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(11) **EP 1 094 143 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.04.2001 Bulletin 2001/17

(51) Int. Cl.⁷: **D06F 37/22**

(21) Application number: **00104591.3**

(22) Date of filing: **15.03.2000**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **21.10.1999 GB 9924832**

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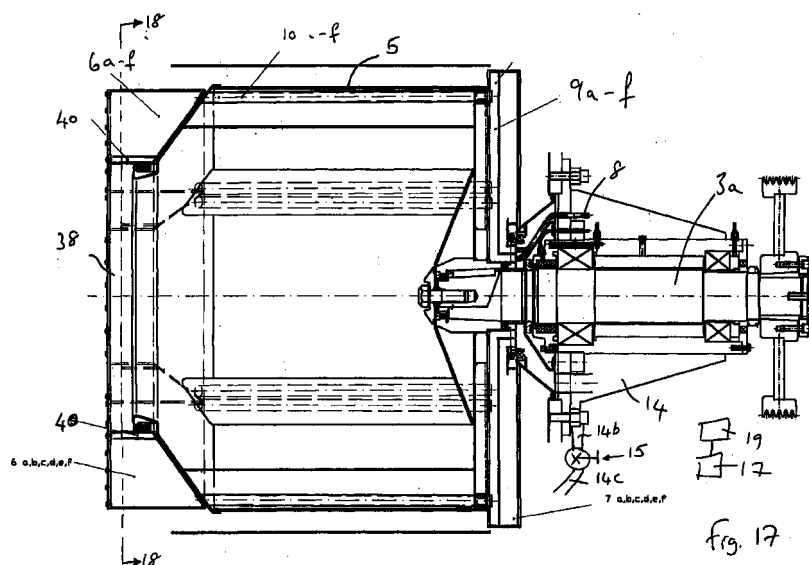
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(54) **System for balancing objects which rotate about an axis**

(57) A machine is described which includes a rotating container (5), e.g. a washing machine. To balance the rotating container one or more chambers (6a to f) may be located on the outer rim of the container. These chambers may be filled with water to provide compensation for any out-of-balance forces. At least a portion of the water which is used for balancing is removed from the balancing chambers when the container no longer rotates and is stored (14) ready for use in the next operation cycle of the machine.

Balancing chambers may be placed in two separate planes or in a single plane. To achieve this, each plane of balancing chambers has a separate water feed (8). The two planes of chambers may also have separate water extraction systems (9a to f). Injection of water can be triggered by the out-of-balance movement or out-of-balance forces exerted by the rotating container.



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Description

TECHNICAL FIELD OF THE INVENTION.

[0001] 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 particular the present invention may relate 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 dividing of the absorbent goods about the inner periphery of the drum during the 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 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 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 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 pre-determined 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] In known methods the balancing chambers or cavities come into contact with soapy water from the drum which can reach a temperature of 90° C. This can cause the openings of the balancing chambers or the injectors of the injection system to be blocked by chalk residue or other contamination. Regularly cleaning of those elements is required which leads to high maintenance costs and can also lead to higher water consumption because of residue liquids in the balancing chambers caused by above mentioned items.

[0006] Another problem exists if Approval Bodies in some countries forbid that a water supply is in direct connection with a space that can be contaminated and can be placed under pressure so that contaminated water is pushed back in the public water system. Thus

open systems may require water supply by means of water pumped out of a separate container. Because of the direct connection between housing and the balancing chambers, the water used to perform the balancing operation is lost after balancing which leads to about 5 to 10 % higher water consumption. Additionally, the balancing chambers may be filled with water during the pre-wash, main-wash and rinse operation which leads to a higher water consumption of between 20 and 30 %. Not only is there a higher water consumption but also the amount of energy needed to heat the water during a pre-wash or wash cycle increases by the same amount. One way of reducing loss of balancing water is to use a sealed liquid balancing system. This may include a simple sealed balancing ring which contains liquid. Due to out-of-balance motion of an unbalanced drum, the free liquid is thrown in a direction which compensates for the movement. Such a simple system can still have serious out-of-balance vibration. More sophisticated designs as disclosed in US 5,913,951 include a motor and pump mounted on the rotating drum to pump liquid between balancing cavities arranged around the periphery of the drum. This increases the complexity and cost of the design and places larger loads on the drive shaft.

[0007] 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.

[0008] With the known methods it is difficult to empty the balancing containers completely because the opening to let the balancing liquid out of the balancing cavities is at a radius smaller than the maximum radius of the balancing chamber. This means that water can be passed from an instantaneously higher chamber to a lower chamber or that liquid in the base of the machine may flow into the lower chambers. To obtain perfect evacuation of the water from the balancing chambers a dehydration cycle is required which is, however, usually not 100% effective.

[0009] 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.

[0010] 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 has a lower liquid consumption than conventional apparatus and methods of this kind.

[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, with which the cavities may be more effectively drained after a high-speed rotation cycle.

[0012] 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, with which contamination of the cavities may be prevented.

DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

[0013] The present inventions are defined in the claims. 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.

[0014] Preferably, the apparatus in accordance with the present invention may be constructed in such a way that the balancing liquid can be re-used. For example, the drum is provided with a draining chamber whose outer radius is larger than the outer radius of the balancing cavities which makes system with non-return valves redundant. The dehydration chamber may be located next to the balancing chambers at the rear of the apparatus. While the liquid is kept within this draining chamber a completely closed system is provided in an easy way which requires no extensive maintenance. From the draining chamber the spent balancing water may be channelled back for use in the next washing cycle. This reduces the water consumption and accordingly the extra heating energy to almost zero thus providing significant environmental savings. During the acceleration phase, the angular velocity of the container can be increased in pre-defined velocity steps until the desired maximum rotational speed is achieved. On each intermediate step there may be performed a balancing oper-

ation if the degree of out-of-balance motion justifies this.

[0015] This partially closed system meets the demand of water supply approvals organisations without needing to inject water from a separate tank because the injection system is separated from the waste water.

[0016] According to the present invention the means for detecting the imbalance can be a simple microswitch and there is no requirement for extra synchronisation of the imbalance signal with the rotational speed of the drum. As a consequence this system is cheaper to manufacture than known systems even on small capacity washing machines.

DESCRIPTION OF THE DRAWINGS

[0017]

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

Fig. 2 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 in the front, six balancing chambers in the rear side each over an angle of 60°.

Fig 3 is a view D-D of Fig. 2 showing the front chambers and the housing mounted on spring or rubber block and the placement of a microswitch.

Fig. 4 is a view C-C of Fig. 2 showing the water injection system.

Fig. 5 is a view B-B of Fig. 2 showing a section view of the rear balancing chambers

Fig. 6 is a view A-A of Fig. 2 showing a section view of the dehydration unit.

Fig. 7 is a graph showing the imbalance signal the signal from the out-of-balance sensor and operating times for the water injection.

Fig. 8 is a schematic representation of a washing machine in accordance with another embodiment of the present invention having one plane balancing and three chambers in the inner periphery of the drum.

Fig. 9 is a view C-C of Fig. 8 showing the water injection system.

Fig. 10 is a view B-B of Fig. 8 showing the water supply to the balancing chambers

Fig. 11 is a view A-A of Fig. 8 showing a section view of the dehydration unit.

