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(54) ROTATING MACHINES WITH OUT-OF-BALANCE OPERATION

ROTIERENDE MASCHINEN MIT AUSWUCHTUNG

MACHINES ROTATIVES AVEC FONCTIONNEMENT A L'ETAT DESEQUILIBRE

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Description

TECHNICAL FIELD OF THE INVENTION.

[0001] The present invention relates generally to rotating objects such as drums especially those which have out-of-balance operation, especially washing machines. One aspect the present invention relates to a rotating object and a method of balancing the object, which turns around an axis and which is provided with balancing chambers which can be selectively filled with a balancing liquid supplied by an appropriate number of liquid feed devices, e.g. a liquid flow controlled by solenoid valves. The liquid feed devices are operated when the out-of-balance operation of the rotating object exceeds a certain maximum limit and the balancing is continued until the movement is again under this pre-set limit. In another aspect the present invention relates to a machine containing a drum for extracting liquid out of liquid absorbent goods like a washing or drying machine whose drum rotates about a horizontal or vertical axis and more particularly to the prevention or reduction of vibration due to imbalanced forces caused by an unequal distribution of the absorbent goods about the inner periphery of the drum during an intermediate or final spin stage.

TECHNICAL BACKGROUND

[0002] US 4,991,247 describes a method of balancing a washing machine whose drum rotates about a horizontal axis. Cavities are provided evenly distributed along the periphery of the drum 5 and these having openings via which liquid can be selectively introduced into a cavity. A sensor is provided for sensing vibrations caused by imbalanced forces resulting from unequally divided linen in the drum. The output signal of the sensor is a measure of the current out-of-balance operation of the drum. The drum is brought to a first rotational speed and the sensor signal is read. A pre-determined amount of liquid is introduced into a randomly selected cavity along the periphery of the drum. The sensor signal is again read and the value is compared with the preceding sensed value. If the value is lower than the preceding one, predetermined amount of water is introduced into the selected cavity while if the value is equal to or greater than the preceding one the predetermined amount is introduced into the immediate following cavity along the periphery. This sequence is repeated until the sensor signal is lower than a predetermined, permissible value at which the container is brought to rotate at a second rotational speed, higher than the first one. The sequence described is repeated for different rotational speeds until the desired rotational speed has been reached and the sensor signal is lower than the predetermined value.

[0003] US 5,280,660 describes a method of balancing a washing machine whose drum rotates about a horizontal axis and is provided with cavities evenly distributed along the periphery thereof and having openings via which liquid can be selectively introduced into a cavity. The magnitude of the out-of-balance is determined by means of an accelerometer mounted on the housing between drum and housing. The location of the out-of-balance is determined by measuring the time that has lapsed between the passage of a target mounted on the rotatable drum and the moment when the accelerometer generates a signal above a certain threshold. The passage of the target is sensed by means of an inductive sensor. By comparing this lapsed time, knowing the speed of the drum, with values stored in a memory element the injector to be activated is determined. The injector stays activated as long as the magnitude of the imbalance exceeds the threshold value. In the preferred embodiment, a single stage cavity injection process is implemented. If time t indicates that the imbalance is located directly across from a cavity, that cavity is injected with water until the magnitude of the imbalance falls below an acceptable level. If time t indicates that the imbalance is not located directly across from a cavity, then two predetermined cavities are injected simultaneously, at the same rate, to effectively move the location of the imbalance directly to be across from another cavity, at which time that new cavity is injected to counterbalance the imbalance.

[0004] EP 0 856 604 describes a method for balancing the drum of a washing machine equipped with three or more hollow water chambers distributed along the internal periphery of the drum. The imbalance is compensated while the drum accelerates from a low initial speed to a high final maximum spinning speed. Water is injected into a selected water chamber which is situated diametrically opposite the imbalance position. The addition of compensating water is continuous, by means of a predetermined flow, during continuous and gradual acceleration, while vibrations are measured continuously, and only the rate of acceleration is dependent upon the result of the vibration measurement. With this known method, smooth rotation is achieved without exceeding an admissible washing machine vibration value by means of drum acceleration at a gradual rate until reaching a maximum speed. It is alleged that the imbalance of the clothes is compensated for in a shorter total process time.

[0005] With the above known methods a synchronisation between the maximum amplitude of the imbalance signal and the rotation of the drum is often required. This may be achieved by a target on the drum, e.g. an encoder, combined with a very accurate measurement of the maximum displacement caused by the imbalance or the maximum out-of-balance force. This measurement of the maximum imbalance requires an accurate sensing device with appropriate filtering of its output signal in order to prevent noise fluctuations from disguising the true maximum. Many years ago Leo Kahn proposed a solution to this problem in US 3,330,168 in which chambers are provided around the circumference of the drum and water is injected into a chamber opposite to the imbalance. It is the imbalanced movement of the drum which activates a microswitch which in turn activates water supply to one of the chambers. However, these known methods start from the premise that the imbalance is determined by the distribution of clothes in the drum and that this cannot be influenced. Also, measurement of the out-of-balance operation of a drum at its circumference involves the complete support mechanism of the drum which is to some extent an elastic and damped system. This involvement of a large number of the components of the machine can result in a complex motion of the drum. In particular, phase changes in the timing of maximum imbalance depending upon rotational speed. Also the motion is not restricted to two-dimensions. The drum can gyrate in various ways in a three-dimensional trajectory. This means that different movements are recorded depending on where the sensors are placed.

[0006] US 2,791,917 describes a two-drum washing machine with a balancing system. Each of a plurality of balancing chambers has an inlet for balancing liquid and also an outlet for discharge of the liquid from the chamber during operation. Also, in one embodiment, two microswitches are located, one on each drum and the control system controls injection of the balancing liquid into the first drum based on the output of the first microswitch and into the second drum based on the second microswitch. However, due to the mechanical linkage between the two drums, the movements of each drum are not independent. It is admitted that there is no known system for guaranteeing that the liquid is injected into the correct chamber. Incorrect injection results in augmentation of imbalance instead of reducing it. The ability to discharge liquid from each chamber allows corrections to be made but this reduces the speed at which balance can be reached.

[0007] Another problem is the contamination of water discharged from washing machines and other processing machines by excessive amount of chemicals such as soap, detergents, starches, bleaches, conditioners, etc. This excessive amount can result from operator error.

[0008] It is an object of the present invention to provide an apparatus with a rotating component and a method of operating the apparatus for balancing the rotation of the component which is more effective and/or economical than known apparatus and methods.

[0009] It is a further object of the present invention to provide an apparatus for extracting a liquid from a solid using a rotating hollow drum and a method of operating the apparatus which reduces the amount of contaminating chemicals discarded compared to conventional apparatus and methods.

[0010] It is still a further object of the present invention to provide an apparatus for extracting a liquid from a solid using a rotating hollow drum with balancing cavities for filling with a balancing liquid and a method of operating the apparatus, which achieves balance in a faster time..

[0011] It is still a further object of the present invention to provide an apparatus for extracting a liquid from a solid using a rotating hollow drum with balancing cavities for filling with a balancing liquid and a method of operating the apparatus, which is simpler in design.

[0012] Yet a further object of the invention is to provide a simple method to determine the location and amplitude of imbalance in a container, which turns around a horizontal or vertical axis. This container can be mounted on a flexible or rigid frame.

DISCLOSURE OF THE INVENTION

[0013] The present invention may provide a method of operating a machine having a rotating container as well as at least one balancing chamber which is fillable with a liquid for correcting out-of-balance rotational operation of the container, characterised by the steps of:

> detecting a degree of out of balance operation of the container at a position in a sub-system of the machine at which a ratio of a maximum rotational frequency of the drum to the resonant frequency of the sub-system is less than 90%, more preferably less than 85% and most preferably less than 80% and injecting the liquid into the at least one balancing chamber to correct for out-of-balance operation of the rotating container based on the detecting step. The balancing liquid may be contained in a closed system so that water is distributed between balancing chambers, e.g. by a pump, or the balancing liquid may be injected into the chambers from an outside liquid source, e.g. a water main. Preferably, the container is mounted on a shaft for rotation thereof and the sub-system is preferably on, in or under the bearing(s) in which the shaft is journalled or in or on this shaft. The method may also be used with a machine having first and as second sets of balancing chambers, the two sets of chambers, respectively having centres of gravity in two planes perpendicular to a cylindrical axis of the container, the method including the steps of: sensing the out-of-balance rotational operation of the container in two planes perpendicular to a cylindrical axis of the container; and controlling the introduction of liquid into a first balancing chamber and into the second chamber based on the results of the sensing step.

[0014] The present invention may also provide a machine having a rotating container as well as at least one balancing chamber which is fillable with a liquid for correcting out-of-balance rotational operation of the container, characterised by: a sensor for detecting a degree of out of balance operation of the container, the sensor being located at a position in a sub-system of the machine at which a ratio of a maximum rotational frequency of the drum to the resonant frequency of the sub-system is less than 90%, more preferably less than 85% and most preferably less than 80%. The balancing liquid may be contained in a closed system so that water is distributed between balancing chambers or the balancing liquid may be injected from an outside liquid source, e.g. a water main. The machine preferably has an injector for injecting the liquid into the at least one balancing chamber to correct for out-of-balance operation of the rotating container based on the detecting step. Preferably the machine includes a control unit for controlling the injection of the liquid into the at least one balancing chamber to correct for out-of-balance operation of the rotating container based on the output of the sensor. Preferably, the container is mounted on a shaft for rotation thereof and the sub-system is preferably on, in or under the bearing(s) in which the shaft is journalled or in or on this shaft. The machine may be a washing machine.

[0015] The present invention may provide a machine comprising: a rotating container for rotating a liquid absorbing plurality of objects in the container, a sensor for sensing out-of-balance rotational operation of the container, wherein the machine includes a control unit for re-distributing the plurality of liquid absorbing objects in response to an output from the sensor. The machine may have at least one balancing chamber which is fillable with a balancing liquid for correcting out-of-balance rotational operation of the container but this is optional. The balancing liquid may be contained in a closed system so that water is distributed between balancing chambers, e.g. by means of a pump or by centrifugal forces, or the balancing liquid may be injected from an outside liquid source, e.g. a water main. The machine may be a washing machine.

