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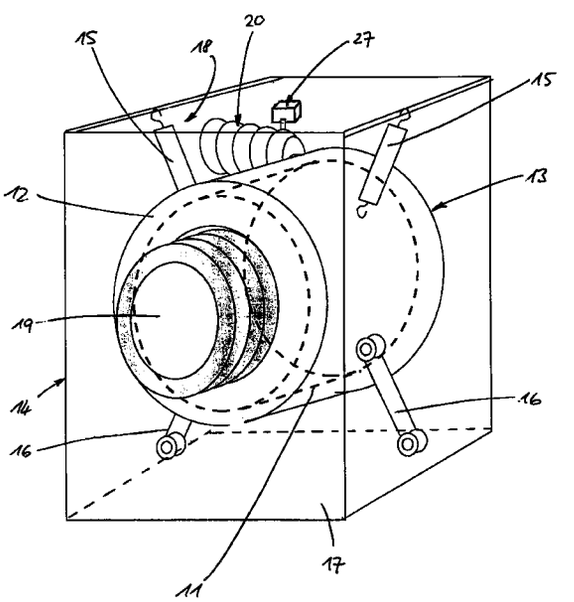
(54) Method for ensuring a correct dynamic trim of the washing assembly of washing machines and washing machine implementing said method

(57) According to the invention, the relative displacements (S) of the washing assembly (13) and the outer stationary structure (14) of a washing machine are converted into corresponding pressure variations (Δp), which are used in a measurement and control arrangement of the manometric type to modify, if necessary, operation parameters of the machine accordingly.

USE: Clothes washing and similar machines with a rotating drum.
PURPOSE/ADVANTAGES: The dynamic trim of the washing assembly is ensured in a substantially unsophisticated, but effective manner.

FIG. 2



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Description

The present invention generally refers to washing machines, in particular, although not limited to, residential-type clothes washing and combined clothes washing and drying machines, that are provided with a washing assembly including a rotating drum mounted inside an outer stationary structure.

The market is increasingly demanding washing machines, usually those with a substantially horizontal-axis drum, which have at least a washing speed and a markedly higher spin-extraction speed which may reach up to 1800 to 2000 rpm. These machines generally pose a quite demanding challenge to their manufacturers in view of being ensured a correct dynamic trim of their washing assembly, so as to enable the machines to operate without vibrations and with a very low noise levels.

An essential role is played in this connection by the solution of the problems arising from an unbalance condition in the distribution of the washload items along the periphery of the rotating drum, especially during spin-extraction phases. It is in fact commonly known that, in such circumstances, the washing assembly of the machines is subject to fluctuating displacements, or oscillations, with respect to the outer stationary structure of the washing machine, said oscillatory displacements, further to giving rise to an undesired level of noise, being capable of even causing parts of the machine to suffer darnages due to shocks and bumps.

As this can be inferred from the disclosures in such documents as EP-A-0 345 120, EP-A-0 349 798, EP-A-0 523 371 and EP-A-0 565 157, those skilled in the art have already come up with a number of solutions aimed at ensuring a correct dynamic trim of the washing assembly.

In particular either tachometric or accelerometric (usually iterative) methods have been incorporated in washing machines to control the displacements of the washing assembly with respect to the outer stationary structure. Such methods comprise a first phase in which signals are detected that are correlated to the rotational speed (rpm) of the electric motor driving the drum, said signals being indicative of the above cited displacements, as well as a second phase in which operation parameters of the machine are modified accordingly, in order to eliminate the causes of unbalance of the rating drum or, at least, to minimize the effects thereof. Control methods of this kind, which operate mainly during the acceleration of the rotating drum from the washing speed to the spin-extraction one, are undeniably effective, although they are based on an indirect detection of the displacements of the washing assembly. However, the devices needed to implement said methods may considerably affect the overall manufacturing costs of a washing machine, since they require the use of quite sophisticated component parts such as accelelometers, tachometers or speedometers and universal electric motors, with the therewith associated microprocessor and related means.

From the disclosure in EP-A-0 539 617, the method is also known consisting in connecting a normally closed microswitch in series with a tachometer which is in turn connected with the electronic drum motor driving module that controls the speed, ie. the rpm, thereof. Said microswitch is arranged to detect an unbalance condition of the drum and, when such an unbalance rises over a pre-determined threshold, it cuts off the connection between the tachometer and the module controlling the motor that drives the rotating drum. On one side, this solution fails to make the washing machine less expensive to any significant extent, since it anyway keeps requiring the use of such sophisticated component parts as the tachometer. On the other side, it is tied up to the use of such a device as a microswitch, the operation of which is of the "on-off" type.

