which depends on the impedance of said coil (9), and processing means operationally connected to said oscillator and adapted to measure said oscillation frequency and to determine, as a function of said oscillation frequency, at least one piece of information which can be associated with said relative displacement, said information being the measurement of the mass or weight of the soft goods loaded in said swinging assembly before said soft goods are subjected to a treatment, in particular a wash treatment.

3. Household appliance according to any of the preceding claims, **characterized in that** said oscillator circuit (12) is adapted to generate a square-wave signal.

4. Household appliance according to any of the preceding claims, **characterized in that** said oscillator is a non stable multivibrator.

5. Household appliance according to any of the preceding claims, **characterized by** comprising sensor means operationally connected to said microcontroller (16) and adapted to detect operating parameters of said household appliance6. Household appliance according to claim 5, **characterized in that** said sensor means comprise a temperature sensor (18), preferably an NTC-type sensor.

7. Household appliance according to any of the preceding claims, **characterized by** comprising an interface device through which said household appliance communicates said information to a user.

8. Household appliance according to any of the preceding claims, **characterized in that** said coil (9) is located on one end of the cylinder (3) of a damper (1).

9. Household appliance according to claim 8, **characterized in that** said end comprising ferromagnetic material is one end of a piston (4) of said damper (1).

10. Household appliance according to any of claims 1 to 7, **characterized in that** said coil (9) is located on one end (41) of the piston (4) of a damper (1).

11. Household appliance according to claim 10, **characterized in that** said end (31) comprising ferromagnetic material is one end of a cylinder of said damper (1).

12. Method for detecting a relative displacement between two elements of a swinging system in a household appliance for treating soft goods, wherein said two elements are telescopically coupled together through two ends, a first of said two ends comprising ferromagnetic material and a second of said two ends comprising a coil (9), **characterized in that:**

- an oscillation frequency of an oscillator circuit (12) is detected, which oscillation frequency depends on the impedance of said coil (9) located on one of said two elements,
- said relative displacement is determined as a function of said oscillation frequency.

13. Method according to claim 12, **characterized in that** said relative displacement is determined on the basis of information, measured by sensor means, relating to operating parameters of said household appliance.

14. Method according to claim 12 or 13, **characterized in that** said relative displacement is determined on the basis of information, transmitted by a central controller of said household appliance, pertaining to the wear of said household appliance.

15. Method according to any of claims 12 to 14, **characterized by** comprising a calibration step, carried out when said swinging assembly is idle, for the purpose of detecting an idle oscillation frequency of said oscillator circuit (12).