Fig 12. is a schematic representation of a washing machine in accordance with an embodiment of the present invention having two plane balancing and six chambers in the inner periphery of the drum in line.

Fig 13 is a view A-A of Fig. 12 showing a section view of the draining chambers of a first dehydration unit.

Fig. 14 is a view B-B of Fig. 12 showing a section

view showing the water supply to the chambers

Fig. 15 is a view C-C of Fig. 12 showing the water injection system.

Fig. 16 is a view D-D of Fig. 12 showing the draining chambers of a second dehydration unit.

Fig. 17 is a schematic cross-sectional representation of a washing machine in accordance with another embodiment of the present invention having one- or two plane balancing.

Fig. 18 shows a cross-section along the line 18-18 of the washing machine of Fig. 17.

DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

[0018] 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. 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.

[0019] 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.

[0020] The present invention may be applied to a washing machine 1 as shown schematically in Fig. 1. Machine 1 includes a housing 2 on suspension units, e.g. rubber blocks 3, and mounted in a frame 4 and a rotatable drum 5 within the housing which is cantilevered from a bearing 32. The housing has a front door 38 for loading washing into the drum 5. A motor 17 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 drying cycles. The present invention starts from the use of a simple suspension such as provided by rubber blocks, while actively reducing the out-of-balance forces and movements to a minimum or even to a negligible amount. In such a case the rubber blocks do not absorb significant motions or energies but rather are only 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 is segregated from the drum by means of a seal. A seal also prevents dirty water from the drum entering the balancing chamber. The out-of-balance operation of the drum is preferably corrected by two-plane compensation using at least two balancing chambers one of which is placed closer to the front of the machine 1 than the other.

[0021] A first embodiment will be described with reference to Figs. 2 to 7. A washing machine 1 to be balanced comprises a housing 2 fixed on suspension units such as rubber blocks 3 or springs which themselves are connected to a frame 4 (frame 4 is not shown in Fig. 2 for clarity purposes). A drum 5 for holding the washing rotates about a horizontal shaft 3a. The drum 5 has a plurality of circumferentially and preferably contiguously distributed and preferably equally spaced balancing chambers 6a, 6b, 6c, 6d, 6e, 6f on the front vertical surface of drum 5 and a plurality of circumferentially and preferably contiguously distributed and preferably equally spaced chambers 7a, 7b, 7c, 7d, 7e, 7f on the rear vertical surface of the drum 5. For example, 6 balancing chambers 6, 7 are particularly preferred. A casing 2a holding bearings for the shaft 3a is fixed to the rear of the housing 2. Injection pipes 8a, 8b supply water from a water source, e.g. a water main, to the front balancing chambers 6a, 6b, 6c, 6d, 6e, 6f via cylindrical space 35 and through connection pipes 5a, 5b, 5c, 5d, 5e, 5f respectively and to rear balancing chambers 7a, 7b, 7c, 7d, 7e, 7f via cylindrical space 37. 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. The out-of-balance sensor 18 may be a microswitch, a strain gauge an accelerometer or similar. Preferably, there are two out-of-balance sensors 18, a first sensor 18-1 which senses the out-of-balance operation of the front of the drum 5 and a second out-of-balance sensor 18-2 which senses the out-of-balance operation of the rear of the drum 5. Where microswitches are used, these may be activated by the movements of an upper frame 21 which is part of or attached to the housing 2 (see Fig. 3). Alternatively, the outer surface of drum 5 may be used to activate the microswitches 18 but this is less preferred as the movement of drum 5 will cause wear of the microswitch con-

tact surfaces.

[0022] In addition, preferably, a dehydration unit 9 is provided which may comprise a plurality of circumferentially and contiguously arranged draining chambers. The dehydration unit 9 is preferably divided into the same number of chambers as the number of balancing chambers, e.g. six chambers 9a, 9b, 9c, 9d, 9e, 9f connected with to the front chambers 6a, 6b, 6c, 6d, 6e, 6f respectively through dehydration tubes 10a, 10b, 10c, 10d, 10e, 10f; 10g, 10h; 10i, 10j; 10k, 10l. Preferably, each front chamber 9 is connected to a pair of dehydration tubes 10. One of the pair can drain water while the other allows entry of air. Otherwise the front chambers 6 are closed so that water ingress and extraction is only by the connections described above.

[0023] A mechanical seal 12 is preferably provided at the centre of the dehydration unit 9 to prevent soapy water from the drum 5 entering into any of the balancing chambers 7. The balancing chambers 6, 7 are connected with the housing 2 through cylindrical spaces 35, 37 and pipes 14b, 14c which can be isolated from each other by means of a valve 15. A water container 14 may be provided to catch surplus balancing water which is recovered from the draining chamber 9 and/or the rear chambers 7. 14a represents a connection to the open air which is an overflow when container 14 is full. Item 16 is a seal which prevents water entering into the bearings.

[0024] 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. For spin drying the speed may be gradually increased according to any one of the following non-limiting speed series:

	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.

[0025] At each pre-determined speed step a drum balancing operation may be performed by injecting balancing liquid independently into any one or both sets of balancing chambers 6 and/or 7 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. A microswitch 18 is activated when the movement of the flexible frame 21 which is mounted on the housing 2 exceeds a certain limit caused by the out-of-balance operation of the drum 5. The skilled person will appreciate that out-of-balance movements of forces on the housing 2 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, physical movement of housing 2 or frame 21 is not necessary for balancing in accordance with the present invention. For rigidly journaled drums 5 there may be little movement but significant forces which may be detected by strain gauges placed in appropriate positions, e.g. on the bearings within casing 2A.

[0026] In a first balancing step a checking cycle or parameter cycle is performed in which a time T1 which elapses between when a signal of the microswitch 18 becomes high and low is measured as well as a time T2 between when the signal of a microswitch 18 becomes low and then high again. T1 + T2 is a measure of the period time or cycle time T of one rotation of the drum 5. In the next step balancing cycles are performed, which are based on the moment at which a microswitch 18 switches from on position to off position. Ideally, water is injected into the balancing chambers 6, 7 either side of the middle point of time period T1 into those chambers 6, 7 which lie opposite the out-of-balance load in the drum 5. By doing this it can be guaranteed that the balancing chambers 6, 7 are filled which are opposite the out-of-balance load in drum 5. It is preferred in accordance with the present invention if water is injected into a sufficient number of contiguous balancing chambers 6, 7 which together make up a certain angle α of the circumference of drum 5. Preferably, this angle is about 120° , e.g. $120^\circ \pm 30^\circ$, or more preferably $120^\circ \pm 15^\circ$. This may be achieved by 6 equally spaced balancing chambers 6, 7 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, 7 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 $\pm 90^\circ$ 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. To ensure that only 120° of chambers are filled with water during balancing, the water injection must only be continued for a time equal to or less than T/3. Therefore, the water injection time T/3 must be located within the time T1 if this time T1 is

greater than T/3 - see Fig. 7. In this case the water injection is started at a time T6 after the microswitch 18 activates. However, if time T1 is less than T/3 then water may be injected for the time T1 or the time T/3 whichever is preferred. As a small time T1 indicates a position close to balance it is preferred if the water injection is only over time T1 if T1 is less than T/3 as usually in this condition less water is necessary to achieve balancing.