[0016] The present invention may provide a method of operating machine comprising:

> a rotating container for rotating a liquid absorbing plurality of objects in the container, comprising the step of: sensing out-of-balance operation of the container and re-distributing the plurality of liquid absorbing objects in the container during rotation in response to the sensing step. The machine may comprise at least one balancing chamber which is fillable with a balancing liquid for correcting out-of-balance rotational operation of the container. The balancing liquid may be contained in a closed system so that water is distributed between balancing chambers or the balancing liquid may be injected from an outside liquid source, e.g. a water main. The machine may be a washing machine.

[0017] The present invention may provide a washing machine having a rotating drum for receipt of a load of washing, a load measuring device for measuring the load of the washing received by the drum and a control unit for dispensing a quantity of processing chemicals in accordance with the measured load.

[0018] The present invention may provide method of operating a washing machine having a rotating drum for receipt of a load of washing, comprising the steps of:

> measuring the load of the washing received by the drum and automatically dispensing a quantity of processing chemicals in accordance with the measured load.

[0019] The present invention may provide an apparatus including a rotating object and a method for balancing the rotating object. The object may be a hollow drum which turns around a horizontal or vertical axis and which is provided with balancing chambers as may be used, for instance in washing machines. The drum may, in particular rotate about a horizontal axis as is typical for front loading or side loading washing machines. Preferably, the drum has at least three balancing chambers more towards the front (the side on which items may introduced into the drum) and/or more towards the rear side of the drum. Preferably, there are six or more chambers. The chambers may be evenly distributed along the inner or outer periphery of the drum.

[0020] One aspect of the present invention is a balancing method for a rigid or flexible mounted container, which turns around a horizontal or vertical axis and which is provided with balancing chambers which can be selectively been filled with balancing liquid, for example as supplied by an appropriate number of solenoid valves. These solenoid valves can be operated when the reaction forces on the bearings (which holds the shaft of the drum) exceeds a certain pre-set limit caused by imbalance in the drum until those forces are again under another pre-set limit. The angular velocity of the container is increased till the reaction forces on the bearings exceeds a certain pre-set limit, at that moment their is performed a balancing operation. This sequence is repeated until the desired final spinning speed is reached. According to the present invention the means for detecting the imbalance can be a movement or force detector and there is no requirement for extra synchronisation of the imbalance signal with the rotational speed of the drum despite the balancing liquid being injected into the correct balancing chambers. As a consequence this system is cheaper to manufacture than known systems even on small capacity washing machines. By the use of two out-of balance sensors two-plane balancing can be carried out.

[0021] The invention will now be described with reference to the following drawings.

DESCRIPTION OF THE DRAWINGS

[0022]

> Fig. 1 is a schematic diagram of a washing machine.

Fig. 2 is a schematic diagram of the force diagram acting upon a rotating drum of a washing machine in accordance with an embodiment of the present invention.

Fig. 3 is a graph of frequency response of a shaft and drum sub-assembly of a washing machine.

Fig. 4 is a schematic representation of a washing machine in accordance with an embodiment of the present invention having two plane balancing and six balancing chambers distributed between the front and the rear side of the machine. (open system) 3 ribs 20°.

Fig. 5 is a sectional view A-A of the washing machine according to Fig. 4

Fig. 6 is a detailed view of the location of a force sensor on the outer ring of a bearing in accordance with an embodiment of the present invention.

Fig. 7 is a graph showing the imbalance signal (A) from a sensor on the front bearings and the imbalance signal (B) from a sensor on the rear bearings in accordance with an embodiment of the present invention.

Fig. 8 is a schematic representation of a washing machine in accordance with another embodiment of the present invention having one plane balancing. (open system) (3 ribs 20°).

DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

[0023] The present invention will be described with reference to certain drawings and certain embodiments but the present invention is not limited thereto but only by the claims. The present invention will mainly be described with reference to front-loaded washing machines in which the shaft of the drum is horizontal and cantilevered from a bearing but the present invention is not limited thereto. For instance, the present invention may be applied advantageously to top-loading washing machines in which the shaft of the drum is vertical as shown, for example and merely for explanatory purposes, in US 5,269,159 and US 5,829,084 or in International Patent Application WO 97/00349. The present invention will mainly be described with reference to injection of balancing liquid from an external source such as a water main, but the present invention is not limited thereto but includes machines in which balancing liquid is re-distributed among chambers in a closed system. In addition the skilled person will appreciate that the methods and apparatus of the present invention may find advantageous use outside washing machines as exemplified by the applications described in US 4,688,355 and US 5,561,993.

[0024] In the following words such as front, back, top, bottom, upper, lower etc. relate to a front loading washing machine in its usual operational position, i.e. the washing is loaded through a door at the front into a drum which is rotatably mounted in a cantilever fashion at the back of the machine.

[0025] The present invention may be applied to a washing machine 1 as shown schematically in Fig. 1A. Machine 1 includes a housing 2. The housing may be solidly mounted to a frame 4 or may be mounted on suspension units, e.g. rubber blocks 3, in frame 4. A rotatable drum 5 is rotatably mounted within the housing, the drum being cantilevered from a bearing 32. The housing has a front door 38 for loading washing into the drum 5. A motor 19 is provided for driving the drum, e.g. through a belt and pulley system. A water supply 30, a drain valve 34 for waste water and a pump 36 for pumping out the waste water are also provided. It is well known that the damping support for a machine should ideally have a low elastic modulus, i.e. be very "soft", with viscous damping to reduce oscillations. Ideally, the system should be designed so that 1.414 times the natural resonant frequency of the system should lie well below the operating frequency of the system. This approach has been used extensively for automobile suspensions and requires an expensive, bulky and sophisticated damper arrangement. Such a suspension system is not very suitable for a washing machine which has to work at low frequencies during washing cycles and higher frequencies during water extraction cycles (spinning). The present invention makes no specific limitations on the suspension system, i.e. whether the drum and housing are solidly mounted or flexibly mounted, such as on rubber blocks. Such rubber blocks may be provided to absorb significant motions or energies or may only be provided to suppress noise. To reduce the out-of-balance forces at least one balancing chamber is provided which may be filled with water to provide the balancing. The water used for balancing may be re-used in the next cycle. The chamber may be segregated from the drum by means of a seal. A seal also may also prevent dirty water from the drum entering the balancing chamber. The out-of-balance operation of the drum is preferably corrected by one or two-plane compensation. At least two balancing chambers are used, whereby in some embodiments, one chamber is placed closer to the front of the machine 1 than the other.

[0026] A first embodiment will be described with reference to Figs. 2 to 7. As best shown in Fig. 4, a washing machine 1 comprises a housing 2 rigidly fixed to a frame 4 or fixed on suspension units such as rubber blocks 3 or springs which themselves are connected to the frame 4. A drum 5 for holding the washing rotates about a horizontal shaft 3a. The drum 5 optionally has a plurality of circumferentially and preferably contiguously distributed and preferably equally spaced balancing chambers 6a, 6b, 6c mounted towards the front vertical surface of drum 5 and optionally a plurality of circumferentially and preferably contiguously distributed and preferably equally spaced chambers 6d, 6e, 6f mounted towards the rear of the drum 5. For example, 6 balancing chambers 6 are particularly preferred. A casing 2a holding bearings 14 for the shaft 3a is fixed to the rear of the housing 2. A balancing fluid can be distributed among the chambers 6 so as to balance the drum 5. In accordance with one embodiment injection pipes 8a, 8b supply liquid such as water from a water source, e.g. a water main, to the front balancing chambers 6a, 6b, 6c though connection pipes 10a, 10b, 10c etc respectively and to rear balancing chambers 6d, 6e, 6f, however the present invention is not limited thereto. The balancing liquid may be included in a closed system and is re-distributed among the chambers 6 to balance the drum as known for example, from EP 795 639 or pumped from one chamber to another.

[0027] In embodiments where water is injected, the water supply is regulated by controllable water valves 13a, b which are under the control of a controller 17. Controller 17 receives as an input the output from at least one out-of-balance sensor 18 and more preferably two sensors 18-1 and 18-2. The out-of balance sensor 18 may be a movement sensor such as microswitch, an accelerometer or a proximity sensor; or a force sensor such as a strain gauge, a piezo-electric force sensor or similar. Where microswitches are used, these may be activated by the movements of drum or movements caused by the drum, i.e. movements of housing 2. The skilled person will appreciate that out-of-balance movements or forces generated by rotation of drum 5 can be detected in different ways such as with a magnetic switch, an inductive sensor or strain-gauge or a piezo-electrical element or any other suitable proximity or force sensor. In particular, measurement of physical movement or displacement is not necessary for balancing in accordance with the present invention. There may be little movement but significant forces may be generated which may be detected by a force sensor or force sensors or strain sensors or strain sensors placed in appropriate positions.

[0028] In a preferred embodiment of the present invention at least one out-of-balance sensor 18 is attached to the shaft, 3A or to one or more of the bearings 14 or to a part of washing machine, e.g. to a part of the drum 5/shaft 3A sub-system which has a natural resonant frequency higher than that of the maximum rotational frequency of the drum 5. Fig. 3 shows a frequency (X axis, in Hz) versus force (Y axis, logarithmic scale) plot for the shaft/drum sub-system of an exemplary washing machine as measured at the bearings 14. Due to the tight mechanical location of shaft 3A in the bearings 14, the first resonant frequency of this sub-system occurs at about 40 Hz which is 2,400 RPM. Typically, a drum of a washing machine will be accelerated to about 1,500 RPM (25 Hz) maximum during spinning which is 62.5% of the resonant frequency of this sub-system. Phase changes have an appreciable affect on balancing when the sub-system used for sensor location has a ratio of maximum rotational frequency of the drum to the resonant frequency of the sub-system of greater than 90%. Hence, in accordance with an embodiment of the present invention, the imbalance sensor or sensors is/are located on a sub-system of machine 1 which has a ratio of maximum rotational frequency of the drum to the resonant frequency of the sub-system of less than 90%, more preferably less than 85% and most preferably less than 80%. This sub-system is preferably on, in or under the bearing(s) 14 or in or on shaft 3A. In addition, it is preferable to select a rotating sub-system of the machine 1 which has a low damping factor "b". The damping factor b, for an ideal viscously damped system, is given by:

$$b^2 = D^2/4km$$

where k is the spring constant, m is the mass to be oscillated, and D is a measure of the damping such that D x velocity of the mass is the force opposing the movement of the mass. For a value of b = 0 (no damping) there is no phase changes provided the rotation frequency stays below the resonant frequency (that is the ratio of angular frequency to resonant angular frequency, ω/Ω, is less than 1). However, in all practical cases b will be finite. The larger the value of b, the larger the value of the phase change at any particular value of ω/Ω. It is preferred in accordance with the present invention if the value of b for the sub-system to be used for sensing is less than 0.1, more preferably less than 0.05. The value of b can be influenced by eliminating play in ant part of the rotating system, e.g. by rigidly mounting the drum 5 to the shaft 3A, by press-fitting the shaft 3A into the bearings 14, by the use of high quality bearings with very low frictional force. It is also preferred to reduce the number or serially mounted elastic members. The drum and shaft are rotating so it is preferred to mount imbalance sensors on the next element in-line, namely the bearings 14. Mounting the sensors on the casing 2A has been found to be unsatisfactory as a further elsatic element is included in the sub-system and this may introduce unwanted phase changes.