FIG. 1

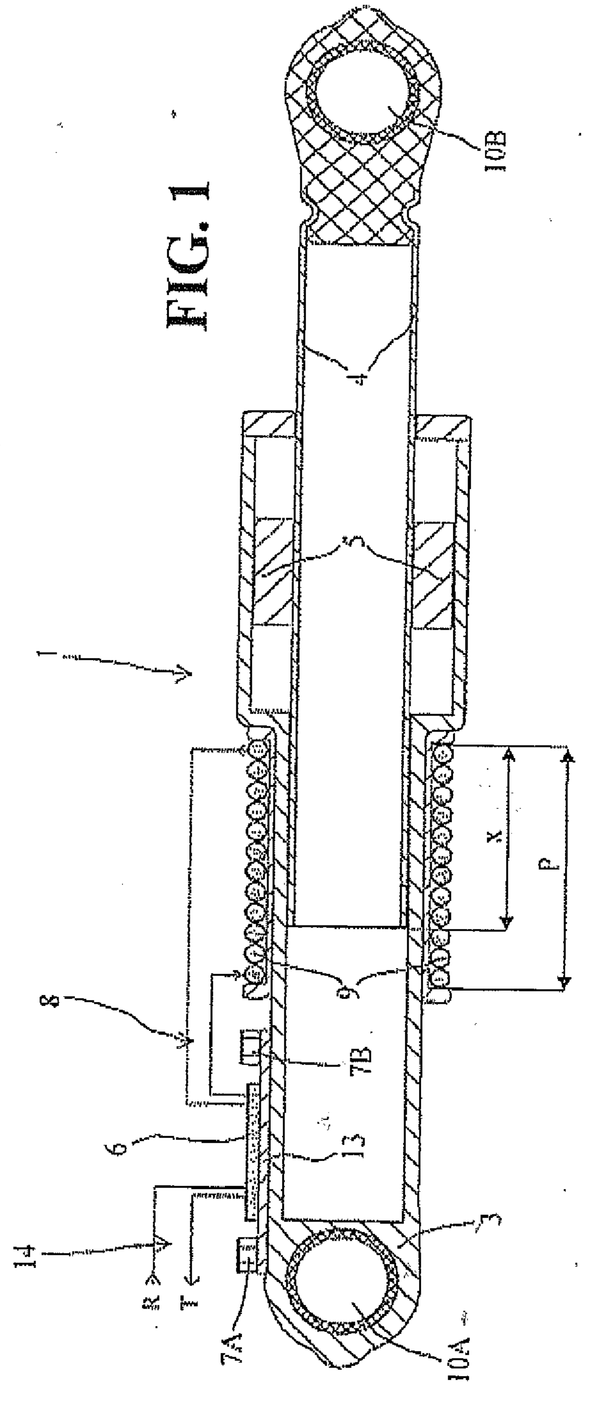
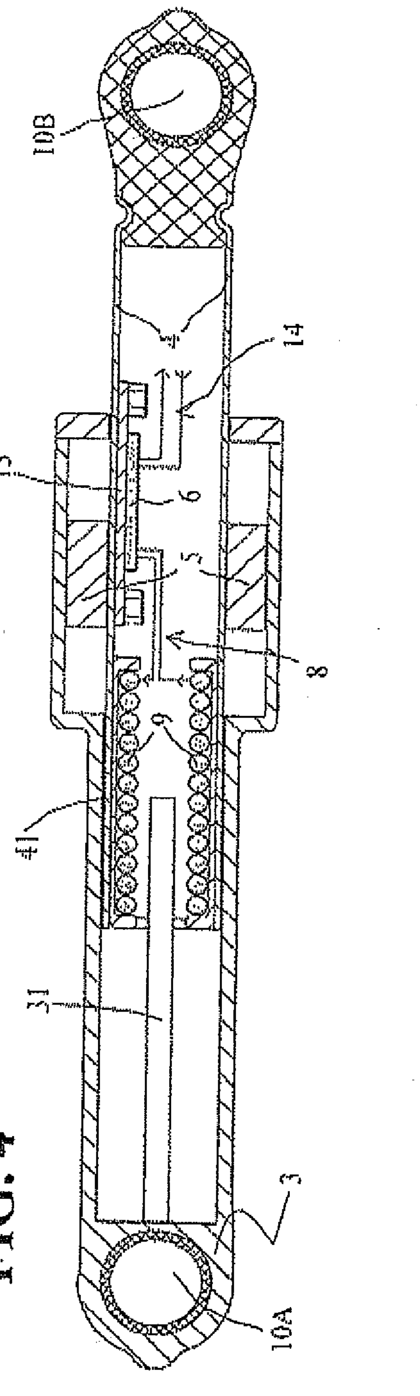