[0027] In addition a further phase correction is preferably applied for determining when water should be introduced into the balancing chambers 6, 7. This correction coefficient is an experimentally determined value which takes into account the phase angle deviation between the movement of the drum 5 and the out-of-balance load in the drum 5. As is well known, there is a phase difference between the force and the movement in a forced viscously damped vibration. Theoretically, the phase correction changes as the operation becomes closer to or further away from the natural resonant frequency of the rotating system and it is within the scope of the present invention that the water injection control includes corrections which take into account the frequency of rotation of drum 5. However, it has been found for practical washing machines that this phase correction is often roughly constant over the frequency range 100 to 1000 rpm so that a fixed correction may be applied to obtain sufficient accuracy.

[0028] The output of microswitch 18-1 at the front of the washing machine 1 is used to control the injection of balancing liquid into the balancing chambers 6 at the front of the machine 1 and the output of the other microswitch 18-2 is used to control the water injected into the rear balancing chambers 7. Both these control procedure are carried out independently of each other so that complex gyratory motions of the drum 5 may be balanced automatically. The advantage of balancing in two planes is that the centre of gravity point of the respective balancing liquid in the front or rear chambers 6, 7 can be exactly in line with the one of the imbalance forces generated by unequal loads of washing in drum 5. This leads to reduced shear forces on the main shaft carrying drum 5.

[0029] The effect of the balancing step will be to reduce movement of drum 5 and at some time both microswitches 18 are no longer activated in any rotation cycle, or, alternatively T1 becomes less than a certain value in relation to the speed of the drum 5. At this point of time the current balancing step is completed and the drum 5 is accelerated until the next pre-determined speed is reached at which there is performed a further balancing operation. If T1 already exceeds a certain maximum value during the acceleration phase then the acceleration can be stopped early and a balancing operation can be performed at a speed between two pre-determined values.

[0030] The balancing operations are repeated until the final spinning speed is reached. The washing machine 1 is held at maximum speed until enough

water has been extracted from the washing load in accordance with the machine design specification. Before deceleration of the drum 5, the drain valve 34 of the washing machine 1 is closed and the water valve 15 opened. All water that is in the balancing chambers 6, 7 and is submitted to a centrifugal force of less than 1 G will be drained into the bottom of housing 2. This draining occurs as the drum 5 turns slowly and is without pumping, i.e. the drainage is gravimetric. This clean water is used in the next cycle for washing purposes. Thus, no clean water is lost in accordance with the present invention. The balancing liquid in the front balancing chambers 6 is drained in the following way. In the upper position of a front balancing chamber 6 the water is drained through the pipes 5 and 14 to the housing 2. In this case the tubes 10 act as an air inlet. When the balancing chamber 6 is in the lower position the water is drained from the front balancing chambers 6 into the specially constructed drain chamber 15 through pipes 10. In this case the pipes 5 act as an air inlet. The water is taken up to higher position through the shutters 33 in the draining chamber (see Fig. 6) so that the balancing liquid is drained to the central cylindrical space 39 and from there into the housing 2 through the pipe 14. A water level sensor 31 is provided to detect when a certain pre-determined level of water is in the housing 2 and when this level is reached, the water valve 15 is closed and the rest of the balancing liquid is caught in the container 14. Balancing water from the rear chamber 7 drains down through pipe 14b into housing 2. Any excess water drained after the water level indicator has been activated is drained into container 14. Water in container 14 is released later into the housing 2 at the moment when the washing machine 1 requires water for pre-, main-wash or rinsing operations by opening valve 15. Not only fresh water is saved but also energy is conserved. When the balancing water is in the balancing chambers 6, 7 it absorbs heat from the drum 5 remaining after the washing cycle. Thus, when this water is re-used in the next cycle less heat energy is required to heat up the water.

[0031] 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 and spirit of this invention. For example in the above embodiment of the present invention only the rear chambers 7 or the front chambers 6 may be provided. All other aspects of conservation of water are maintained.

[0032] Another embodiment of the present invention is shown in Figs. 8 to 12 in which three longitudinal discrete balancing chambers 7a, 7b, 7c are provided which are drained by dehydration unit 9. Reference numbers in the drawings which are the same as the numbers in Figs. 1 to 6 refer to the same items. The chambers are located in a longitudinal direction on the outer rim of drum 5. All other aspects of collecting and

re-using water are as described above. As only one set of chambers 7 is provided, only one out-of-balance sensor 18 is required. Dehydration unit 9 may be provided by narrow channels 9a, 9b, 9c as shown in Fig. 11. The number of discrete chambers 7 may be increased to 6 or 12 for instance.

[0033] Yet another embodiment will be described with reference to Figs. 13 to 16. Reference numbers in the drawings which are the same as the numbers in Figs. 1 to 6 refer to the same items. In this embodiment two sets of discrete balancing chambers 6, 7, one at the front (6) and one at the back (7), are provided on the rim of drum 5. Each set of chambers 6, 7 has its own draining chamber 9, 11 respectively for draining balancing water from the front chambers 6 and rear chambers 7 respectively. Each dehydration unit is similar to the dehydration unit of the first embodiment. All other aspects of water and energy conservation are maintained.

[0034] Yet another embodiment will be described with reference to Figs. 17 and 18. Reference numbers in the drawings which are the same as the numbers in Figs. 1 to 6 refer to the same items. In this embodiment one set of discrete balancing chambers 6a to f at the front are provided on the rim of drum 5. Optionally, a further set of balancing chambers 7a to f may be provided at the back but these will not be described. Each balancing chamber 6a to f has its own draining chamber 9a to f, respectively, of a dehydration unit for draining balancing water from the front chambers 6. Each dehydration unit is similar to the dehydration unit of the first embodiment. All other aspects of water and energy conservation are maintained. This embodiment makes use of combining parts of the filling and draining or dehydration mechanisms of the previous embodiments. The connection pipes 5a to f for supplying balancing liquid to the front chambers 6a to f are combined with the return pipes 10a to f so that supply of liquid to front chambers 6 as well as draining of liquid to the dehydration unit 9 is done through pipes 10a to f. Liquid is supplied to these tubes 10 from liquid supply tube 8 via the draining chambers 9a to f. Rear balancing chambers 7a to f, if present, are filled directly from tube 8. In addition, all the front chambers 6a to f are linked by a tube system, e.g. by a connecting pipe 40, which is located at an inner radial position with respect to the chambers 6a to f.

[0035] In operation, the liquid level in the chambers 6a to f and 9a to f will be the same as these chambers are linked by the pipes 10a to f. During draining the drum rotation reduces until the force on the liquid in the chambers 9 which are at the top flows down towards the central axis of drum 5 and exits through chamber 14 which is shown here as surrounding horizontal shaft 3a. Chamber 14 holds sufficient balancing liquid for this quantity to be a useful addition to the washing water in the next cycle. When chambers 6 are at the top the liquid flows down through pipe 40 to the lower ones of

chambers 6 at that moment. From here the liquid returns along pipes 10 to the draining chambers 9. When these chambers 9 reach the top again, this liquid drains to the centre and from there to chamber 14. The liquid may be released from chamber 14 by valve 15.

