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(54) A method for improving washing performances of a washing machine and horizontal axis washer using such method

(57) A method for improving washing performances in a washing machine (10) having a perforated drum with a substantially horizontal axis comprises rotating the drum at a low tumbling speed according to a cyclic sequence of rotation intervals in both directions, wherein said cyclic sequence comprises, at predetermined intervals, a rotation of the drum at a fast speed (F) so that only a portion of the laundry load is retained against the drum wall by centrifugal force.

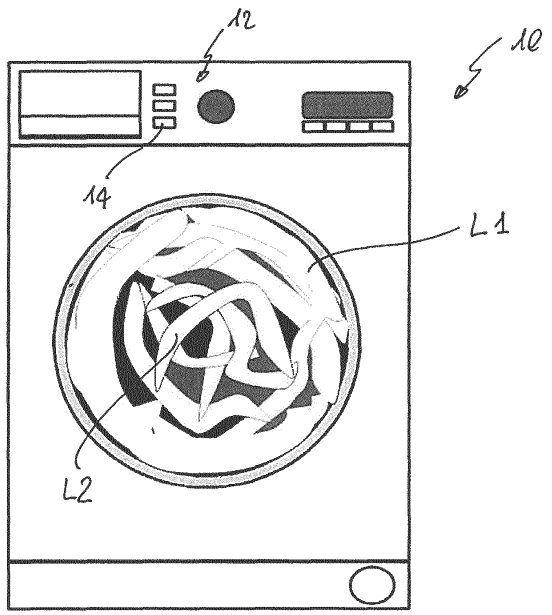

Fig. 1

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Description

[0001] The present invention relates to a method for improving washing performances in a washing machine having a perforated drum with a substantially horizontal axis, wherein said drum is rotated at a tumbling speed according to a cyclic sequence of rotation intervals in both directions.

[0002] It is well known the present trend according to which users prefer to buy washing machines with large rated capacity (the rated capacity being the mass of dry standard laundry - according to IEC standard - which the washing machine is able to wash in the European Energy Label cycle, according to the manufacturer's declaration). Such trend towards larger and larger rated capacities has been one of the major market trends and major development drivers within the past 10 years, particularly in the EU market, replacing an earlier trend towards fast and fast maximum spin speeds.

[0003] The European Energy Label does not connect the rated capacity to the actual drum volume. It is expensive for appliance manufacturers to increase the drum volume and most consumers do not have space in their homes for washing machines that exceed the usual 60 cm x 60 cm footprint.

[0004] The highest rated capacities in the market have far more than doubled (+ 150 %) in the past 10 to 15 years while drum volumes were only enlarged within narrow limits (+ 60 %). Today's rated capacities correspond to a heavily overloaded machine. For example, drum volumes which 12 years ago were used for 5 kg dry load are today declared to have 7 kg capacity.

[0005] Such overloading is so extreme that for Energy Label testing (in the manufacturer's lab or in a private or state-run testing institute's lab) the IEC standard load has to be squeezed into the washer drum with a lot of force. The Energy Label requires a combination (weighted average) of full load and partial (half) load test runs. While in the partial load test laundry has still space to perform falling movements (tumbling) and to redistribute during the wash cycle, in the full load test laundry is so forcefully compressed inside the drum that the items cannot mix and redistribute. When the machine is unloaded after end of wash cycle, the load items and standard soil strips are still in the same order as they were put in, layer after layer. There is no falling/tumbling movement of the load and very little mixing of the wash liquor. The same applies to washing cycle carried out in a domestic environment when the user loads a high amount of laundry in the drum, i.e. close to the nominal capacity of the washing machine (i.e. the one indicated in the label and instructions for use of the washing machine). This behaviour affects the wash performance. As it is well known in the art of washing machines, the mechanical action (load and water motion and forces exerted to the laundry load during washing) is one of the four contributors to the cleaning result according to Herbert Sinner's circle, the other contributors being chemistry (detergents), temperature and time.

[0006] The European Energy Label requires a Wash Performance ratio (spectrophotometric reflectance of standard soil strips after wash, ratio of value of manufacturer's machine versus the standard washer defined in IEC standard) larger than 1.03, otherwise the manufacturer is not permitted to sell such machine in the European Union. The Wash Performance is a measure of how well the machine removes soil from laundry in the Energy Label wash cycle.