[0029] By limiting ω/Ω and b as indicated above, the maximum angular phase shift in going from zero frequency up to a maximum of 1500 RPM should be less than 30°. To be safe the injection angle α of the balancing liquid is preferably reduced by 30° or an appropriate angle to allow for the phase changes from zero frequency to $\omega/\Omega = 1$.

[0030] A preferred method of locating a force sensor 18-1 on the bearings 14 of shaft 3a is shown schematically in Fig. 6. The shaft 3a is securely but rotatably secured in bearing 14-2 which in turn is mounted in casing 2a. bearing 14-2 may be a roller bearing or simlar, typically sealed and lubricated for life. A section of the outer circumference of bearing 14-2 is not supported by casing 2a and a force sensor 18-1 is mounted on the supported portion of the bearing 14-2. As shaft 3a rotates and is subject to out-of-balance force, the unsupported region of bearing 14-2 will flex very slightly and this slight strain is measured by force sensor 18-1. Sensing the imbalance can be also done by micro-translators, strain gauges, capacitive or flux position sensors, piezo-electric force transducers. These may be mounted on the outer ring of the bearings or by special previsions directly onto the shaft 3a.

[0031] An AC motor 19 may be controlled by a frequency converter 20 so that the drum 5 can be rotated with speeds between 10 rpm and 1000 rpm or higher. In some embodiments of the present invention the speed necessary for spin drying may be reached by gradually increasing speed according to any one of the following nonlimiting speed series having discrete steps:

	Series 1	Series 2	Series 3
n_1	100 rpm	125 rpm	100 rpm
n_2	200 rpm	250 rpm	150 rpm
n_3	400 rpm	500 rpm	300 rpm
n_4	800 rpm	1000 rpm	400 rpm
n_5	1000 rpm		550 rpm
n_6	1200 rpm		800 rpm
n_7			1000 rpm

It is clear that any other sequence can be chosen according the construction parameters of the machine. Instead of using fixed frequency steps, it is preferred if the drum may be accelerated until the out-of-balance operation of drum 5 has reached a certain level at which point acceleration is stopped and a balancing operation is carried out.

[0032] The controller 17 may be a microcontroller or a programmable microcontroller and may include some local intelligence, i.e. a microprocessor or programmable gate array for controlling the operation of the water valves as well as the motor 19. The local intelligence, e. g. microprocessor or programmable gate array, is preferably programmed to carry out any of the control algorithms of the present invention as explained below.

[0033] In an initial stage an optional optimalisation cycle may be carried out in accordance with an embodiment of the present invention. This cycle may be used with machines with or without balancing chambers provided there is a means for sensing the out-of-balance operation of the drum 5. In this optimalisation cycle an attempt is made to re-distribute the washing in the drum when this distribution is not optimal. Where balancing chambers are provided, they may be a sealed system including a balancing liquid or the balancing liquid may be injected from an external source. To achieve optimalisation of the load in the drum 5, the drum is accelerated to a first rotational speed fl at which the force on the wet clothes is slightly in excess of 1G. This means that the washing is forced against the inside outer surface of the drum by centrifugal action. The degree of out-of-balance is measured using the one or more out-of-balance sensors 18. If the measured level of out-of-balance exceeds a pre-determined limit an attempt at re-distribution is made. If the out-of-balance is less than this limit a normal drum acceleration is continued. The re-distribution can be carried out in several ways. Typically, the speed will be reduced so that the centrifugal force on the washing is slightly less than 1G, for instance it is reduced to f1/2. This initiates a tumbling cycle, known in itself from tumble dryers. The motion of the drum can be optimised, for instance it may be given a series of intermittent impulses to generate a non-linear rotational motion thus jogging the washing into a variety of tumbling motions. After this tumbling cycle, the drum is re-accelerated to fl. Again the out-of-balance level is measured. If less than the pre-determined limit level, the drum is now accelerated normally, if not a further re-distribution attempt may be made. This optimalisation cycle may be repeated a certain number of times. If after these attempts no improvement has been obtained, the drum 5 may be balanced by a drum balancing operation if such a balancing system is provided or it may be accelerated to the final spinning speed. Alternatively, it may be accelerated until the out-of-balance level exceeds a second pre-determined level at which a balancing operation is then carried out.

[0034] In a further initial phase, the quantity of processing chemicals, such as soap, detergent, conditioner, bleach, starch or equivalent may be determined automatically. In this method the fact that the drum 5 is stationary is first checked. This can be done by determining from a rotation sensor on shaft 3a that there is no motion. Then, as indicated above, the washing machine 1 is accelerated up to the rotational speed fl. During this acceleration, one property is measured which relates to the amount of washing in the drum, for example the load on motor 19 is measured by the controller 17, for instance, the current flowing through the windings of the motor 19 or the time to reach speed fl. From previous experiments, the ratio between motor load or the time to reach fl and the load of washing in the washing machine 1 is determined experimentally and stored in a suitable non-volatile memory in controller 17, e.g, in the form of a look-up table in which the specific property is related to an amount of processing chemicals. Then, when a specific amount of washing is accelerated to fl, the measured control property is determined and the look-up table consulted to determine the amount of processing chemicals. This amount of chemical is then dispensed into the drum of the washing machine. For example, when the detergent is in liquid form, this may be dispensed by opening a valve for a pre-determined length of time, the valve being controlled by the controller 17. Alternatively, the washing load may be determined by measuring the bending moment on the shaft 3a. In a first step it is determined that the shaft 3a is stationary as described above. Then the load on the force sensor 18-1 is measured. As best shown in Fig. 4, sensor 18-1 is placed at the top of bearing 14-2. Thus an additional load on drum 5 caused by the addition of washing will increase the output from force sensor 18-1. This output provides a direct measure of the washing load in drum 5. Hence, this output may be used to determine the quantity of processing chemicals to be used in the washing cycle.

[0035] At each drum balancing operation balancing liquid may be injected independently into any one or both sets of balancing chambers 6 a-c and/or 6 d-f if drum 5 is out-of-balance, e.g. because the washing inside the drum 5 is located all at one spot the drum has an out-of-balance motion to be corrected. The balancing step in accordance with the present invention will be described with reference to Fig. 7 for a washing machine shown in Fig. 4.

[0036] In Fig. 7 curve A shows the measured out-of-balance force F_{fb} on the front bearing as determined by sensor 18-2. Curve B shows the measured out-of-balance force F_{rb} on the rear bearing as determined by sensor 18-1. Preferably, sensors 18-1 and 18-2 are mounted at an angle to each to each other with respect to shaft 3A so that the out-of-balance forces measured by the two sensors are in phase. For instance, the two sensors may be placed 180° out of phase with reference to shaft 3A. Generally, the larger of the two measured forces would be taken for balancing purposes but for explanation purposes it will be assumes that F_{fb} is the larger. In embodiments of the present invention where there is only one sensor 18, only one measured force value would be available anyway.

[0037] In the next step a balancing cycle is performed. When F_{fb} reaches a maximum value F_{fbmax} a balancing cycle is commenced. The injection time for balancing liquid is determined in accordance with a second predetermined level F_{fbmin}. This minimum value may be made dependent on the drum rotational angle α over which balancing liquid is to be injected. For instance, if the angle α is 60° the time for injection is shorter than if the angle α is 120°. It is preferred in accordance with the present invention if water is injected into a sufficient number of contiguous balancing chambers 6 which together make up the angle α of the circumference of drum 5. Preferably, this angle is about 120°, e.g. 120° ± 30°, or more preferably 120° ± 15°. This may be achieved by 6 equally spaced balancing chambers 6 which each have an included angle of 60°. Water should be injected in such a way that 2 chambers are filled with balancing water thus making up 120° of the circumference of the drum 5. It has been found that introducing water into one narrow chamber 6 is not as efficient as into a chamber or chambers having a total angle of about 120°. The narrower the chamber, the less water it can hold and the smaller the correction effect. On the other hand chambers close to ± 90° from the position opposite the out-of-balance load have little balancing effect as the balancing force is in a direction 90° to the direction of the out-of-balance load so that it has no correction effect. Some included angle between the extremes of 180° and about 10° is therefore optimum and about 120° as been found to be suitable. This is achieved most easily by 3, 6, 9 or 12 equally distributed balancing chambers about the circumference of drum 5. One way of ensuring that only 120° of chambers are filled with water during balancing is to trigger water injection by the intersection points of curve A and the predetermined minimum $F_{fbmin120°}$. For 60° injection the intersection points of curve A with $F_{fbmin60°}$ are used. Ideally, balancing liquid is injected into the balancing chambers 6 either side of the middle point of time period determined by the intersection points. Due to the fact that sensors 18 have been placed at a position in a sub-system which has a resonance frequency greater than the maximum rotational frequency, there is little or no or an insignificant phase change with rotational frequency of the drum. Hence, the only correction required may be a correcting constant phase offset which can be determined experimentally.

[0038] When balancing chambers 6 are located with their centres of gravity lying in two different planes which are perpendicular to the axis of shaft 3a and spaced along this axis, it is necessary to decide whether balancing liquid is introduced into the front or back chambers 6. The advantage of balancing in two planes is that the centre of gravity point of the combined balancing liquid amounts in the front or rear chambers 6 can be exactly aligned with the centre of gravity of the imbalance forces generated by imbalanced loads of washing in drum 5. This leads to reduced shear forces on the main shaft 3a which carries drum 5.

[0039] Fig. 2 shows a simplified force diagram on of forces acting on a rotating drum with an imbalanced load in a machine as shown in Fig. 4, where:

F_{fb} = the reaction force on the front bearing 18-2 (measured)

F_{rb} = the reaction force on the rear bearing 18-1 (measured)

F_u = periodic unbalanced force on the system (unknown)

L_{fbu} = distance between front bearing and centre of gravity of imbalance (unknown)

L_{rbu} = distance between rear bearing and centre of gravity of imbalance (unknown)

Lb = fixed distance between front and rear bearings.