[0036] Certain aspects of the present invention will be understood from the above description. A balancing method of an object such as a container or hollow drum is described which turns around a horizontal or vertical axis and which is provided with balancing chambers. These chambers may be combined in various ways, e.g. at least three chambers evenly distributed in the inner or outer periphery of the drum or with at least 6 chambers (preferably, is 12 chambers) in the front and/or rear side of the drum. The chambers on the outer or inner periphery of the drum may be further divided into two a front and rear set. Each of the distributed chambers is connected with a cylindrical shaped volume 35, 37 so that balancing liquid can be supplied continuously. Alternatively, the water may be supplied from one cylindrical shaped volume having tubes like spokes of a wheel leading to the chambers. In this case it is sufficient to have only one water valve for each balancing plane.

[0037] Filling of the axial chambers is done continuously by means of connecting each separate chamber to a respective cylindrical shaped volume 35., 37 or discontinuously by means of connecting each chamber in a direct or indirect way to the respective part of a cylindrical shaped volume 35, 37 divided in an equal number of chambers like the number of balancing chambers in the front respective the rear side of the drum.

[0038] Further, a flexibly mounted rotating machine has been described whose out-of-balance movement is detected by means of a suitable sensor, such as a microswitch, a strain gauge, the plunger of the water valve, inductive-, optical sensor or any other means that can directly or indirectly can detect a movement. This can be done in a simple way by a simple device such as a microswitch so that this invention makes it possible to implement the system on a small washing machine. The microswitch is mounted so that the direction of its movement is perpendicular to the movement that is caused by the imbalance. To enable this the machine may also be mounted on rubber blocks or springs with a high k factor so that there is no or negligible movement in vertical direction to be expected. Having it mounted on rubber blocks has the consequence that the spring constant k is high resulting in a resonant frequency of the system which is also high. Thus resonance at low frequencies can be avoided.

[0039] In the machine in accordance with the present invention the balancing chambers is sealed from the housing by means of a mechanical seal. An injection collector volume is provided with a small diameter which is connected through pipes with the balancing chambers. A means is provided for quick draining of the balancing chambers. Two or more tubes connect each front chamber for draining towards the back. One

tube is situated on the maximum radius of the chamber. The other tube is situated on the smallest radius of the chamber. Those tubes are situated in the spare space formed between the outer periphery of the drum and the rib of the washing drum. The tubes on the outer periphery are all connected with a cylindrical chamber at the rear side of the drum also divided in an equal number of chambers as there are at the front side of the drum. The outer radius of this cylindrical chamber is bigger than the radius of the front balancing chambers and the width of it as small as possible. In this way a quick draining of the front chambers is achieved.

[0040] Acceleration may be provided by predetermined steps of increasing speed. Each increment of speed is followed by a balancing operation until the measured time of microswitch operation, T_1 , falls under a certain limit according the speed of the drum.

[0041] Further, a balancing cycle may consist out of determining the respective microswitch operating times $T_{1\text{Front}}$ and $T_{1\text{Rear}}$ during which the microswitch in the front respectively in the rear, is activated and time $T_{2\text{Front}}$ and $T_{2\text{Rear}}$ during which the microswitches, in the front, respectively in the rear, are not activated.

[0042] Depending on the position of the out-of-balance sensors 18 with respect to the water injection points, different delays may be required between the operation of a sensor 18 and the water injection time. For example, if the sensor 18 is at the bottom of the housing 2 and the water injection is into chambers 6, 7 at the top of the machine 1, then a delay of $T/6$ may be appropriate (see Fig. 7). On the other hand if the injection point and the sensors 18 are located at about the same place then it necessary to wait until the next half cycle, that is a time $T/4$ (Fig. 7). $T_{4\text{Rear}}$ or $T_{4\text{Front}}$ may be determined independently which is the delay time before activating the injection water valve after detecting the rising edge of the microswitch. The water valve is generally activated for a period $T/3$.

[0043] A balancing system is provided for a washing machine which is sealed from the housing of the washing machine so that there are no problems to comply with water approval authority regulations and with which no problems are to be expected due to contamination in the balancing chambers.

[0044] Recycling the balancing liquid is provided without any need of extra pumps so that there is no additional water consumption compared to a conventional washing machine. To achieve this, the housing drain valve is closed before decelerating the drum. The water valve 15 is opened during deceleration so that the balancing water drains to the housing. Water valve 15 is closed if a water level sensor senses that the water has reached almost the outer diameter of the drum so that the rest of the balancing water is collected in a container 14. The moment that there is a request for water for washing or rinsing the valve 15 is opened until water is drained out of the container 14 towards the drum 5 and then closed again. For this the bottom of the container

15 is higher than the highest water level to be expected in the housing 2 when receiving the maximum to be expected balancing liquid. The volume of the container 14 is preferably equal to the maximum to be expected imbalance liquid minus the volume of water that can be contained in the housing before the water touches the drum.

[0045] The dehydration unit may be divided into an equal number of chambers as there are balancing chambers in the respective balancing plane. These draining chambers have a radius bigger than the one of the balancing chamber and are connected to each other with at least one pipe at the maximum radius of the balancing chamber. This assures a complete dehydration of the balancing chambers and makes it also possible by this to make a closed system without any mechanical or electrical dehydration valves.

[0046] DC operated water valves may be used which are opened with a positive voltage impulse to achieve short opening times and are closed by a normal negative voltage to have a small closing time. The controller 17 may be a microcontroller or a programmable microcontroller and may include some local intelligence, e.g. a microprocessor for controlling the operation of the water valves and/or the motor 19.

Claims

1. 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 and an operation cycle of the rotating container which uses the liquid and then discards the liquid; comprising the steps of:
 - balancing the rotating container by introducing the liquid into the at least one chamber during a first operation cycle;
 - using the liquid from the balancing chamber in a subsequent operation cycle; and
 - discarding the liquid at the end of the subsequent operation cycle.
2. The method according to claim 1, wherein the machine is a washing machine.
3. The method according to claim 1 or 2 wherein the liquid is water.
4. The method according to any previous claim, further comprising the step of:
 - sensing the out-of-balance rotational operation of the container; and
 - introducing the liquid into the at least one chamber in accordance with the sensed out-of-balance operation.
5. The method according to any previous claim, wherein the container is cylindrical and rotates about its cylindrical axis and at least two balancing chambers are provided, a first balancing chamber lying substantially in a first plane perpendicular to the cylindrical axis and a second balancing chamber lying in a second plane perpendicular to the cylindrical axis, comprising the steps of:
 - sensing the out-of-balance rotational operation of the container in the two planes perpendicular to the cylindrical axis; and
 - controlling the introduction of liquid into the first balancing chamber based on the results of the sensing in the first plane and controlling the introduction of liquid into the second chamber based on the results of the sensing in the second plane.
6. The method according to claim 5, further comprising the step of draining the liquid from the first balancing chamber after the balancing step in a direction parallel to the cylindrical axis into a drainage channel common to both the first and second balancing chambers.
7. The method according to any previous claim, further comprising storing at least a portion of the liquid drained from the first and/or second balancing chambers after the balancing step.
8. 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 and an operation cycle of the rotating container which uses the liquid and then discards the liquid; wherein the machine is adapted to balance the rotating container by introduction of the liquid into the at least one chamber during a first operation cycle, using the liquid from the balancing chamber in a subsequent operation cycle and discarding the liquid at the end of the subsequent operation cycle.
9. The machine according to claim 8, wherein the machine is a washing machine.
10. The machine according to claim 8 or 9 wherein the liquid is water.
11. The machine according to any of the claims 8 to 10, further comprising:
 - a sensor for sensing the out-of-balance rotational operation of the container; and
 - a control unit for introducing the liquid into the at least one chamber in accordance with the output of the sensor.