[0007] Therefore, if the mechanical action is decreased, one of the other components in Sinner's circle must be increased to stay within the wash performance requirement. As consumers also prefer washers with low energy consumption on the Energy Label, the temperature usually cannot be increased because more heating of the water would require more electrical energy (though, recently, there are also other partial solutions entering the market, such as storing water in a tank so that the water can reach 23 °C standard room temperature before starting the wash cycle, as opposed to using fresh water of 15° C standard temperature from the water tap). The detergent amount and composition is fixed by IEC standard and cannot be manipulated by the washer manufacturer.

[0008] As a result, the only remaining factor is time. Wash cycle durations in the Energy Label cycle ranged from 1.5 to 2 hours fifteen years ago. Today they range from 3 to 5 hours.

[0009] Such long wash cycles are considered unreasonable and somehow a nuisance by many consumers. They are also difficult to handle for large families who may need to launder several wash loads in one day.

[0010] There is therefore a high interest in improving the wash mechanics, finding ways to redistribute even the highly compressed full wash load. Improved mixing of the wash liquor is also crucial to obtaining the required wash result while keeping the wash cycle short.

[0011] One of the current known solutions is to re-circulate washing liquor through a pump between the sump of the washing tub and a nozzle spraying washing liquor on the load. This known solution is expensive, because it needs a recirculation pump, hoses, injection nozzle and a more complex controller. Moreover, recirculating the water leads to excessive foaming, adversely affecting wash result, with the possibility that foam leaks out from detergent dispenser. Another disadvantage of recirculation is that insoluble components of detergent and soil are redeposited onto the wash load. Instead of separating the soil from the laundry, soiled water is brought back into the laundry and distributed evenly. This can cause greying of laundry and incrustation of the fabrics with detergent components such as zeolite (an insoluble detergent ingredient which reduces water hardness). Incrustation makes laundry items look faded and feel stiff and heavy.

[0012] A further disadvantage of recirculation is that it requires a lot of development work for control algorithm creation because the details of when and how to recirculate have to be carefully worked out, tested and tuned, to avoid too much foaming and too much redeposition of soil and zeolite.

[0013] Another solution is disclosed by EP 0 618 323 and relates to a speed asymmetry of reversing movement (e.g. low soaking speed counter clockwise, high near-spin speed clockwise). In this solution the efficiency depends on whether the machine has adapted lifters. The method of asymmetric speed is designed for combination with asymmetric lifters which work like paddle-wheels, scooping washing liquor from the bottom to the top of the drum. There is a high risk of excessive foam production, noise increase and high motor energy consumption due to the high speed applied in each reversing interval, e.g. twice per minute. This known method does not allow an efficient redistribution of the load, rather only a better distribution of wash liquor. Another solution is disclosed by EP 0 781 881 and relates to a reversing washing pattern containing a total of five different speeds, i.e. two (soak, wash) + three (soak, wash, spin) different speeds. This known solution has the disadvantage of high motor energy consumption because each reversing period has five different speeds with acceleration between them. There is also an increased foam production and acoustic noise.

[0014] Another known method for increasing mechanical action is to carry out an aggressive drum movement with very short motor-off times (zero to 2 s motor-off phase) between the motor-on tumbling phases. This known method causes high friction which damages the load, high mechanical energy consumption leading to high electrical energy consumption, bad tangling of load, leading to high unbalance in spinning and bad spin / rinse performance.

[0015] Another known method is to carry out a very fast acceleration of the drum (more than 50 rpm/s) at the start of each motor-on phase. This method requires a strong motor and precise motor control, which lead to a more expensive appliance. Moreover it increases electrical energy consumption.

[0016] Another solution is to use two adjacent drum cylinders with a sealed circular connection, rotating in opposite directions. A washing machine adopting this solution was known in the market with the name "The Dyson Contrarotator". Despite the very good wash performance, this solution is very expensive and technically challenging because of the need to seal the two drums against one another and still enabling all functions such as independent rotation and spinning. Other disadvantages derive from a high friction that may damage the load and an increased tangling of load that may lead to increased unbalance in spinning unless careful measures are taken to de-tangle the load before spinning.

[0017] Another solution shown in Haier washing machines with a direct drive motor comprises a short spinning (at 200 rpm for 30 seconds) after main wash filling and then every 15 minutes throughout the main wash, to press out water (a kind of cheap replacement for recirculation system). This method has the advantage of a temporarily fast level of free liquor, but several disadvantages as a significantly high electrical energy consumption due to the spins, a compression of the load due to a high spin speed which does not allow the load to redistribute, a stirring up of insoluble detergent components and soils which are transported back into the load, and a high acoustic noise due to high spin speed.