F_{cr} = force correction to be created at the rear of the drum 5 by injecting balancing liquid

F_{cf} = force correction to be created at the front of the drum 5 by injecting balancing liquid

A = distance from rear bearing to the centre of gravity of rear balancing chambers

B = distance from front bearing to the centre of gravity of rear balancing chambers

[0040] From the requirement that $\Sigma F = 0$ and $\Sigma M = 0$ for stability to be maintained the following equation can be derived:

$$F_u = F_{fb}-F_{rb}$$

$$L_{fbu} = F_{rb} \times L_b/(F_{fb} - F_{rb})$$

[0041] In a balanced situation, Ffb and Frb should be close to or equal to zero. In this case:

$$F_u = F_{cr} + F_{cf}$$

$$F_{cf} = F_{cr} (L_{fbu} -A) / (B - L_{fu})$$

and hence:

$$F_{fb}/F_{rb} \sim F_{cr} / F_{cf}$$

[0042] A practical control algorithm can be made which relies on calculating F_{fb}/F_{rb} from the measured values. At start up it is assumed that the drum is balanced and the value of $T1_{front}/T1_{rear}$ is equal to 1. If as the speed increases, the value of F_{fb}/F_{rb} increases then it means that balancing liquid must be introduced into the rear chambers. If it decreases, liquid must be injected into the front chambers. Once F_{fb}/F_{rb} has reached a value close to a constant such as 1 the drum is balanced or sufficiently balanced. By this means the drum may be kept equally balanced throughout its the speed range. The necessary calculations and valve control can be carried out by programming the controller 17 appropriately. By accelerating uniformly and not too fast the balancing steps and the monitoring of the imbalance may be done continuously without having to slow done the acceleration procedure. This can provide an optimum acceleration time.

[0043] The effect of the balancing step will be to reduce movement of drum 5 and the measured curves A and/or B both have a maximum on or below F_{fbmin}, F_{rbmin}. At this point the drum has reached a satisfactory level of balance the current balancing step is completed. The drum 5 may then be safely accelerated until the next pre-determined speed is reached or until the unbalanced forces exceed F_{fbmax} again, at which there is performed a further balancing operation. Control of the balancing operation is done by controller 17 programmed to carry out the control actions described above.

[0044] The balancing operations are repeated until the final spinning speed is reached. The washing machine 1 is held at maximum speed by controller 17 until enough water has been extracted from the washing load in accordance with the machine design. Before deceleration the drain valve of the washing machine is closed and the water valve 15 opened. All water that is in the balancing chambers and is submitted to a centrifugal force less then 1-G will be drained.

[0045] While the invention has been shown and described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes or modifications in form and detail may be made without departing from the scope of this invention. For example in the above embodiment of the present invention only the rear chambers 6 d, e, f or the front chambers 6 a, b,c may be provided.

[0046] Another embodiment of the present invention is shown in Fig. 8. This machine differs from the machine of Fig. 4 in that there is only one set of balancing chambers 6a, b, c circumferentially arranged about an outer periphery of drum 5 and there is only one out-of-balance sensor 18-1 which is preferably mounted on the outer ring of the rear bearing 14-2. The machine is suitable for on-plane balancing.

[0047] Advantages of the present invention can be:

1. It provides the possibility to determine the amount of loaded linen and by this adapt the required amount of water and soap needed to wash the linen effectively with wasting the smallest amount of energy, water and detergents.
2. It offers the opportunity in washers, which are not equipped for water balancing of the rotating drum to still obtain a desirable distribution of cloths so that vibrations are limited to the minimum.
3. It allows 1 plane or 2 plane balancing without the necessity of having a target on the drum in order to determinate the phase differentiation between cause (unbalance force) and consequence (vibration) because phase differentiation is minimum.
4. If the imbalance is sensed at the bearings normal maintenance of the machine will not be affected. Bearings are calculated to last the life time of the machine
5. There are no movable parts in case of a rigid mounted machine so that no fatigue of any component is to be expected. Especially in the case of flexible mountings with rubbers blocks their characteristics change with time and with environmental aspects (like humidity, temperature etc).
6. In some embodiments the speed of the drum is increased until a certain limit of forces on the bearings is reached thus making the time for balancing as short as possible.
7. Because the maximum frequency of turning of a washer drum is up to 25 Hz and the resonant frequency of the washer sub-system where sensing is carried out is above 45 Hz,no extra synchronisation of the unbalance signal with the rotation speed of the drum is required. As a consequence this system is cheaper then known systems which makes it profitable to implement the system also on small capacity washing machines.

Claims

1. A method of operating a machine (1) having a rotating container (5) as well as at least one balancing chamber (6a-f) which is fillable with a liquid for correcting out-of-balance rotational operation of the container (5), comprising:

   detecting a degree of out of balance operation of the container (5) and injecting the liquid into the at least one balancing chamber (6a-f) to correct for out-of-balance operation of the rotating container (5) based on the detecting step, **characterized by** the detecting being carried out at a position in a sub-system of the machine (1) at which a ratio of a maximum rotational frequency of the container to the resonant frequency of the sub-system is less than 90%, more preferably less than 85% and most preferably less than 80%, the damping factor b of the sub-system being less than 0.1.

2. The method according to claim 1, wherein the container (5) is mounted on a shaft (3a) for rotation thereof and the sub-system includes the container (5) and the shaft (3a).

3. The method according to claim 2, wherein the sub-system is limited to the container (5), the shaft (3a) and bearings (14) in which the shaft (3a) is journalled.

4. The method according to any previous claim, used with a machine (1) having first and second sets of balancing chambers (6a-c, 6d-f), the two sets of chambers (6a-c, 6d-f), respectively having centers of gravity in two planes perpendicular to a cylindrical axis of the container (5), the method including the steps of: sensing the out-of-balance rotational operation of the container (5) in two planes perpendicular to a cylindrical axis of the container (5); and controlling the introduction of liquid into a first balancing chamber (6a-c) and into the second chamber based on the results of the sensing step.

5. The method according to any previous claim, wherein the damping factor b of the sub-system is less than 0.05.

6. The method according to any previous claim, wherein the rotating container (5) is for rotating a liquid absorbing plurality of objects in the container (5), further comprising the step of: sensing out-of-balance operation of the container (5) and re-distributing the plurality of liquid absorbing objects in the container (5) during rotation in response to the sensing step.

7. The method according to claim 6, further comprising the steps of: accelerating the container (5) to a rotating speed such that an object in the container (5) experiences a force of 1 G or greater, measuring the out-of-balance load, and, in response to the measurement, lowering the speed of rotation so that an object in the container experiences a force of less than 1G.

8. The method according to any previous claim, wherein the machine (1) is a washing machine.

9. The method according to claim 8, wherein the rotating container (5) is for receipt of a load of washing, further comprising the steps of: measuring the load of the washing received by the container (5) and automatically dispensing a quantity of processing chemicals in accordance with the measured load.

10. The method according to any previous claim, further comprising the step of accelerating the container (5) until a degree of imbalance is sensed which is above a pre-determined limit and then carrying out a container balancing step.

11. A machine (1) having a rotating container (5) as well as at least one balancing chamber (6a-f) which is fillable with a liquid for correcting out-of-balance rotational operation of the container (5), **characterised by**: a sensor (18) for detecting a degree of out of balance operation of the container (5), the sensor (18) being located at a position in a sub-system of the machine (1) at which a ratio of a maximum rotational frequency of the container (5) to the resonant frequency of the sub-system is less than 90%, more preferably less than 85% and most preferably less than 80%, the damping factor b of the sub-system being less than 0.1

12. The machine (1) according to claim 11, wherein the balancing liquid is contained in a closed system.

13. The machine (1) according to claim 12, wherein the balancing liquid is supplied from a liquid source external to the machine (1).

14. The machine (1) according to any of claims 11 to 13, further comprising an injector device (8a,b) for injecting the liquid into the at least one balancing chamber to correct for out-of balance operation of the rotating container.

15. The machine (1) according to claim 14, wherein the machine (1) has a control unit for controlling the injection of the liquid into the at least one balancing chamber (6a-f) to correct for out-of balance operation of the rotating container (5) based on the output

of the sensor (18).

16. The machine (1) according to any of the claims 11 to 15, wherein the container (5) is mounted on a shaft (3a) for rotation thereof and the sub-system includes the container (5) and the shaft (3a).

17. The machine (1) according to claim 16, wherein the sub-system is limited to the container (5), the shaft (3a) and bearings (14) in which the shaft (3a) is journalled.

18. The machine (1) according to an of the claims 11 to 17, further comprising first and second sets of balancing chambers (6a-c, 6d-f), the two sets of chambers (6a-c, 6d-f), respectively having centers of gravity in two planes perpendicular to a cylindrical axis of the container, first and second out of balance sensors (18-1, 18-2) for sensing out of balance rotational operation of the container (5) in two planes perpendicular to a cylindrical axis of the container (5); and a controller (17) for controlling the introduction of liquid into a first balancing chamber and into the second chamber in response to the outputs from the sensors (18-1, 18-2).

19. The machine (1) according to any of the claims 11 to 18, wherein the damping factor b of the sub-system is less than 0.05.

20. The machine (1) according to any of the claims 11 to 19, wherein the rotating container (5) is for rotating a liquid absorbing plurality of objects in the container (5), further comprising a controller (17) for redistributing the plurality of liquid absorbing objects in the container (5) during rotation in response to the output of the sensor (18).

21. The machine (1) according to claim 20, wherein the controller (17) controls the acceleration of the container (5) to a rotating speed such that an object in the container (5) experiences a force of 1G or greater and lowering the speed of rotation of the cantainer (5) so that an object in the container (5) experiences a force of less than 1G in response to the output of the sensor (18).

22. The machine (1) according to any of the claims 11 to 21, wherein the machine (1) is a washing machine.

23. The machine (1) according to claim 22, wherein the rotating container (5) is for receipt of a load of washing, further comprising a controller for automatically dispensing a quantity of processing chemicals in accordance with the output of the sensor (18).