12. The machine according to any of the claims 8 to 10, wherein the container is cylindrical and rotates about its cylindrical axis and has at least two balancing chambers, a first balancing chamber lying substantially in a first plane perpendicular to the cylindrical axis and a second balancing chamber lying in a second plane perpendicular to the cylindrical axis, further comprising:

a first sensor for sensing the out-of-balance rotational operation of the container in the first plane;

a second sensor for sensing the out-of-balance rotational operation of the container in the second plane; and

the control unit is adapted to control the introduction of liquid into the first balancing chamber based on the output of the first sensor and to control the introduction of liquid into the second chamber based on the output of the second sensor.

13. The machine according to any of the claims 6 to 12, wherein the container is cylindrical and rotates about its cylindrical axis and has at least two balancing chambers, a first balancing chamber lying substantially in a first plane perpendicular to the cylindrical axis and a second balancing chamber lying in a second plane perpendicular to the cylindrical axis; further comprising a first drainage channel running in a direction parallel to the cylindrical axis for draining the liquid from the first balancing chamber into a second drainage channel common to both the first and second balancing chambers.

14. The machine according to any of the claims 6 to 13, further comprising a vessel for storing at least a portion of the liquid drained from the first and/or second balancing chambers.

15. A method of balancing the rotation of an object, wherein the object is cylindrical and rotates about its cylindrical axis and at least two balancing chambers are provided fillable with a liquid for correcting out-of-balance rotational operation of the object, a first balancing chamber lying substantially in a first plane perpendicular to the cylindrical axis and a second balancing chamber lying in a second plane perpendicular to the cylindrical axis, comprising the steps of:

sensing the out-of-balance rotational operation of the object in the two planes perpendicular to the cylindrical axis; and

controlling the introduction of liquid into the first balancing chamber based on the results of the sensing in the first plane and controlling the introduction of liquid into the second chamber

based on the results of the sensing in the second plane.

16. The method according to claim 15, wherein the machine is a washing machine.

17. An apparatus for balancing the rotation of an object, wherein the object is cylindrical and rotates about its cylindrical axis and at least two balancing chambers are provided fillable with a liquid for correcting out-of-balance rotational operation of the object, a first balancing chamber lying substantially in a first plane perpendicular to the cylindrical axis and a second balancing chamber lying in a second plane perpendicular to the cylindrical axis, comprising:

a first sensor for sensing the out-of-balance rotational operation of the container in the first plane;

a second sensor for sensing the out-of-balance rotational operation of the container in the second plane; and

the control unit is adapted to control the introduction of liquid into the first balancing chamber based on the output of the first sensor and to control the introduction of liquid into the second chamber based on the output of the second sensor.

18. The apparatus according to claim 17, wherein the apparatus is a washing machine.

19. An apparatus for balancing the rotation of an object, wherein the object is cylindrical and rotates about its cylindrical axis and at least two balancing chambers are provided fillable with a liquid for correcting out-of-balance rotational operation of the object, a first balancing chamber lying substantially in a first plane perpendicular to the cylindrical axis and a second balancing chamber lying in a second plane perpendicular to the cylindrical axis, comprising: a first drainage channel running in a direction parallel to the cylindrical axis for draining the liquid from the first balancing chamber into a second drainage channel common to both the first and second balancing chambers.

20. An apparatus according to claim 19, further comprising: a first sensor for sensing the out-of-balance rotational operation of the object in the first plane; a second sensor for sensing the out-of-balance rotational operation of the object in the second plane; and

a control unit for controlling the introduction of liquid into the first balancing chamber based on the output of the first sensor and to control the introduction of liquid into the second chamber

based on the output of the second sensor.

- 21.** The apparatus according to claim 19 or 20, further comprising a vessel for storing at least a portion of the liquid drained from the first and/or second balancing chambers. 5
- 22.** A method of balancing the rotation of an object, wherein the object is cylindrical and rotates about its cylindrical axis and at least two balancing chambers are provided fillable with a liquid for correcting out-of-balance rotational operation of the object, a first balancing chamber lying substantially in a first plane perpendicular to the cylindrical axis and a second balancing chamber lying in a second plane perpendicular to the cylindrical axis, comprising the steps of: 10
- draining the liquid from the first balancing chamber after the object has been balanced in a direction parallel to the cylindrical axis into a drainage channel common to both the first and second balancing chambers. 15 20
- 23.** The method according to claim 22, further comprising storing at least a portion of the liquid drained from the first and/or second balancing chambers after the balancing step. 25
- 24.** The method according to claim 22 or 23, wherein the drainage is gravimetric. 30
- 25.** A treatment apparatus including a rotating drum for receiving water absorbing materials to be treated and at least one balancing chamber on the drum for receiving water and to correct out-of-balance operation of the drum, further comprising a seal to prevent water from the drum from entering the at least one balancing chamber. 35 40

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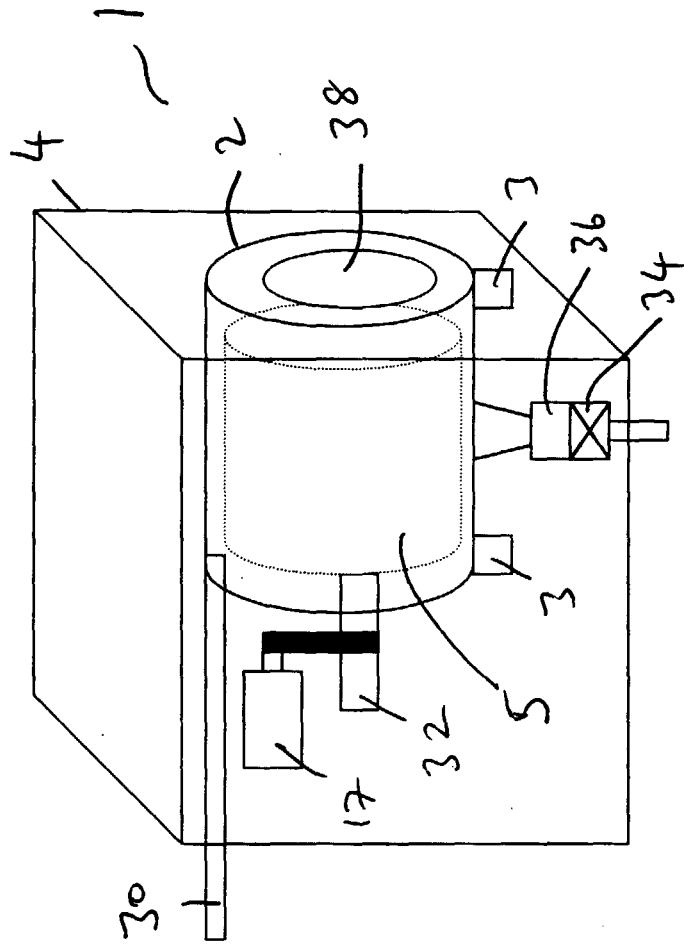