FIG. 4



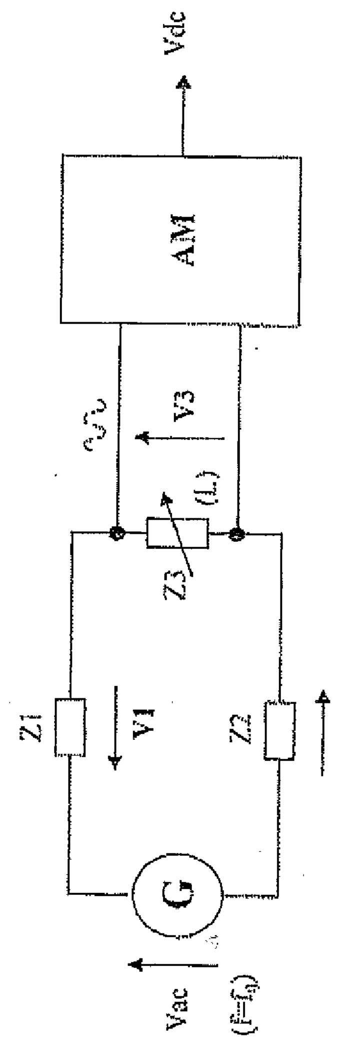

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FIG. 2a

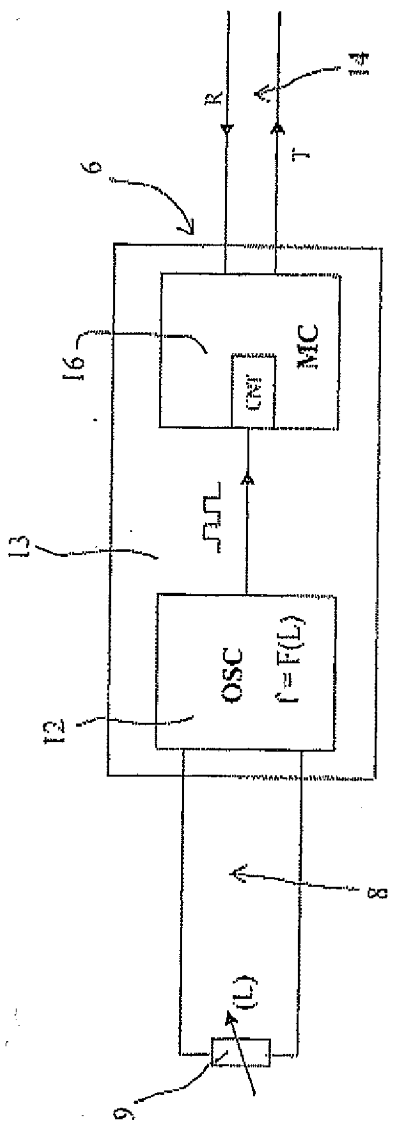
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FIG. 2b