Patentansprüche

1. Verfahren zum Betreiben einer Maschine (1) mit einem drehbaren Behälter (5) sowie wenigstens einer Ausgleichskammer (6a-f), welche mit einer Flüssigkeit zur Korrektur eines Ungleichgewichts eines Drehbetriebes des Behälters (5) füllbar ist, mit folgenden Schritten:

Erfassen eines Grades des Ungleichgewichts des Betriebs des Behälters (5) und Einspritzen der Flüssigkeit in die wenigstens eine Ausgleichskammer (6a-f) für eine Korrektur des Ungleichgewichts des Betriebes des sich drehenden Behälters (5) auf Grundlage des Erfassungsschrittes,

dadurch gekennzeichnet,
dass das Erfassen bei einer Stellung in einem Untersystem der Maschine (1) ausgeführt wird, in welcher das Verhältnis einer maximalen Drehfrequenz des Behälters zu der Resonanzfrequenz des Untersystems weniger als 90%, vorzugsweise weniger als 85% und am meisten bevorzugt weniger als 80% beträgt, wobei der Dämpfungsfaktor b des Untersystems weniger als 0,1 beträgt.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** der Behälter (5) auf einem Schaft (3a) für eine Drehung darauf montiert wird und dass das Untersystem den Behälter (5) und den Schaft (3a) umfasst.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** das Untersystem auf den Behälter (5), den Schaft (3a) und Lager (14) begrenzt ist, in welchen der Schaft (3a) achsgelagert wird.

4. Verfahren nach wenigstens einem der vorhergehenden Ansprüche zur Verwendung mit einer Maschine (1), welche einen ersten und zweiten Satz an Ausgleichskammern (6a-c, 6d-f) aufweist, wobei die beiden Sätze der Kammern (6a-c, 6d-f) jeweils Schwerpunkte in zwei Ebenen senkrecht zu einer zylindrischen Achse des Behälters (5) aufweisen, wobei das Verfahren die folgenden Schritte aufweist: Erfassen des Ungleichgewichts des Drehbetriebs des Behälters (5) in zwei Ebenen senkrecht zu einer zylindrischen Achse des Behälters (5); und Steuern der Einfuhr der Flüssigkeit in eine erste Ausgleichskammer (6a-c) und in die zweite Kammer auf Grundlage der Ergebnisse des Erfassungsschrittes.

5. Verfahren nach wenigstens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Dämpfungsfaktor b des Untersystems weniger als 0,05 beträgt.

6. Verfahren nach wenigstens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der sich drehende Behälter (5) einem Drehen einer Vielzahl von flüssigkeitsabsorbierenden Gegenständen in dem Behälter (5) dient, wobei das Verfahren ferner den folgenden Schritt aufweist: Erfassen eines Ungleichgewichts des Betriebes des Behälters (5) und Rückverteilen der Vielzahl von flüssigkeitsabsorbierenden Gegenständen in dem Behälter (5) während der Drehung als Antwort auf den Erfassungsschritt.

7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** es ferner folgende Schritte aufweist: Beschleunigen des Behälters (5) auf eine Drehgeschwindigkeit derart, dass ein Gegenstand in dem Behälter (5) einer Kraft von 1 G oder mehr ausgesetzt wird, Messen des Ungleichgewichts der Last und, in Antwort auf die Messung, Verringern der Drehgeschwindigkeit derart, dass ein Gegenstand in dem Behälter einer Kraft von weniger als 1 G ausgesetzt wird.

8. Verfahren nach wenigstens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Maschine (1) als Waschmaschine ausgebildet wird.

9. Verfahren nach Anspruch 8, **dadurch gekennzeichnet, dass** der sich drehende Behälter (5) einer Aufnahme einer zu waschenden Last dient, wobei das Verfahren ferner folgende Schritte aufweist: Messen der in dem Behälter (5) aufgenommenen, zu waschenden Last und automatisch Ausgeben einer Menge von prozessierenden Chemikalien in Übereinstimmung mit der gemessenen Last.

10. Verfahren nach wenigstens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** es ferner folgenden Schritt aufweist: Beschleunigen des Behälters (5), bis ein Grad eines Ungleichgewichts erfasst wird, welcher oberhalb einer vorbestimmten Grenze liegt, und anschließend Ausführen eines Schrittes zum Ins-Gleichgewicht-Bringen des Behälters.

11. Maschine (1) mit einem sich drehenden Behälter (5) sowie wenigstens einer Ausgleichskammer (6a-f), welche mit einer Flüssigkeit für eine Korrektur eines Ungleichgewichts des Drehbetriebes des Behälters (5) füllbar ist, **gekennzeichnet durch** einen Sensor (18) zum Erfassen eines Grades eines Ungleichgewichts des Betriebes des Behälters (5), wobei der Sensor (18) an einer Stelle in einem Untersystem der Maschine (1) angeordnet ist, an welcher das Verhältnis einer maximalen Drehfrequenz des Behälters (5) zu der Resonanzfrequenz des Untersystems weniger als 90%, vorzugsweise weniger als 85%, und am meisten bevorzugt weniger als 80% beträgt, wobei der Dämpfungsfaktor b des Untersystems weniger als 0,1 beträgt.

12. Maschine (1) nach Anspruch 11, **dadurch gekennzeichnet, dass** die Ausgleichsflüssigkeit in einem geschlossenen System enthalten ist.

13. Maschine (1) nach Anspruch 12, **dadurch gekennzeichnet, dass** die Ausgleichsflüssigkeit von einer außerhalb der Maschine (1) vorgesehenen Flüssigkeitsquelle zuführbar ist.

14. Maschine (1) nach wenigstens einem der Ansprüche 11 bis 13, **dadurch gekennzeichnet, dass** sie ferner eine Einspritzvorrichtung (8a, b) für ein Einspritzen der Flüssigkeit in die wenigstens eine Ausgleichskammer für eine Korrektur des Ungleichgewichts des Betriebes des sich drehenden Behälters aufweist.

15. Maschine (1) nach Anspruch 14, **dadurch gekennzeichnet, dass** die Maschine (1) eine Steuereinheit zum Steuern des Einspritzens der Flüssigkeit in die wenigstens eine Ausgleichskammer (6a-f) für eine Korrektur eines Ungleichgewichts des Betriebes des sich drehenden Behälters (5) auf Grundlage der Ausgabe des Sensors (18) aufweist.

16. Maschine (1) nach wenigstens einem der Ansprüche 11 bis 15, **dadurch gekennzeichnet, dass** der Behälter (5) auf einem Schaft (3a) für eine Drehung darauf montiert ist und dass das Untersystem den Behälter (5) und den Schaft (3a) umfasst.

17. Maschine (1) nach Anspruch 16, **dadurch gekennzeichnet, dass** das Untersystem auf den Behälter (5), den Schaft (3a) und Lager (14) begrenzt ist, in welchen der Schaft (3a) achsgelagert ist.

18. Maschine (1) nach wenigstens einem der Ansprüche 11 bis 17, **dadurch gekennzeichnet, dass** sie ferner einen ersten und einen zweiten Satz an Ausgleichskammern (6a-c, 6d-f) aufweist, wobei die zwei Sätze an Kammern (6a-c, 6d-f) jeweils Schwerpunkte in zwei Ebenen senkrecht zu einer zylindrischen Achse des Behälters aufweisen, wobei die ersten und zweiten Ungleichgewichtssensoren (18-1, 18-2) einer Erfassung eines Ungleichgewichts des Drehbetriebes des Behälters (5) in zwei Ebenen senkrecht zu einer zylindrischen Achse des Behälters (5) dienen; und eine Steuereinheit (17) zum Steuern der Einführung von Flüssigkeit in eine erste Ausgleichskammer und in die zweite Kammer als Antwort auf die Ausgaben der Sensoren (18-1, 18-2) aufweist.

19. Maschine (1) nach wenigstens einem der Ansprüche 11 bis 18, **dadurch gekennzeichnet, dass** der Dämpfungsfaktor b des Untersystems weniger als 0,05 beträgt.

20. Maschine (1) nach wenigstens einem der Ansprüche 11 bis 19, **dadurch gekennzeichnet, dass** der sich drehende Behälter (5) einem Drehen einer Vielzahl von flüssigkeitsabsorbierenden Gegenständen in dem Behälter (5) dient, wobei sie ferner eine Steuereinheit (17) für eine Rückverteilung der Vielzahl von flüssigkeitsabsorbierenden Gegenständen in dem Behälter (5) während der Drehung als Antwort auf die Ausgabe des Sensors (18) umfasst.

21. Maschine (1) nach Anspruch 20, **dadurch gekennzeichnet, dass** die Steuereinheit (17) die Beschleunigung des Behälters (5) bis zu einer Drehgeschwindigkeit derart steuert, dass ein Gegenstand in dem Behälter (5) einer Kraft von 1 G oder mehr ausgesetzt ist und die Drehgeschwindigkeit des Behälters (5) derart verringert, dass ein Gegenstand in dem Behälter (5) einer Kraft von weniger als 1 G in Antwort auf die Ausgabe des Sensors (18) ausgesetzt ist.

22. Maschine (1) nach wenigstens einem der Ansprüche 11 bis 21, **dadurch gekennzeichnet, dass** die Maschine (1) als Waschmaschine ausgebildet ist.

23. Maschine (1) nach Anspruch 22, **dadurch gekennzeichnet, dass** der sich drehende Behälter (5) einer Aufnahme einer zu waschenden Last dient, wobei sie ferner eine Steuereinheit für ein automatisches Ausgeben einer Menge von prozessierenden Chemikalien in Übereinstimmung mit der Ausgabe des Sensors (18) aufweist.

Revendications

1. Procédé de mise en oeuvre d'une machine (1) ayant un conteneur rotatif (5) aussi bien qu'au moins une chambre d'équilibrage (6a-f) qui peut être remplie avec un liquide pour corriger le fonctionnement déséquilibré en rotation du conteneur (5), comprenant :

la détection d'un degré de fonctionnement déséquilibré du conteneur (5) et l'injection du liquide dans l'au moins une chambre d'équilibrage (6a-f) pour corriger le fonctionnement déséquilibré du conteneur rotatif (5) sur la base de l'étape de détection, **caractérisé en ce que** la détection est effectuée à une position dans un système secondaire de la machine (1) à laquelle un rapport d'une fréquence de rotation maximale du conteneur sur la fréquence de résonance du système secondaire est inférieur à 90 %, de préférence inférieur à 85 % et encore mieux inférieur à 80 %, le facteur d'amortissement b du système secondaire étant inférieur à 0,1.