Fig. 1

Two plane balancing
6 chambers in the front
6 chambers in the rear

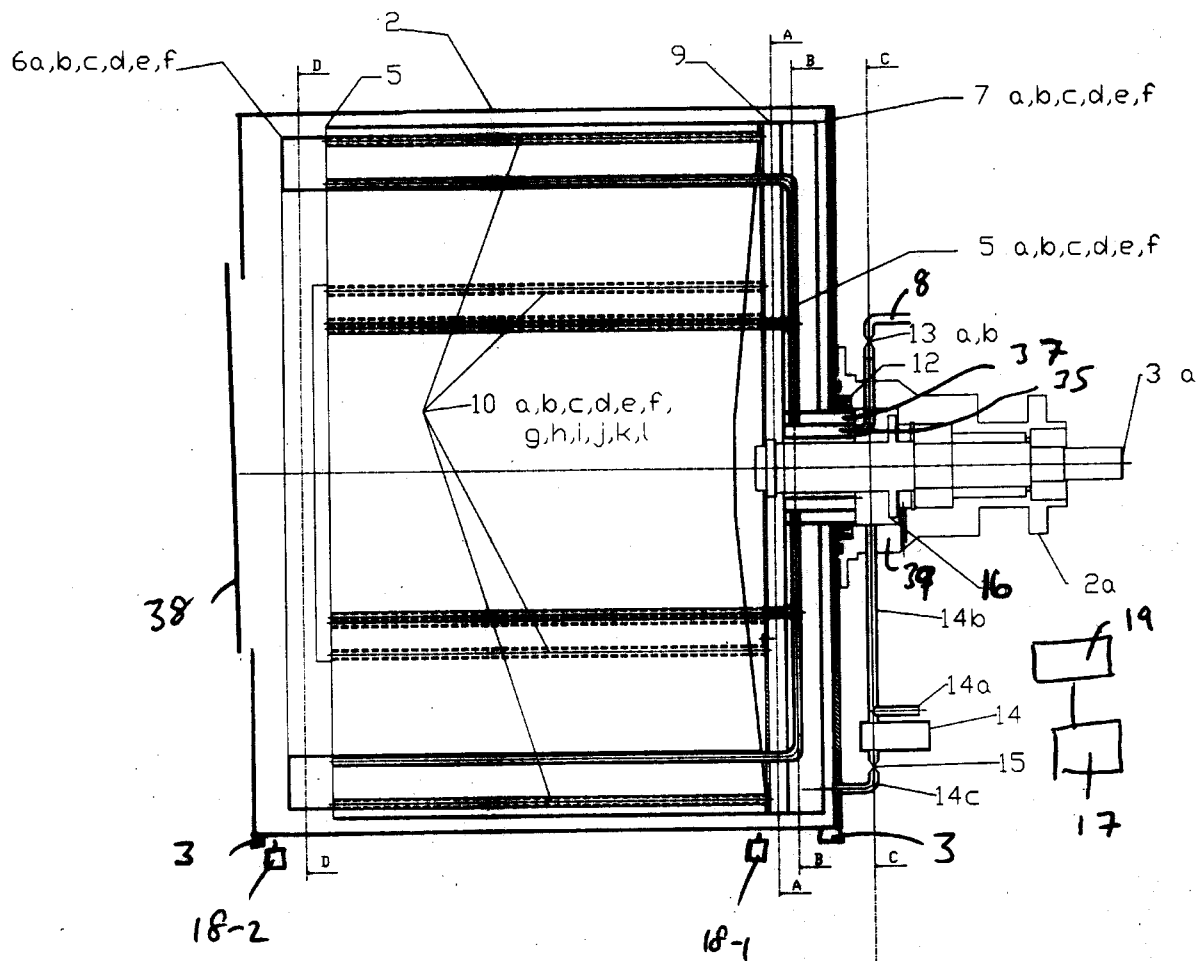


Fig. 2