[0018] It is an object of the present invention to provide a method for improving washing performances of a washing machine, particularly a washing machine with a high load of laundry, which does not present the drawbacks of the above known methods and which assures a sufficiently high mechanical action on the laundry.

[0019] The above object is reached thanks to the features listed in the appended claims.

[0020] According to the invention, the applicant has discovered that by adding to the usual cyclic sequence of tumbling rotations one or more rotations at fast speed so that only a portion of the load is retained against the drum wall by centrifugal force, the washing performances are surprisingly increased if compared to a washing cycle with the same high load but without said rotations at fast speed spaced at predetermined intervals.

[0021] According to a preferred feature of the method according to the invention, said rotations (i.e. 360° turns) at the fast speed are carried out for a predetermined number of rotations, preferably between 3 and 8 and more preferably between 4 and 7 rotations.

[0022] The interval between said fast speed rotations is preferably comprised between 5 and 15 minutes, more preferably between 8 and 12 minutes.

[0023] According to an embodiment of the present invention, the rotation at said fast speed is followed by a rotation at a low speed which is lower than the tumbling speed and which is preferably carried out for a predetermined limited number of rotations, preferably comprised between 3 and 8, more preferably comprised between 4 and 7 rotations.

[0024] The above fast speed and low speed depends mainly on the drum diameter. As far as the fast speed is concerned, it may be determined by experimental testing on a certain washing machine by assessing when only a certain desired portion of the load is retained against the wall of the drum.

[0025] As far as the low speed is concerned, in the usual range of drum diameters it is preferably comprised between 20 and 35 rpm, with a direction of rotation which is preferably identical to the direction of rotation at fast speed.

[0026] The main advantage of a method according to the present invention is not only a good improvement in washing performances when a high volume of laundry is loaded in the drum, but also a very low cost of implementation due to a simple control algorithm and to no additional components needed. Moreover a cheap traditional motor can be used for rotating drum (either with motor and belt system or with direct drive one) because very little added electrical energy is required, almost negligible.

[0027] Moreover, the method according to the invention does stir up only a small fraction of insoluble detergent ingredients and soils and does not cause foaming (at least not to any significant degree that would affect the wash).

[0028] By applying fast speed only once in e.g. 10 min for few seconds (e.g. 4 seconds), the method according to the invention avoids excessive foam production and motor energy consumption. Another energy saving derives from the same rotation sense at fast speed rotation and low speed rotation.

[0029] The method according to the invention further avoids tangling of wash load, improving washing efficiency since tangled laundry layers will squeeze out water and cannot take up new water, and therefore it cannot be cleaned well.

[0030] It improves gentleness, eliminating friction, and improves water extraction in spinning because unbalance is avoided due to redistribution of the load and improved liquor transport.

[0031] When slow rotation follows immediately fast rotation, the load is quickly wetted again, avoiding that the laundry stays in non water saturated conditions for too long. Thanks to the method according to the invention, the load is not strongly compressed; on the contrary, a large fraction of the load is loosened such that it can move more freely. Last but not least, the method allows a reduction of acoustic noise if compared with method using a higher fast speed.

[0032] Further advantages and features according to the present invention will be clear from the detailed description, provided by way of non limiting example, with reference to the attached drawings in which:

- figure 1 is a schematic front view of a washing machine according to the invention in which the laundry load is partly satellized (i.e. retained against the drum wall by centrifugal force) and partly free-moving inside the drum;
- figure 2 is an experimental graph showing rotation speed vs. time in a washing process carried out in the washing machine of figure 1; and
- figure 3 is a graph showing the free water level vs. time in the washing process of figure 2.