It is therefore a main purpose of the present invention to surmount the drawbacks found in the state of the art by proposing a method and a washing machine incorporating such a method, which ensure a correct dynamic trim of the washing assembly during the operation cycle (or, at least, during the entire phase of acceleration of the rotating drum from the washing speed up to the spin-extraction speed) of the machine.

The features and advantages of the present invention will anyway be more readily understood from the description of a preferred embodiment thereof which is given below by way of non-limiting example with reference to the accompanying drawings, in which:

- Figure 1 is a block flow-chart representing the method according to the invention;

- Figure 2 is a simplified through-view of a clothes washing machine having a drum rotating about a substantially horizontal axis and a front loading opening, for the implementation of the above method;

- Figure 3 is a view of an embodiment of the device representing the key element of a clothes washing machine according to the invention.

A method for ensuring a correct dynamic trim of the washing assembly, for instance of the washing machine illustrated in Figure 2, comprises the phases shown in Figure 1.

The block 1 in Figure 1 represents the operating state (ON) of the clothes washing machine or, more precisely, the phase of the programmed cycle during which the drum 11, which is driven by an electric motor (not shown in Figure 2 for greater simplicity), is for instance at the beginning of an acceleration from a washing speed of 60 rpm up to a spin-extraction speed of 1500 rpm. The drum 11 and the non-perforated tub 12 enclosing it are part of a so-called washing assembly,

which is generally shown at 13. It has a front opening 19 surrounded by a bellows-type gasket for loading the washload items into the drum 11.

The washing assembly 13 is connected to the outer stationary structure 14, which is in the shape of an outer casing or cabinet, through suspension springs 15 and friction-type shock-absorber struts 16 that are mounted between the tub 12 and the base 17 of the machine. The distance from the washing assembly 13 and the outer casing 14 in fact varies, with respect to the condition in which the machine is at a standstill with no washload in its drum, owing to the effects of the washload, which is constituted by both the clothes items to be washed and the wash liquor itself.

When, during the phase of acceleration from the washing speed to the spin-extraction speed, the washload items happen to be evenly distributed all along the periphery of the rotating drum 11, the washing assembly 13 is balanced, ie. it has a correct dynamic trim. Even at the highest possible spin-extraction speeds , said distance from the washing assembly 13 to the outer casing 14 will in fact remain substantially unaltered, ie. will not decrease to such values as to be likely to cause other parts of the washing machine to suffer damages due to the oscillations of the washing assembly 13, which is usually provided with appropriate counterweights (not shown in Figure 2), with respect to the outer casing 14.

On the contrary, when during the above cited speed acceleration phase the washload is not distributed evenly along the periphery of the rotating drum 11, the washing assembly 13 becomes unbalanced and is therefore subject to oscillations or fluctuating displacements S, with respect to the trim it assumes when in a balanced condition (block 2 in Figure 1). As it has already been stated earlier, the present invention ensures a correct dynamic trim of the washing assembly 13 which therefore prevents, even under these circumstances, the other parts of the machine from being damaged.

To this purpose, the method according to the present invention provides for converting, as this is represented by the block 3 in Figure 1, the afore mentioned fluctuating displacements S of the washing assembly 13 into variations Δp in the pressure of the medium contained in a transducer 20, which will be described in greater detail further on, as well as making use of such pressure variations in a therewith associated manometric device 27. Such a conversion can be represented by a mathematical function $\Delta p = f(S)$. The instantaneous value Δp_I of such a function is constantly monitored and detected (block 4 in Figure 1) throughout the operating cycle of the washing machine or, at least, during the acceleration of the drum 11 from washing speed to spin-extraction speed. Immediately thereafter, said instantaneous value Δp_I is compared with a limit value Δ_M (block 5 in Figure 1) which is either pre-set at the design stage of the washing machine or, possibly, pre-selected by the same user of the washing machine among a plurality of available options, for instance according to the type of clothes to be washed. At most, said limit value Δ_M is equal to the value that said function $\Delta p = f(S)$ takes in correspondence of the greatest allowable displacement S_M in view of still avoiding damages due to the washing assembly 13 bumping against the outer casing 14 of the washing machine.