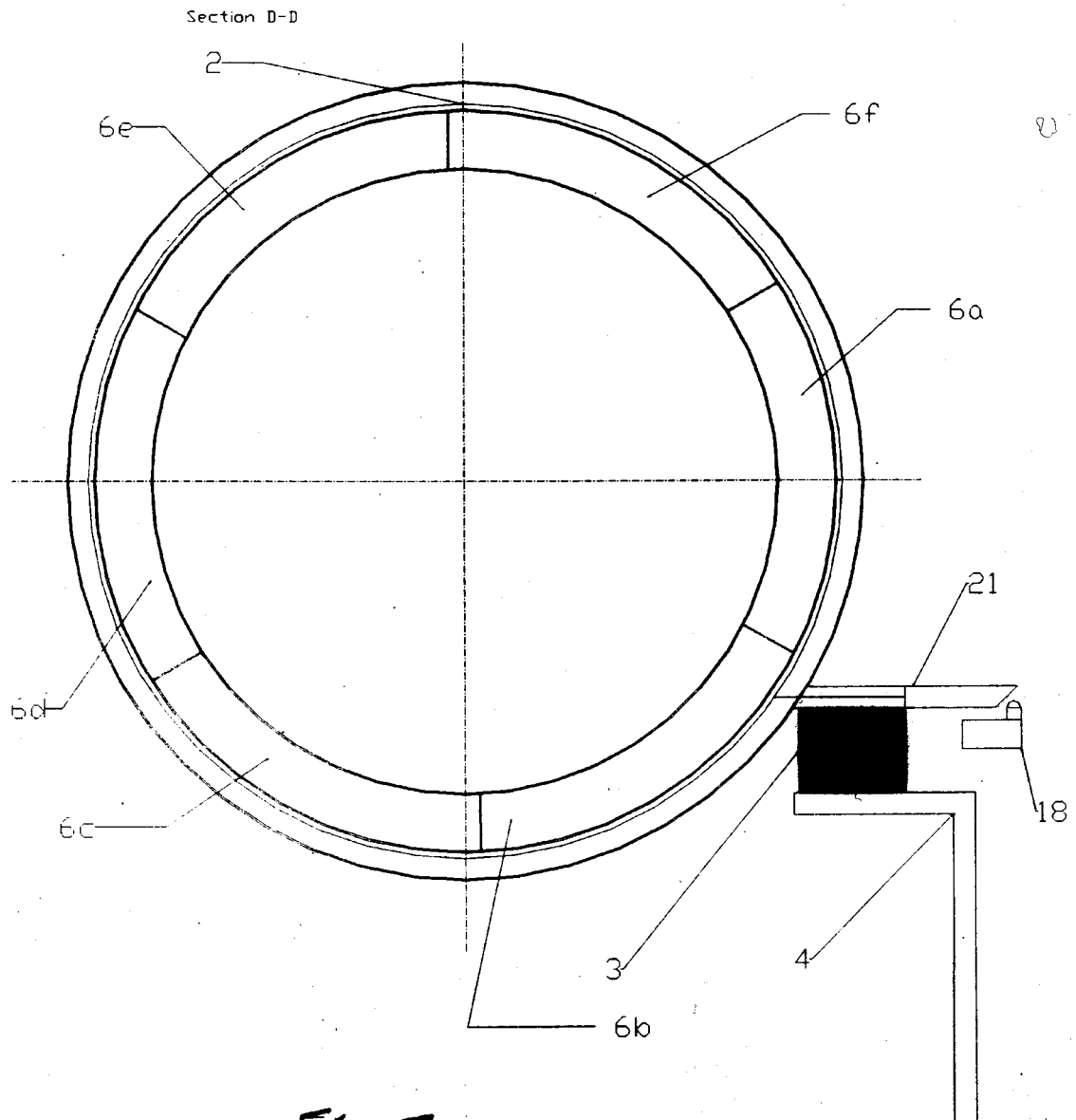


Fig 3

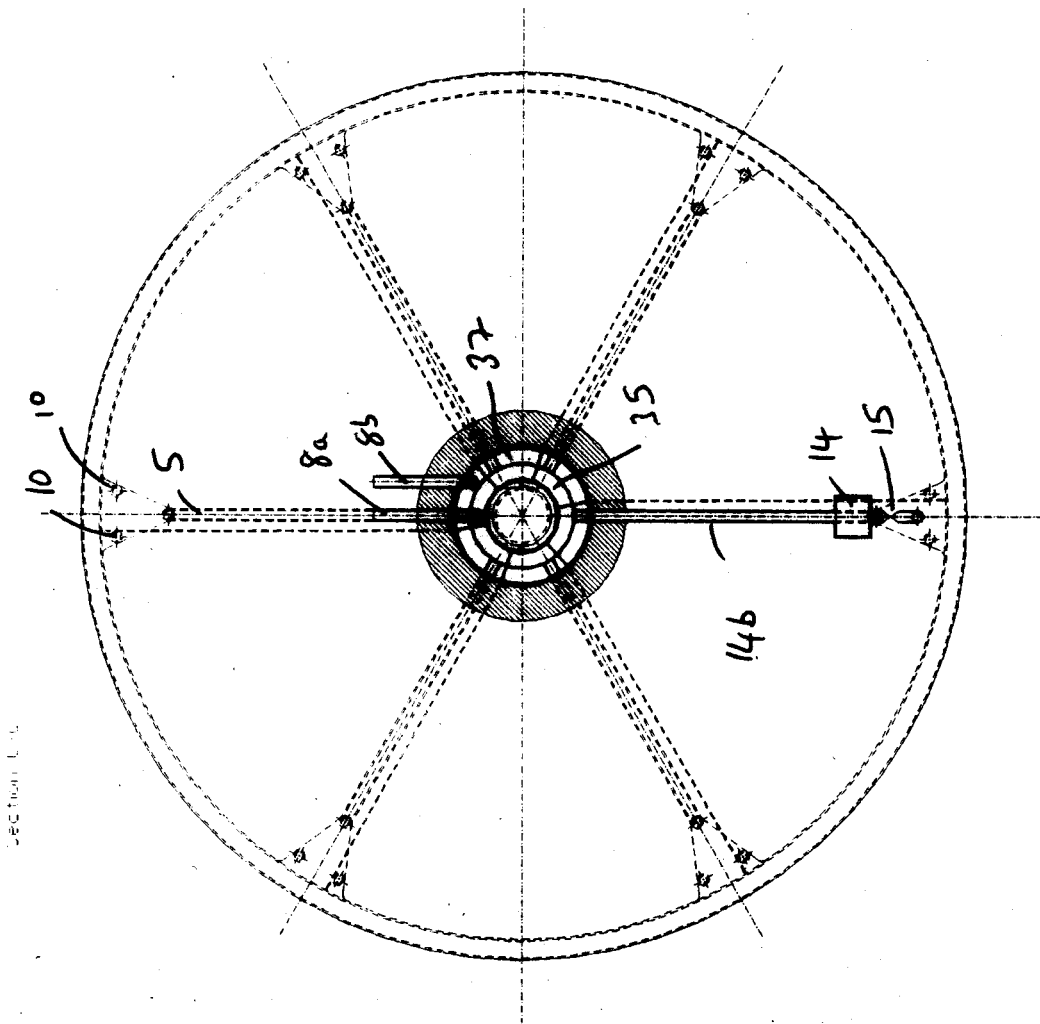
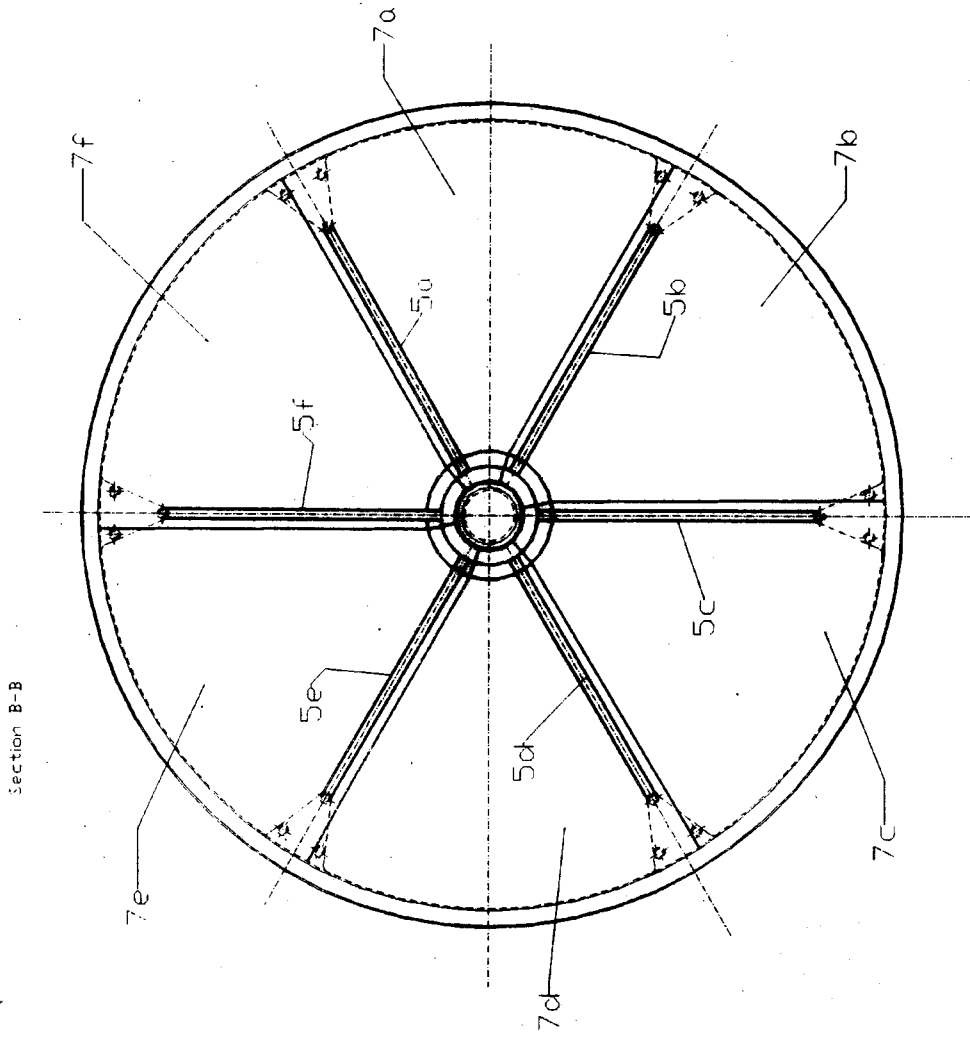