2. Procédé selon la revendication 1, dans lequel le conteneur (5) est monté sur un arbre (3a) pour la rotation de ce dernier, et le système secondaire comprend le conteneur (5) et l'arbre (3a).

3. Procédé selon la revendication 2, dans lequel le système secondaire est limité au conteneur (5), à l'arbre (3a) et à des paliers (14) sur lesquels l'arbre (3a) est monté à tourillon.

4. Procédé selon l'une quelconque des revendications précédentes, utilisé avec une machine (1) ayant des premier et second ensembles de chambres d'équilibrage (6a-c, 6d-f), les deux ensembles de chambres (6a-c, 6d-f), ayant respectivement des centres de gravité dans deux plans perpendiculaires à un axe cylindrique du conteneur (5), le procédé comprenant les étapes consistant à : détecter le fonctionnement déséquilibré en rotation du conteneur (5) dans deux plans perpendiculaires à un axe cylindrique du conteneur (5) ; et commander l'introduction de liquide dans une première chambre d'équilibrage (6a-c) et dans la seconde chambre sur la base des résultats de l'étape de détection.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel le facteur d'amortissement b du système secondaire est inférieur à 0,05.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel le conteneur rotatif (5) sert à faire tourner une pluralité d'objets absorbant du liquide dans le conteneur (5), comprenant de plus l'étape consistant à : détecter un fonctionnement déséquilibré du conteneur (5) et à redistribuer la pluralité d'objets absorbant du liquide dans le conteneur (5) pendant la rotation en réponse à l'étape de détection.

7. Procédé selon la revendication 6, comprenant de plus les étapes consistant à : accélérer le conteneur (5) à une certaine vitesse de rotation de sorte qu'un objet dans le conteneur (5) éprouve une force de 1 G ou plus, mesurer la charge déséquilibrée et, en réponse à la mesure, abaisser la vitesse de rotation de sorte qu'un objet dans le conteneur éprouve une force inférieure à 1 G.

8. Procédé selon l'une quelconque des revendications précédentes, dans lequel la machine (1) est une machine à laver.

9. Procédé selon la revendication 8, dans lequel le conteneur rotatif (5) sert à réceptionner une charge de lavage, comprenant de plus les étapes consistant à : mesurer la charge de lavage reçue par le conteneur (5) et distribuer automatiquement une quantité de produits chimiques de traitement selon la charge mesurée.

10. Procédé selon l'une quelconque des revendications précédentes, comprenant de plus l'étape consistant à accélérer le conteneur (5) jusqu'à ce qu'un degré de déséquilibre soit détecté, lequel est supérieur à une limite prédéterminée et ensuite à exécuter une étape d'équilibrage de conteneur.

11. Machine (1) ayant un conteneur rotatif (5) aussi bien qu'au moins une chambre d'équilibrage (6a-f) qui peut être remplie avec un liquide pour corriger un fonctionnement déséquilibré en rotation du conteneur (5), **caractérisée par** : un capteur (18) pour détecter un degré de fonctionnement déséquilibré du conteneur (5), le capteur (18) étant situé à une position dans un système secondaire de la machine (1) à laquelle un rapport d'une fréquence de rotation maximale du conteneur (5) sur la fréquence de résonance du système secondaire est inférieur à 90 %, de préférence inférieur à 85 %, et encore mieux inférieur à 80 %, le facteur d'amortissement b du système secondaire étant inférieur à 0,1.

12. Machine (1) selon la revendication 11, dans laquelle le liquide d'équilibrage est contenu dans un système fermé.

13. Machine (1) selon la revendication 12, dans laquelle le liquide d'équilibrage est fourni en provenance d'une source de liquide externe à la machine (1).

14. Machine (1) selon l'une quelconque des revendications 11 à 13, comprenant de plus un dispositif d'injection (8a, b) pour injecter le liquide dans l'au moins une chambre d'équilibrage pour corriger le fonctionnement déséquilibré du conteneur rotatif.

15. Machine (1) selon la revendication 14, dans laquelle la machine (1) possède une unité de commande pour commander l'injection du liquide dans l'au moins une chambre d'équilibrage (6a-f) pour corriger le fonctionnement déséquilibré du conteneur rotatif (5) sur la base de la sortie du capteur (18).

16. Machine (1) selon l'une quelconque des revendications 11 à 15, dans laquelle le conteneur (5) est monté sur un arbre (3a) pour la rotation de ce dernier et le système secondaire comprend le conteneur (5) et l'arbre (3a).

17. Machine (1) selon la revendication 16, dans laquelle le système secondaire est limité au conteneur (5), à l'arbre (3a) et à des paliers (14) sur lesquels l'arbre (3a) est monté à tourillon.

18. Machine (1) selon l'une quelconque des revendications 11 à 17, comprenant de plus des premier et second ensembles de chambres d'équilibrage (6a-c, 6d-f), les deux ensembles de chambres (6a-c, 6d-f) ayant respectivement des centres de gravité dans deux plans perpendiculaires à un axe cylindrique du conteneur, des premier et second capteurs de déséquilibre (18-1, 18-2) pour détecter le fonctionnement déséquilibré en rotation du conteneur (5) dans deux plans perpendiculaires à un axe cylindrique du conteneur (5) ; et une unité de commande (17) pour commander l'introduction de liquide dans une première chambre d'équilibrage et dans la seconde chambre en réponse aux sorties provenant des capteurs (18-1, 18-2).

19. Machine (1) selon l'une quelconque des revendications 11 à 18, dans laquelle le facteur d'amortissement b du système secondaire est inférieur à 0,05.

20. Machine (1) selon l'une quelconque des revendications 11 à 19, dans laquelle le conteneur rotatif (5) sert à faire tourner une pluralité d'objets absorbant du liquide dans le conteneur (5), comprenant de plus une unité de commande (17) pour redistribuer la pluralité d'objets absorbant du liquide dans le conteneur (5) pendant la rotation en réponse à la sortie du capteur (18).

21. Machine (1) selon la revendication 20, dans laquelle l'unité de commande (17) commande l'accélération du conteneur (5) à une vitesse de rotation de sorte qu'un objet dans le conteneur (5) éprouve une force de 1 G ou plus et abaisse la vitesse de rotation du conteneur (5) de sorte qu'un objet dans le conteneur (5) éprouve une force inférieure à 1 G en réponse à la sortie du capteur (18).

22. Machine (1) selon l'une quelconque des revendications 11 à 21, dans laquelle la machine (1) est une machine à laver.

23. Machine (1) selon la revendication 22, dans laquelle le conteneur rotatif (5) sert à recevoir une charge de lavage, comprenant de plus une unité de commande pour distribuer automatiquement une quantité de produits chimiques de traitement selon la sortie du capteur (18).