If the output of the comparison "$\Delta p_I < \Delta_M$?", which is carried out by the block 5, is "yes", then the method goes on along the line Y up to the block 6 which represents a continuation of the operation of the washing machine according exactly to the performance profile provided for by the programmed cycle (operation OK).

If on the contrary the output of the comparison "$\Delta p_I < \Delta_M$?" is "no", ie. if the extent of the fluctuating displacements S of the washing assembly 13 is unbearable or dangerous, the method according to the present invention provides for an instantaneous modification of operation parameters of the washing machine to take place along the line N, as this is represented by the block 7.

Indicative examples of practical manners in which such a modification can be carried out to the purpose of ensuring a correct dynamic trim of the washing assembly are as follows:

a) After a short interruption in the rotation of the drum 11, the washing machine re-starts at a lower spin-extraction speed (eg. 1000 rpm) than the one called for by the programmed cycle (eg. 1500 rpm). The value of such a lower spin-extraction speed is defined in the design stage of the washing machine so as to prevent the fluctuating displacements of the washing assembly from exceeding the afore cited value S_M under any circumstance.

b) Temporary slowing down of the rotational speed of the drum 11, or even temporary interruption of the rotation thereof, so as to give the washload items the possibilty of coming or falling off the periphery of the drum to then re-distribute more evenly along the same periphery. In this case, the only operation parameter to be modified is the duration, which becomes longer to a varying extent than the standard one, of the programmed cycle.

In both cases, after such a modification (or after each modifications, in the case of an iterative method) of operation parameters of the washing machine, the detection of the pressure variation $\Delta p = f(S)$ and the comparison of the new instantaneous value Δp_I with the pre-set limit value Δ_M, as described above, are repeated along the dashed-line loop Z shown in Figure 1.

Another operation parameter of the washing machine that can be modified, in the presence of a "yes" output in the block 5 of Figure 1 and when the friction-

type shock-absorber struts 16 contain a magnetorheological medium, consists of an increase in the vabration damping power of the friction-type shock-absorber struts through a variation in the voltage and/or current that generates the magnetic field in said magnetorheological medium. This does not enable the cause of the unbalance condition of the rotating drum 11 to be eliminated, actually, but the effect thereof is correspondingly reduced since the extent of the fluctuating displacements S is forcedly limited. The method of the present invention can most advantageously be integrated with the method described in the pending Italian patent application no. PN97A000029 filed on May 15, 1997 by the same Applicant.

The key elements required for implementing the method according to the present invention are, as it may have been inferred from the above description, a transducer means adapted to convert into pressure variations Δp the afore mentioned fluctuating displacements S of the washing assembly 13 of the machine, and a therewith associated manometric device. An embodiment of said means is illustrated, albeit schematically, in Figure 3.

The transducer means 20 substantially consists of a hollow body with a roughly cylindrical configuration, formed by mutually opposing first and second portions 21 and 22 that are made of a rigid material. eg. metal, and are in the shape of a cup, as well as a third portion 23 for connecting said first and second portions 21 and 22 to each other, which is made of an elastically deformable material, eg. rubber, and has a bellows-like shape.

The above cited end portions 21 and 22 are provided with an elongated appendix 24 and 25, respectively, that enables them to be rigidly attached to the tub 12 and a side wall 18 of the outer casing 14 of the washing machine, respectively. Such an attachment of the tansducer 20 can for instance be carried out by means of nuts (not shown) if said appendices 24 and 25 are threaded and appropriate eyelet-like seats (not shown, either) are provided on the tub 13 and the inner face of the side wall 18. Since air is most suitably used as a working fluid, in the same second portion 22 of the transducer 20 there is provided a compensating hole 28.

To one of said two end portions, eg. said second portion 22, of the transducer 20 there is furthermore attached the end attachment fitting of a rubber tube 26 leading to a therewith associated manometric device 27 that may for example be constituted by an analogue electronic pressure switch.

As a result, the diplacements S (represented by an arrow in Figure 3) of the washing assembly 13, and therefore of the first end portion 21 of the transducer 20, with respect to the outer casing 14, and therefore of the second end portion 22, are converted in the transducer 20 into pressure variations Δp of the therein contained medium owing to the elastic deformations of the bellows-like portion 23. Via the pressure switch 27, which is rated and adjusted in accordance with the pre-deterinined limit value Δ_M, the instantaneous values Δp_I of the pressure variations are therefore detected, compared and used, according to the afore described principle and method, to accordingly modify, when the circumstances are such as to require this, operation parameters of the washing machine.