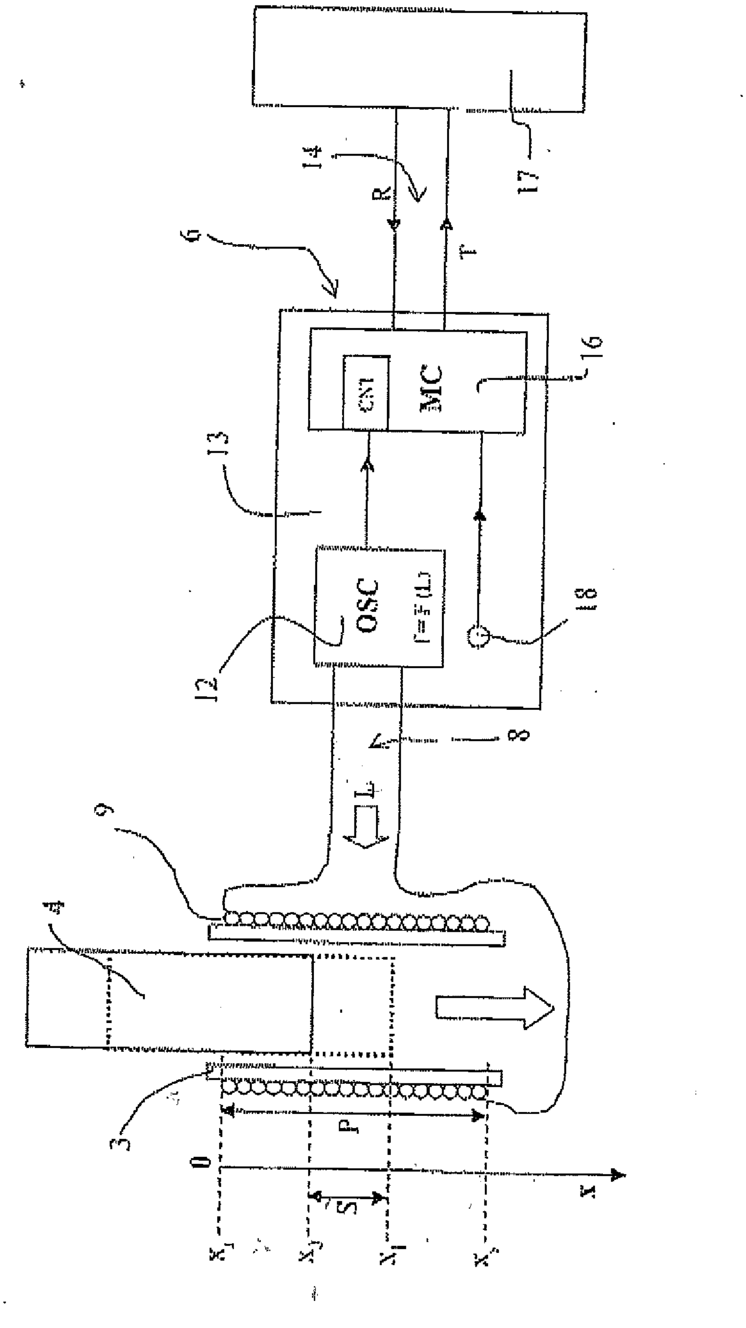

FIG. 3

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PARTIAL EUROPEAN SEARCH REPORT

under Rule 62a and/or 63 of the European Patent Convention.
This report shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number
EP 10 19 6804

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	EP 1 094 239 A2 (SUSPA HOLDING GMBH [DE] SUSPA COMPART GMBH [DE]) 25 April 2001 (2001-04-25) * paragraph [0009] - paragraph [0019]; figures 1-6 *	2-15	INV. D06F37/20
Y,D	DE 43 19 614 C1 (BAUKNECHT HAUSGERAETE [DE]) 18 August 1994 (1994-08-18) * column 3, line 29 - column 4, line 64; figures 1-3 *	2-15	
Y,D	EP 1 220 961 B1 (SUSPA HOLDING GMBH [DE]) 25 February 2004 (2004-02-25) * paragraph [0011] - paragraph [0020]; figures 1-12 *	2-15	
Y	JP 9 313777 A (NIPPON KENTETSU CO LTD; MITSUBISHI ELECTRIC CORP) 9 December 1997 (1997-12-09) * abstract *	2-15	

TECHNICAL FIELDS SEARCHED (IPC)

D06F
F16F

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

3

Place of search	Date of completion of the search	Examiner
Munich	18 March 2011	Fachin, Fabiano

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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INCOMPLETE SEARCH SHEET C

Application Number
EP 10 19 6804

Claim(s) completely searchable:
2-15

Claim(s) not searched:
1

Reason for the limitation of the search:

The independent claims 1 and 2 do not meet the requirements of Rule 43(2) EPC because their content does not fall within the scope of the exceptions listed in Guidelines Part C-III-3.2.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 19 6804

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The members are as contained in the European Patent Office EDP file on
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18-03-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1094239 A2	25-04-2001	AT 265633 T	15-05-2004
		DE 19950747 A1	26-04-2001
		ES 2218044 T3	16-11-2004
DE 4319614 C1	18-08-1994	NONE	
EP 1220961 B1	25-02-2004	AT 260355 T	15-03-2004
		DE 10046712 A1	19-04-2001
		WO 0127375 A1	19-04-2001
		EP 1220961 A1	10-07-2002
		ES 2214325 T3	16-09-2004
		TR 200200877 T2	21-06-2002
JP 9313777 A	09-12-1997	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE 4319614 **[0010]**
- EP 1220961 A **[0012]**
- EP 1094239 A **[0012]**
- EP 654140 A **[0017] [0034]**