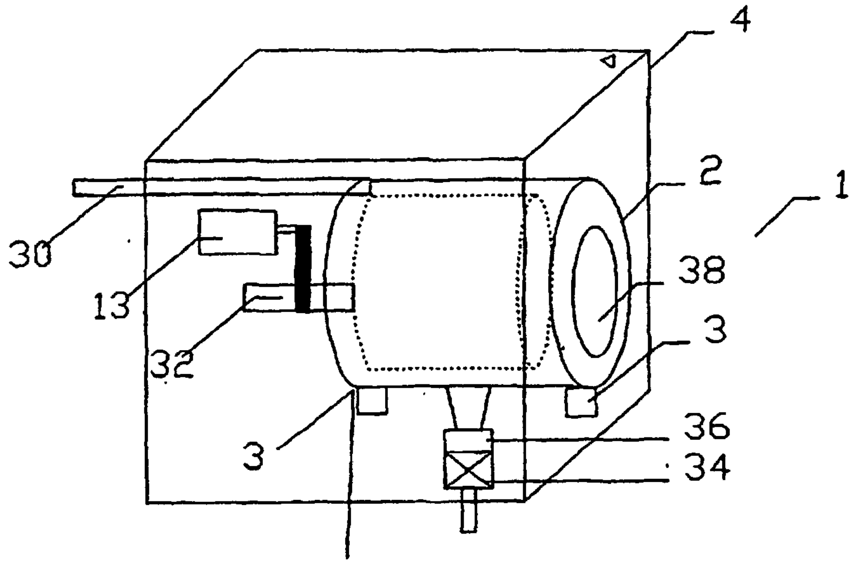

4
2
1
30
13
38
3
32
36
3
34

Fig 1

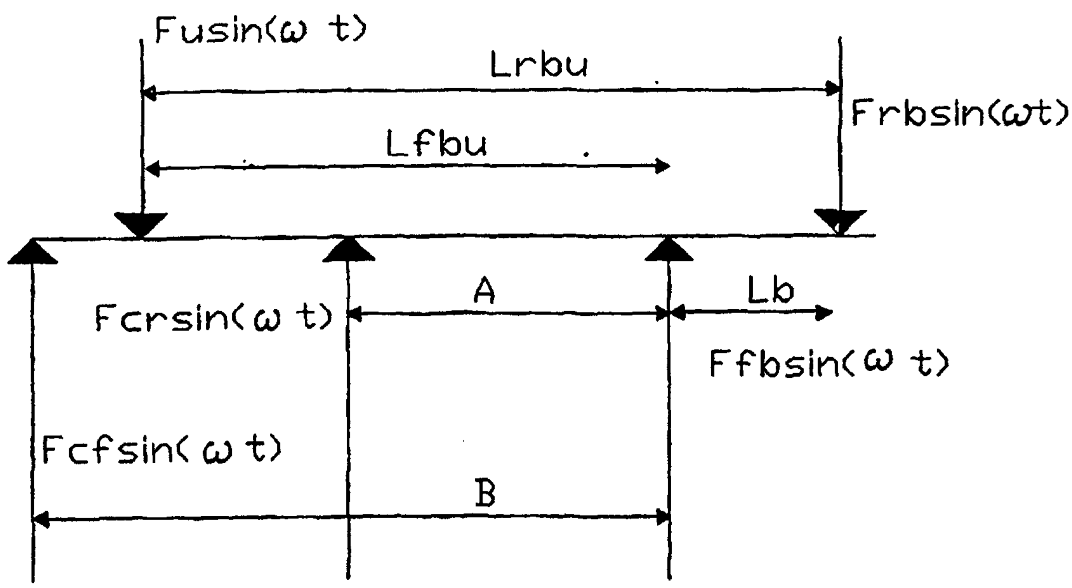
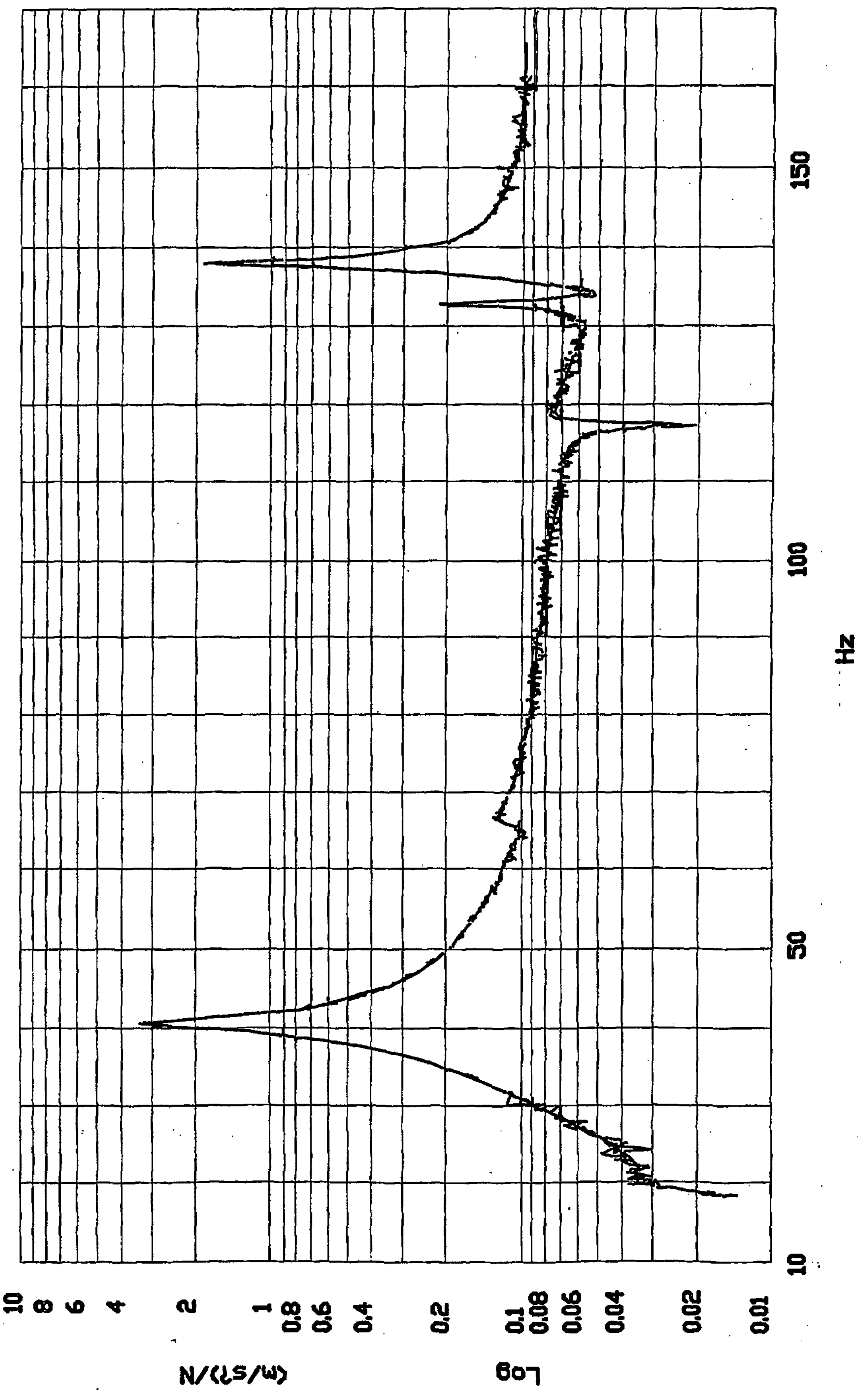

Fusin(ω t)
Lrbu
Frbsin(ωt)
Lfbu
A
Lb
Fcrsin(ω t)
Ffbsin(ω t)
Fcfsin(ω t)
B

Fig 2

Fig 3


10
8
6
4
2
1
0.8
0.6
0.4
0.2
0.1
0.08
0.06
0.04
0.02
0.01
Log
(m/s2)/N
10
50
100
150
Hz

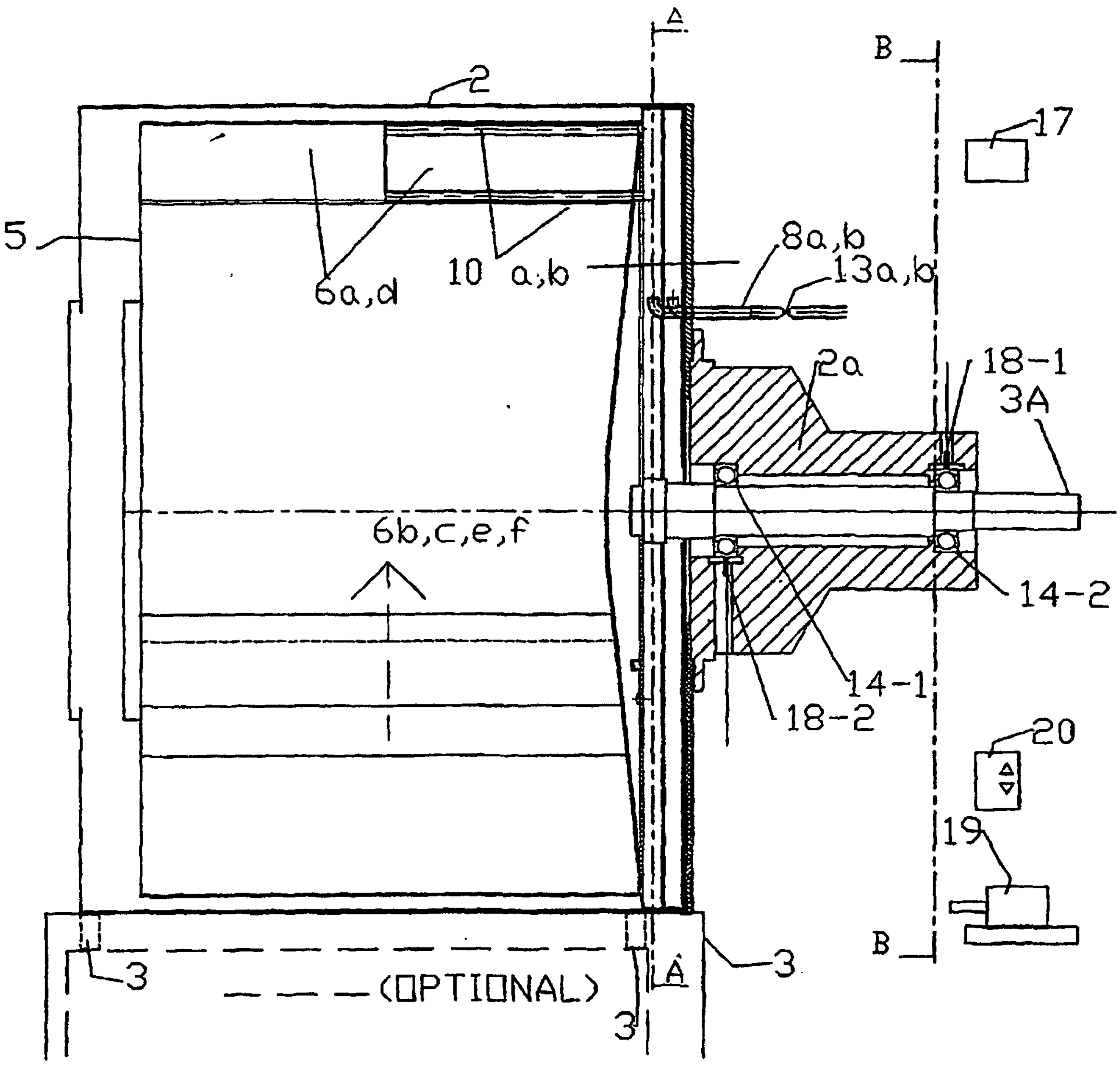

A
B
2
17
5
6a,d
10 a,b
8a,b
13a,b
2a
18-1
3A
6b,c,e,f
14-2
14-1
18-2
20
19
B
3
A
(OPTIONAL)
3
3

Fig 4.