The advantages of the invention may be summarized as follows:

- possibility of almost directly and immediately detecting any relative displacement of the washing assembly with respect to the outer stationary structure of the machine;
- possibility of implementing the method by making use of means that are considerably less sophisticated and expensive than the tachometric and accelerometric generators and the universal electric motors, respectively, that are used traditionally;
- multiplicity of the manners in which operation parameters of a washing machine can be modified to eliminate the causes of an unbalance condition of the rotating drum;
- possibility for well-known, readily available, substantially inexpensive and reliable component parts, such as for instance analogue pressure switches, to be used to build the manometric device.

It will finally be appreciated that it is well within tha capabilities of anyone skilled in the art to use the innovative principles of this invention to derive a number of possible variants and modifications that therefore do not depart from the scope of the present invention.

Claims

1. Method to ensure a correct dynamic trim of the washing assembly of a washing machine having an outer stationary structure (14) and a washing assembly (13) with a rotating drum (11) connected to the stationary structure (14) through elastic means (15) and vibration damping means (16), said method comprising a first phase in which the relative displacements (S) between the stationary structure (14) and the washing assembly (13), which are brought about by a non-uniform distribution of the washload items along the periphery of the rotating drum (11), are detected (4) and compared (5) with pre-determined limit values, and further comprising a second phase (7) in which operation parameters of the washing machine are modified, possibly through sequential iterations of the same method, to eliminate the causes of said displacements and/or minimize the negative effects

thereof, said method being **characterized in that** said relative displacement (S) between the washing assembly (13) and the outer stationary structure (14) are converted (3) into corresponding pressure variations (Δp) that are used during said second phase (7) in a measurement and control arrangement of the manometric type.

2. Method according to claim 1 which, in a washing machine whose drum (11) rotates at at least one washing speed and at least one spin-extraction speed, is characterized in that it is carried out, during the programmed washing cycle, throughout the period of time corresponding to the acceleration of the drum (11) from the washing speed up to the spin-extraction speed.

3. Method according to claim 1 or 2, **characterized in that** an operation parameter of the washing machine that is modified during the above cited second phase (7) is the speed of rotation of the drum (11).

4. Method according to claim 1 or 2, **characterized in that** an operation parameter of the washing machine that is modified during the above cited second phase (7) is the duration of the washing cycle.

5. Method according to claim 1 or 2, **characterized in that**, in a washing machine in which the vibration damping means (16) of the washing assembly (13) have an adjustable shock-absorbing or vibration-damping power, an operation parameter of the washing machine that is modified during the above cited second phase (7) is the above cited vibration-damping power of the friction-type shock-absorber means (16).

6. Washing machine for implementing the method according to any of the preceding claims 1 to 5, which comprises an outer stationary structure (14); a washing assembly (13) connected to said outer stationary structure (14) through elastic means (15) and vibration-damping means (16), and comprising a rotating drum (11) driven by an electric motor at at least two different rotational speeds during the washing and spin-extraction phases of the cycle, respectively; means adapted to ensure a correct dynamic trim of the washing assembly, through which the relative displacements (S) of the washing assembly (13) and the stationary structure (14) are detected (4) and compared (5) with pre-determined limit values, and operation parameters of the washing machine are then modified accordingly; said washing machine being **characterized in that** the above cited means adapted to ensure a correct dynamic trim of the washing assembly (13) comprise at least a transducer (20) adapted to convert said relative displacements (S) into corresponding pressure variations (Δp), and a measurement and control arrangement (27) of the manometric type that makes use of such pressure variations (Δp) during the afore cited second phase (7).

7. Washing machine according to claim 6, **characterized in that** said manometric-type arrangement (27) is a pressure switch, preferably an analogue pressure switch.

8. Washing machine according to claim 6 or 7, comprising a programme selector switch for selecting and controlling the operation cycles of the same machine, **characterized in that** said manometric-type arrangement (27) is connected to said programme selector switch.

9. Washing machine according to claim 6 or 7, wherein the vibration damping means (16) are of the type containing a magnetorheological medium and have a vibration damping power that can be controlled and adjusted by means of a magnetic field generated within said medium, **characterized in that** said manometric-type arrangement (27) varies the voltage and/or current generating the above cited magnetic field.