[0033] With reference to the drawings, a horizontal axis washing machine 10 is designed to carry out a complete main wash which includes water filling and soaking phases and which may include an enzyme phase (filling, soaking and enzyme phases are carried out approximately during the first half hour of the main wash in Energy Label cycles). The washing machine 10 comprises a control unit (not shown) which control and drives the components of the washing machine. The main wash cycle comprises also a usual reversing (= counter clockwise & clockwise tumbling) movement. According to the invention, such reversing movement is momentarily interrupted after every 10 minutes with from 4 to 7 rotations, for instance with 5 rotations in the examples shown in figures 2 and 3 at a speed F (figure 2) that is high enough to satellize a large fraction of the load but not all of it. Another large portion of the load is moving freely in the space that was vacated through the satellization of the first load fraction. "Satellize" means that the centrifugal forces are high enough to make the load adhere to the drum wrapper wall. For a washer drum of 490 mm diameter the speed proven to give the desired result was 90 rpm (reasonable range: 90 rpm +/- 20 rpm for 490 mm drum diameter).

[0034] The above situation at speed F is shown in figure 1, where with L1 is indicated the load fraction which is retained against the wall of the drum by centrifugal force, and with L2 is indicated the load fraction which can still tumble freely in the central portion of the drum.

[0035] If the speed is lower than speed F, no significant fraction of the load is satellized. If it is higher, the entire load is satellized and no laundry item is moving freely.

[0036] The optimum speed F can be determined in experimental way for each kind of washing machine by visually judging the movement of load items. The target is to see the largest possible fraction of the load moving loosely in the middle space which is freed by the satellization of some outer laundry layers. More precision in this experimental design phase can be reached by a two-step approach, with visual assessment to determine an approximate speed range in the first step, followed by series of spectrophotometric wash efficiency measurements and energy measurements at several speeds within this range as a second step.

[0037] After the few high-speed rotations F the washer is going back to normal tumbling rotation speed, for instance at 47 rpm.

[0038] After each 10 minutes the process is repeated, but with alternating direction of the fast-speed rotation (e.g. first time 90 rpm counter clockwise, then after 10 minutes 90 rpm clockwise, again after 10 minutes 90 rpm counter clockwise and so on).

[0039] A further improvement of the method according to the invention is to have the high-speed rotation at speed F followed immediately by very low speed G (figure 2) lower than the tumbling speed T. The method according to this second embodiment of the invention was proven to deliver improved wash result: immediately after 5 rotations at 90 rpm, apply 5 rotations at 30 rpm. (a reasonable range of low speed G for a 490 mm drum diameter is from 20 to 35 rpm). Then the method proceeds with normal wash rotation speed T.

[0040] To save electrical energy further, the slow rotation at speed G should be done in the same direction as the fast rotation (e.g. 5 rotations of 90 rpm counter clockwise followed immediately by 5 rotations of 30 rpm counter clockwise, then after 10 minutes 90 rpm clockwise followed by 30 rpm clockwise and so on).

[0041] This method has significantly improved the wash performance in tests carried out by the applicant. With the method according to the invention (fast & slow speed pattern, i.e. 5 rotations at 90 rpm + 5 rotations at 30 rpm every 10 minutes of a main wash cycle) the average wash performance ratio was approximately 1.036, i.e. a value typical of a class A washer. Without the method according to the invention, i.e. by using a constant tumbling speed, the wash performance ratio was approximately 1.029, i.e. a value typical of a class B washer.

[0042] If the user desires a shorter washing cycle, the method according to the invention allows obtaining similar washing performances of traditional washing cycles with an overall shorter cycle (20 minutes time saving in the tests carried out by the applicant).

[0043] In the graph of figure 3 it is clear how and when the water is pressed out from wash load during the fast rotation at speed F. The level of free water rises (peaks W in figure 3) and this water is quickly reabsorbed into the load though slower rotation at speed G.

[0044] The positive effects of having fast rotation sequences at speed F are as follows:

- creating a free space in the inner half of the drum which allows a large portion (e.g. half) of the wash load to move freely for some seconds. This portion of the load is redistributed and de-tangled.
- pressing out several litres of water from the laundry. This amount of water is changing its state from "bound liquor" (= water absorbed in the load) to "free liquor" (= water that moves freely and can enable exchange of detergent with the load and soil removal). Thus there is temporarily more free water available. As the water amounts in main wash were also continuously decreased by all manufacturers over the past years in order to save heating energy, there is today very little free water in the main wash. A larger amount of free water improves the wash performance.

[0045] The positive effect of preferred slow rotation sequences at speed G isallowing effective absorption of free water into the load, thus accelerating the exchange between free liquor and bound liquor and avoiding that the load stays undersatured with water for too long. If the laundry is insufficiently wetted this decreases the wash performance. Therefore the remixing of liquor should be achieved as fast as possible. This soaking process is accelerated by pulling the load slowly through the free water, thus increasing the contact time between the laundry items' surfaces and the free water.