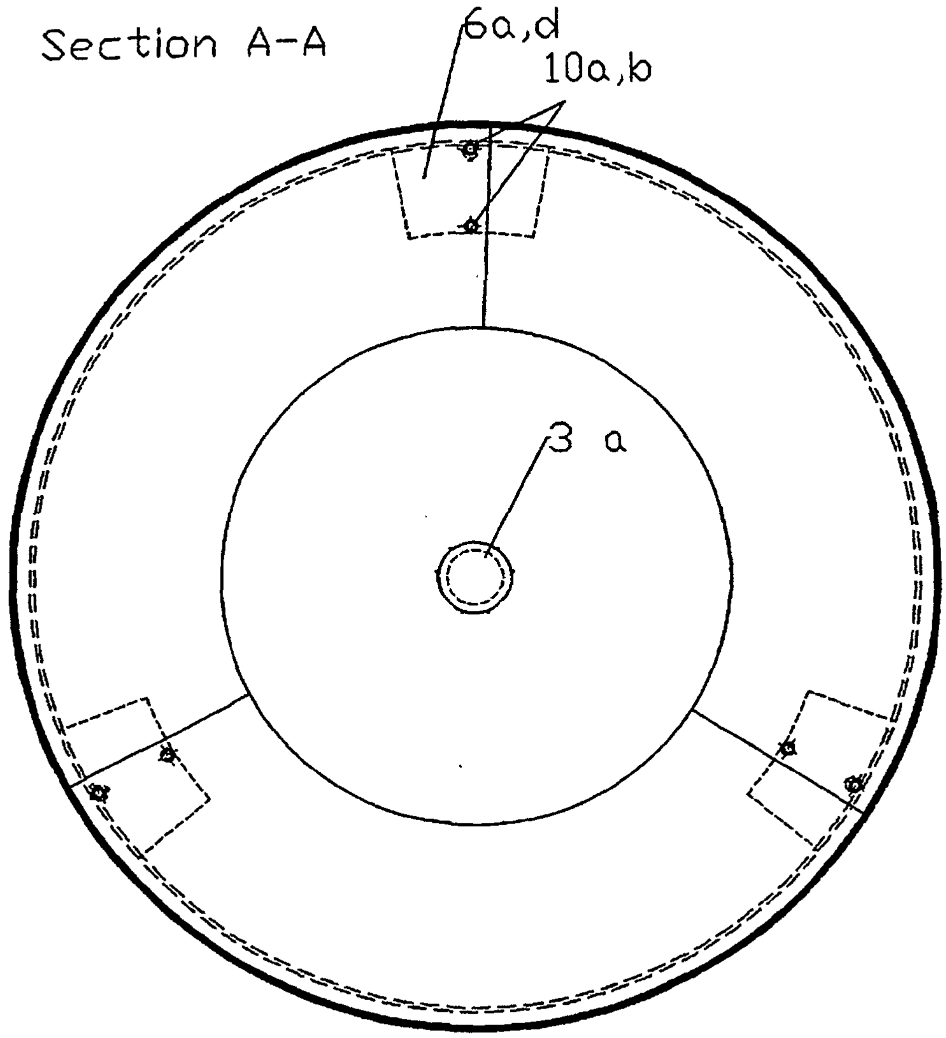
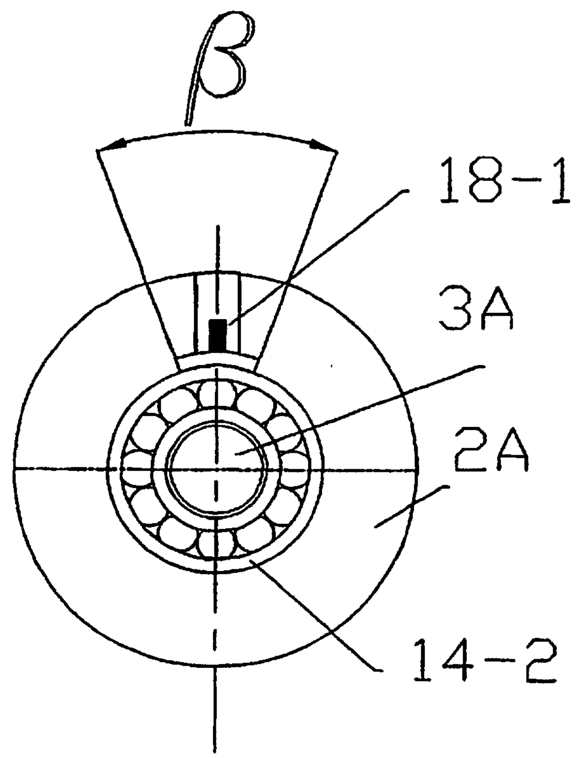


Fig 5.



SECTION B-B OF
Fig 4.

Fig 6.

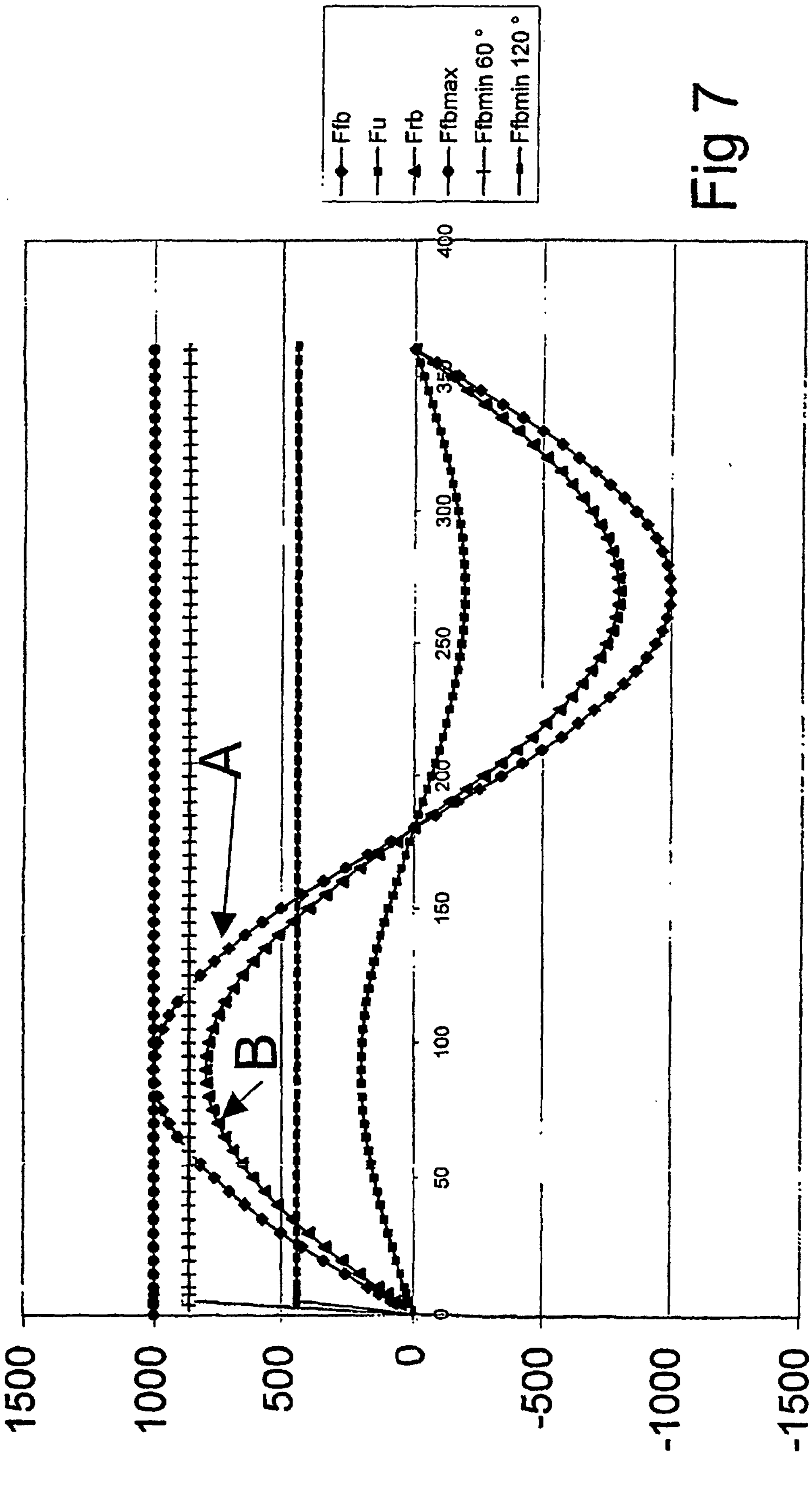

Ffb
Fu
Frb
Ffbmax
Ffbmin 60 °
Ffbmin 120 °
A
B
1500
1000
500
0
-500
-1000
-1500
0
50
100
150
200
250
300
350
400

Fig 7

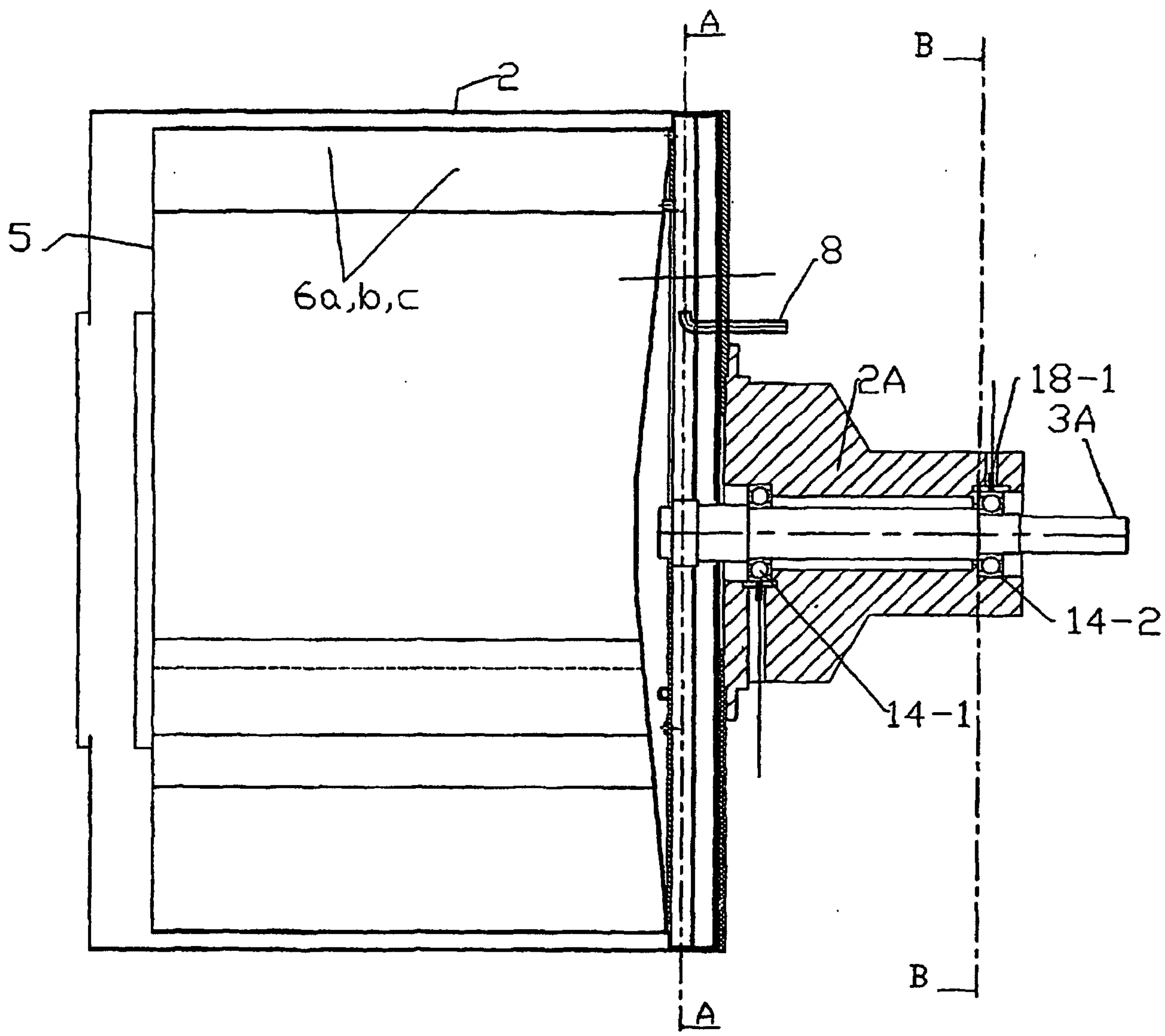


Fig 8.