10. Clothes washing or combined clothes washing and drying machine according to claim 2, **characterized in that** said transducer (20) essentially includes a first portion (21) provided with means (24) for attachment to the washing assembly (13), a second portion (22) provided with means (25) for attachment to the outer stationary structure (14), and a third portion (23) which is arranged between said first two portions (21, 22) and, associated to said manometric-type arrangement (27), is capable of being deformed elastically.

FIG. 1

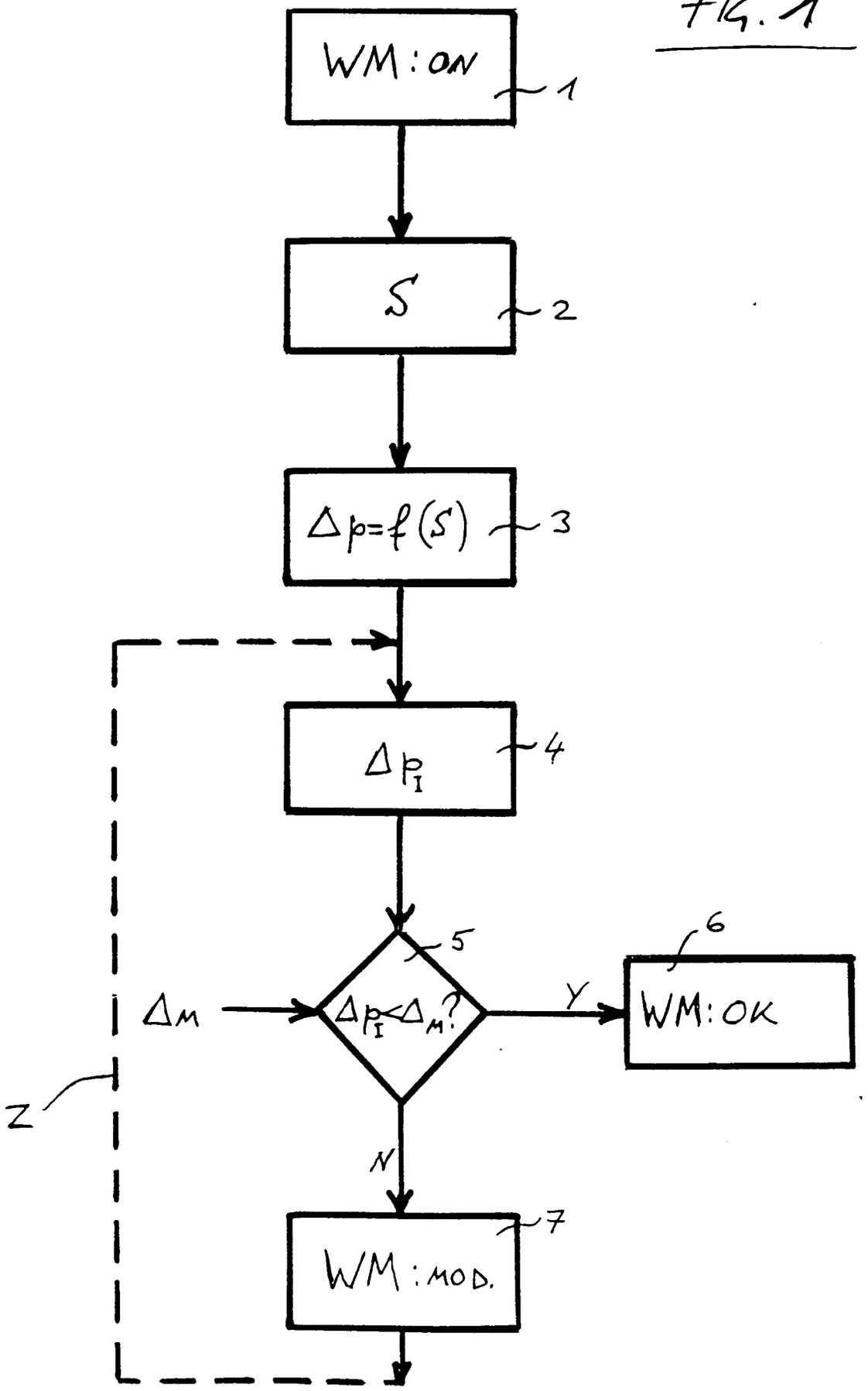
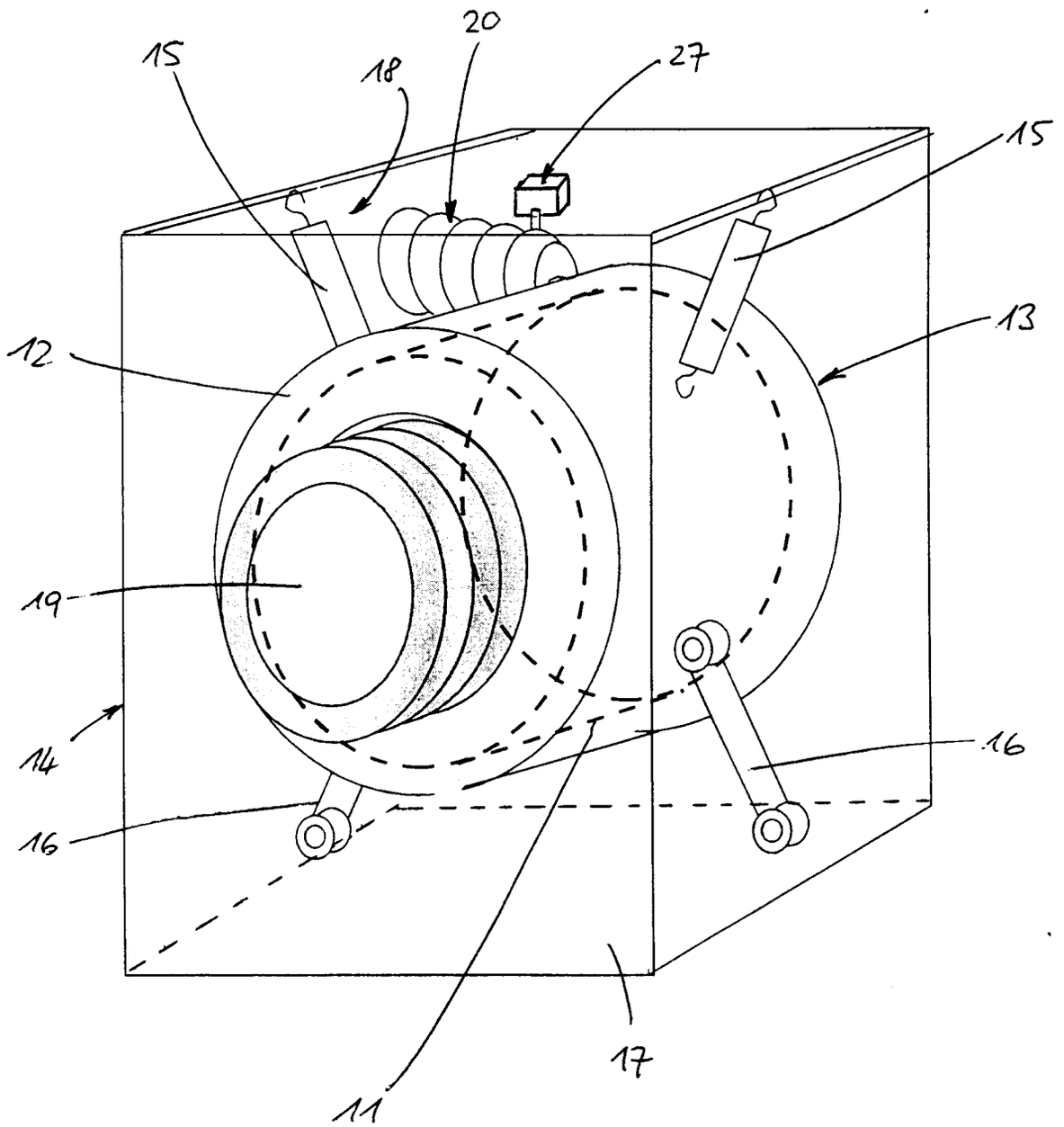