[0046] The positive effect of using a reduced number of rotations (approximately five rotations) for the fast and the slow speed F and G are as follows:

- fewer rotations would not sufficiently instigate redistribution and soaking of the load.
- more rotations would lead to bad wash performance because for each drum diameter; there is an optimum rotation speed for long-time tumbling. For 490 mm drum diameter the long-time optimum is approx. 47 rpm. If we stay far above or far below this speed for a large fraction of the wash cycle, the wash performance will drop.

[0047] The 5-rotation method means that we differ from the optimum long-term rotation speed only for 13 seconds each 10 minutes, which means 2.2 % of time. This is a good compromise according to the test carried out by the applicant.

- more rotations at high speed would press out too much water from the load, which has two adverse effects:
  - The amount of free water is temporarily very large, and this is known to promote excessive foam creation.
  - The load is insufficiently wetted for too long a time, and it takes too long till it has absorbed the free water again. This reduces the wash performance.
- more rotations at high speed would cause more acoustic noise.

[0048] Due to the de-tangling effect the method according to the invention also improves the spinning result. Less tangling means less unbalance in spinning, so the water can be more easily extracted from the load. Better spinning efficiency in intermediate and final spin also means better rinsing efficiency, because less detergent stays on the load if more of the water-detergent-solution is spun out and drained off.

[0049] In washers that can detect the dry load mass either directly for instance through known motor torque measurement or by measuring load soakability it is preferable to apply the method according to the invention only if large load is detected (typically more than 0.1 kg of dry load per litre of drum volume). Small and medium loads have sufficient tumbling space in the drum. The wash efficiency advantage of the method according to the invention for small and medium loads may be too small to justify additional drive energy, depending on setting.

[0050] Instead of using an automatic detection of the laundry load according to which the control unit of the washing machine determines automatically whether to carry out the washing phase with or without the fast speed sequence according to the invention, the decision can be taken by the control unit depending on the load value chosen by the user through a user interface 12 (for instance when user presses "high load" button 14 or the like).

[0051] Even if the above description has been referred to a front loading washing machine as shown in figure 1, the method according to the invention can be applied to a top loading washing machine as well. Same considerations apply for washing machines where the axis of rotation is not horizontal, rather slightly inclined.

[0052] Moreover, the method according to the invention may be carried out also during the so called enzyme phase after water filling.

Claims

1. Method for improving washing performances in a washing machine having a perforated drum with a substantially horizontal axis, wherein the drum is rotated at a low tumbling speed according to a cyclic sequence of rotation intervals in both directions, **characterised in that** said cyclic sequence comprises, at predetermined intervals, a rotation of the drum at a fast speed (F) so that only a portion (L1) of the laundry load is retained against the drum wall by centrifugal force.

2. Method according to claim 1, wherein said rotation of the drum at fast speed (F) is carried out for a predetermined number of rotations.

3. Method according to claim 2, wherein said number of rotation is comprised between 3 and 8, more preferably between 4 and 7.

4. Method according to any of the preceding claims, wherein said predetermined intervals are comprised between 5 and 15 minutes, more preferably between 8 and 12 minutes.

5. Method according to any of the preceding claims wherein said rotation at fast speed (F) is immediately followed by a rotation at a low speed (G).

6. Method according to claim 5, wherein the direction of rotation at low speed (G) is the same of the direction of rotation at fast speed (F).

7. Method according to claim 5 or 6, wherein said rotation at low speed (G) is carried out for a predetermined number of rotations, preferably between 3 and 8, more preferably between 4 and 7.

8. Method according to any of claims 5 to 7, wherein the low speed (G) is comprised between 20 and 35 rpm.

9. Method according to any of the preceding claims, wherein it comprises an assessment of the laundry amount in the drum and a subsequent comparison between such amount and a predetermined threshold value, the washing machine performing said rotations of the drum at fats speed (F) at predetermined intervals only if the assessed value is above said threshold value.

10. Horizontal axis washing machine having a perforated drum, wherein the drum is adapted to be rotated at a low tumbling speed according to a cyclic sequence of rotation intervals in both directions, **characterized in that** it comprises a control unit adapted to drive the rotation of the drum in said cyclic sequence which further comprises, at predetermined intervals, a rotation of the drum at a fast speed (F) so that only a portion (L1) of the laundry load is retained against the drum wall by centrifugal force.