FIG. 2



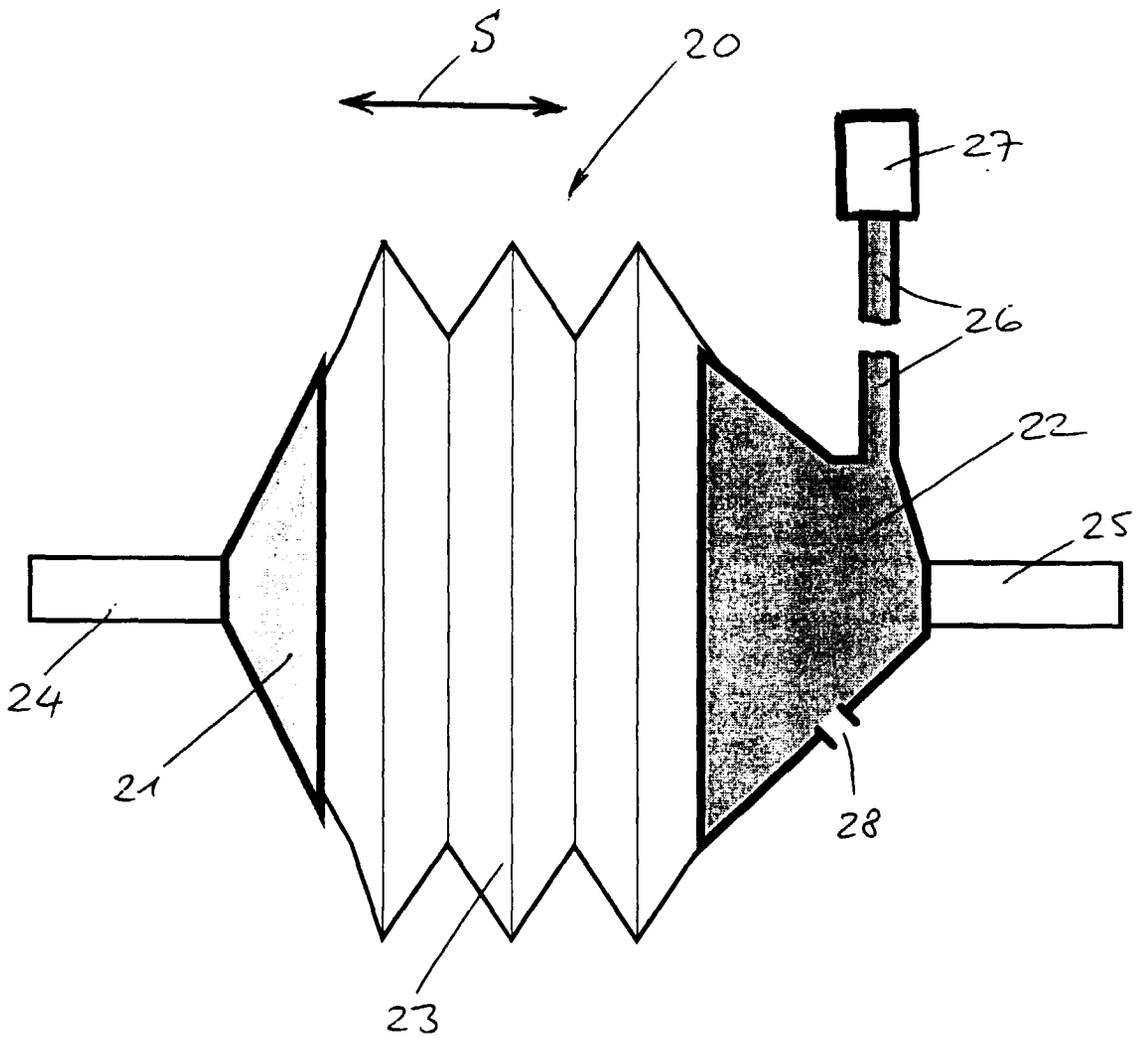


FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 6693

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP 0 750 065 A (MIELE & CIE) 27 December 1996 * page 3, line 5 - page 5, line 1; figures 1,2 *	1-4,6-8	D06F37/20
X	US 5 375 282 A (DAUSCH MARK E ET AL) 27 December 1994 * column 4, line 37 - column 7, line 29; figure 3 *	1,4,6,7	
X,P	DE 196 16 635 A (AEG HAUSGERAETE GMBH) 30 October 1997 * the whole document *	1	
A	GB 2 079 791 A (LICENTIA GMBH) 27 January 1982 * abstract; figure 1 *	1,10	
A	US 5 277 281 A (CARLSON J DAVID ET AL) 11 January 1994 * abstract; figure 1 *	1,6,9	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 September 1998	Norman, P

CATEGORY OF CITED DOCUMENTS

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