11. Horizontal axis washing machine according to claim 10, wherein the control unit is adapted to drive the drum at a low speed (G) immediately after the fast speed (F), and preferably in the same direction of rotation.

12. Horizontal axis washing machine according to claim 11, wherein the rotation of the drum at fast and low speed (F, G) is carried out for a limited number of rotations, preferably from 3 to 8, more preferably from 4 to 7 rotations.

13. Horizontal axis washing machine according to any of claim s10 to 12, wherein it comprises a user interface (12) for inputting a indication of "high load" or the like, such input triggering the adoption of the fast speed rotations (F) at predetermined intervals.

14. Horizontal axis washing machine according to any of claims 10 to 12, wherein the control unit is adapted to assess the laundry load and to compare such assessed load with a threshold predetermined value, the result of such comparison triggering the adoption of the fast speed rotations (F) at predetermined intervals only if the assessed load value is higher than the threshold value.

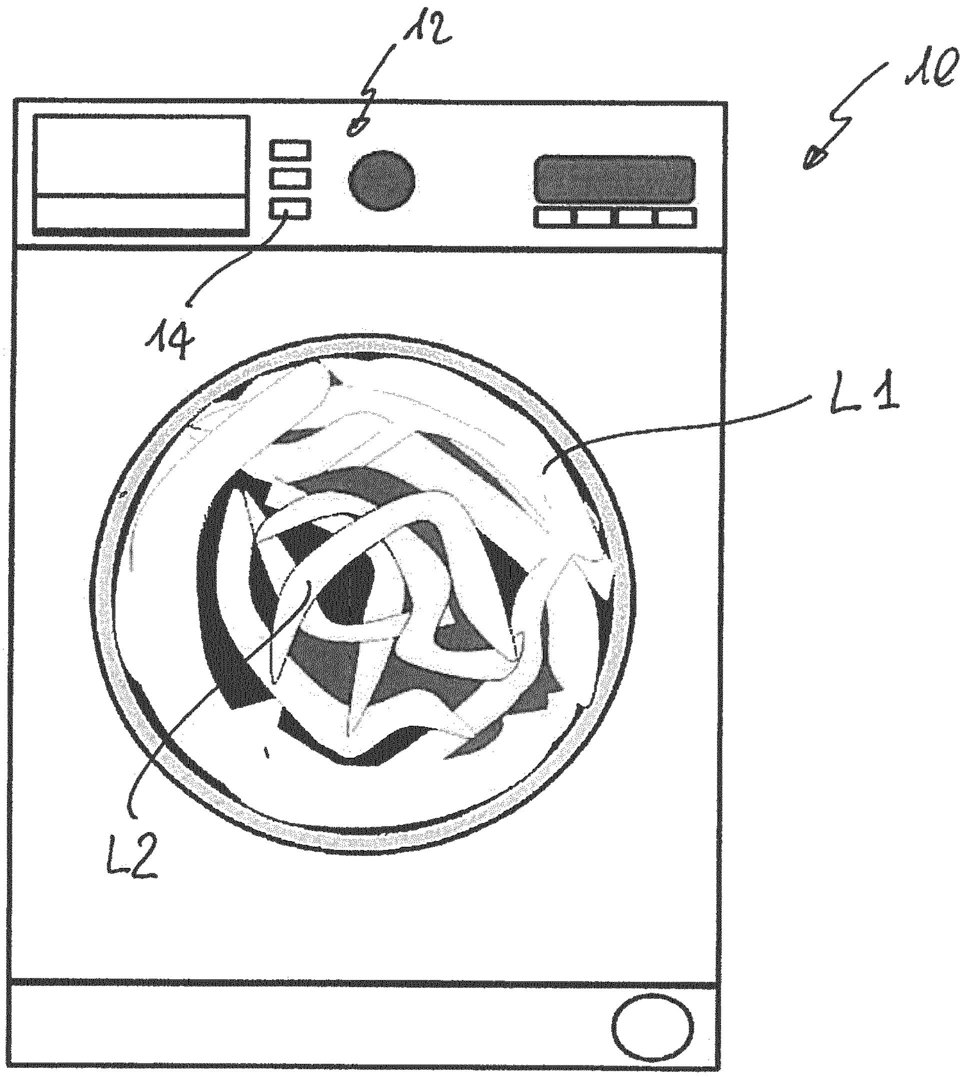
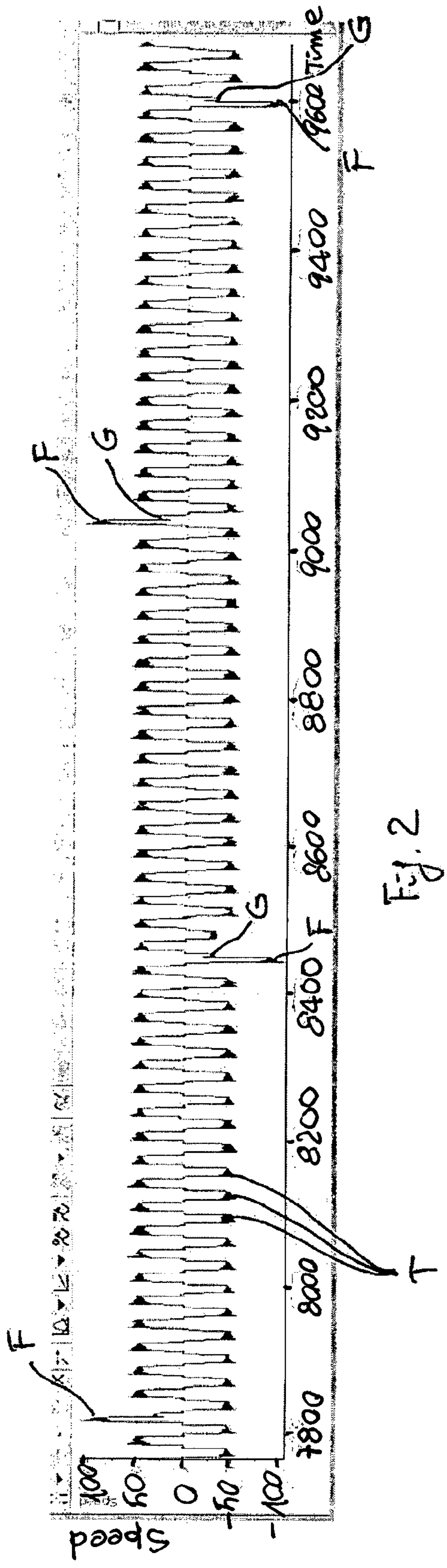


Fig. 1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-50
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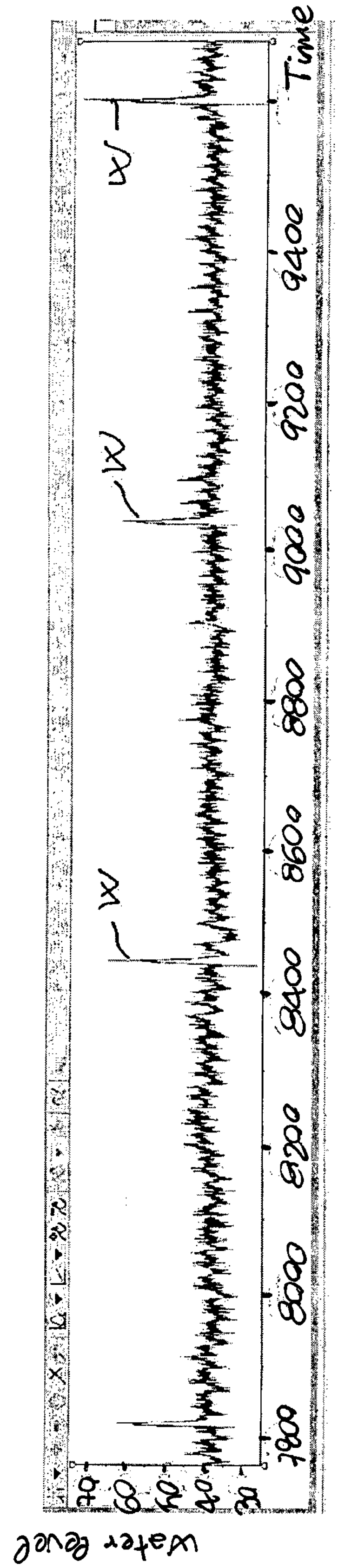
Time
F
G
T

Fig. 2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8000
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Time
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Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 1649

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

D06F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	31 March 2014	Engelhardt, Helmut

CATEGORY OF CITED DOCUMENTS

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