Fig. 4



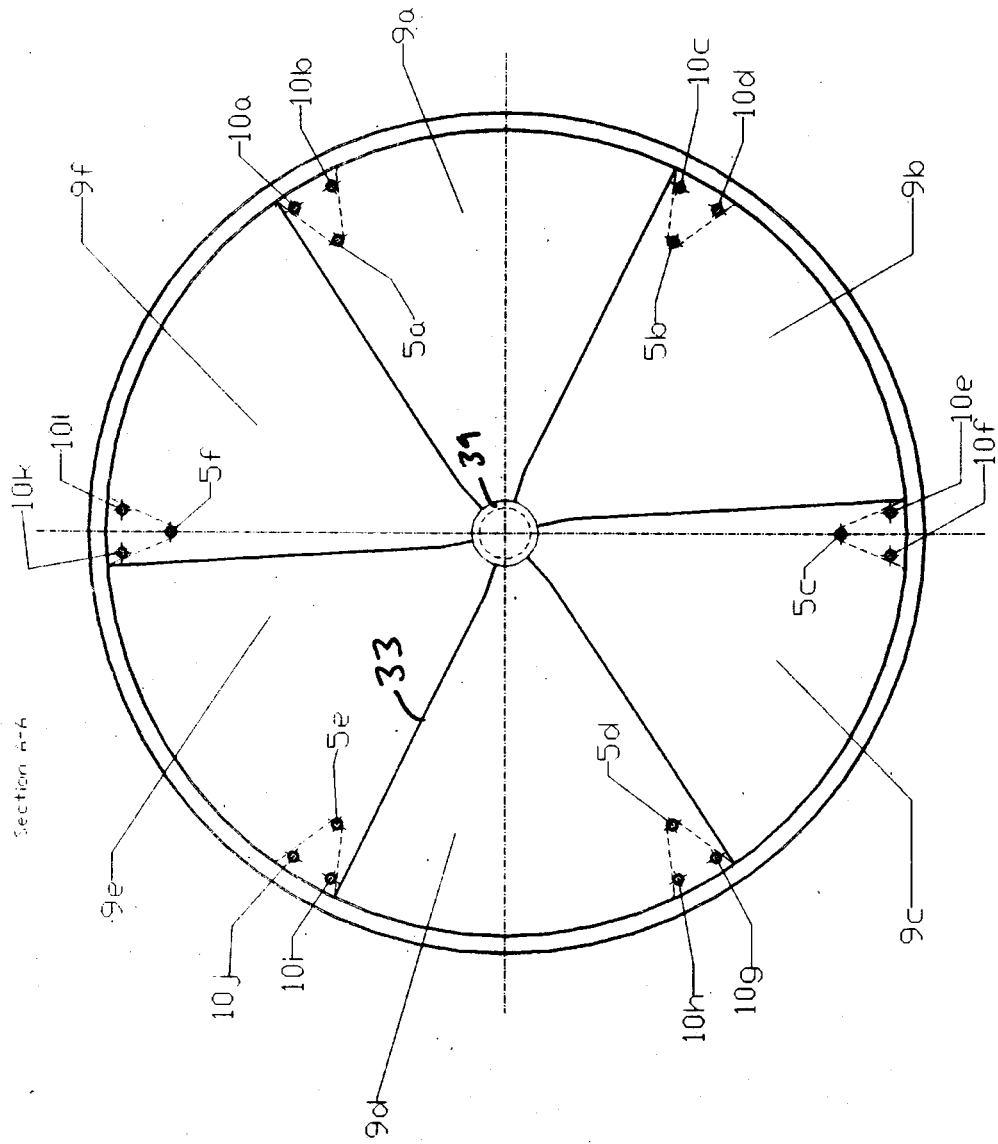


Fig. 6

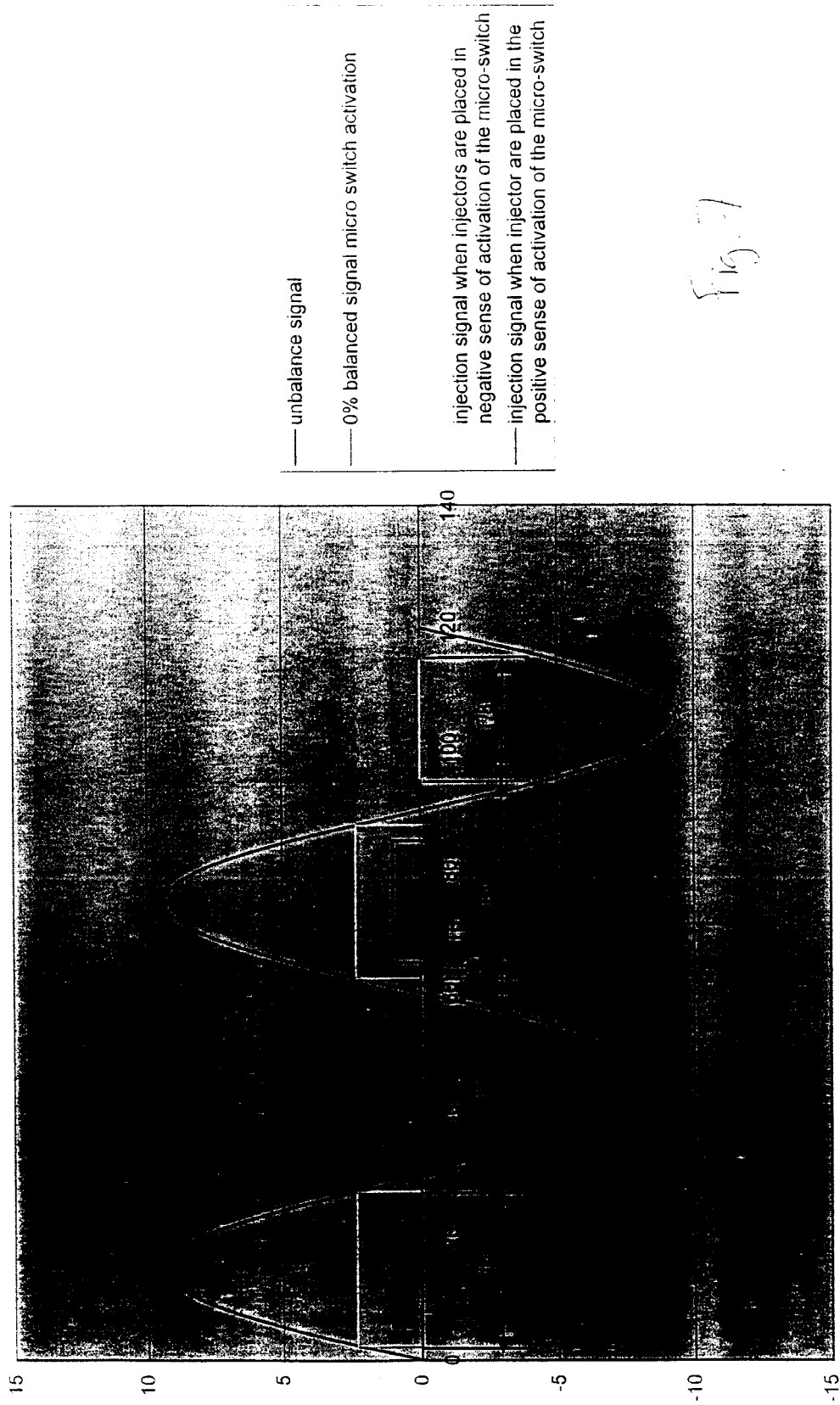


Fig. 7

1 pneumatic balancing
3 ribs 20°

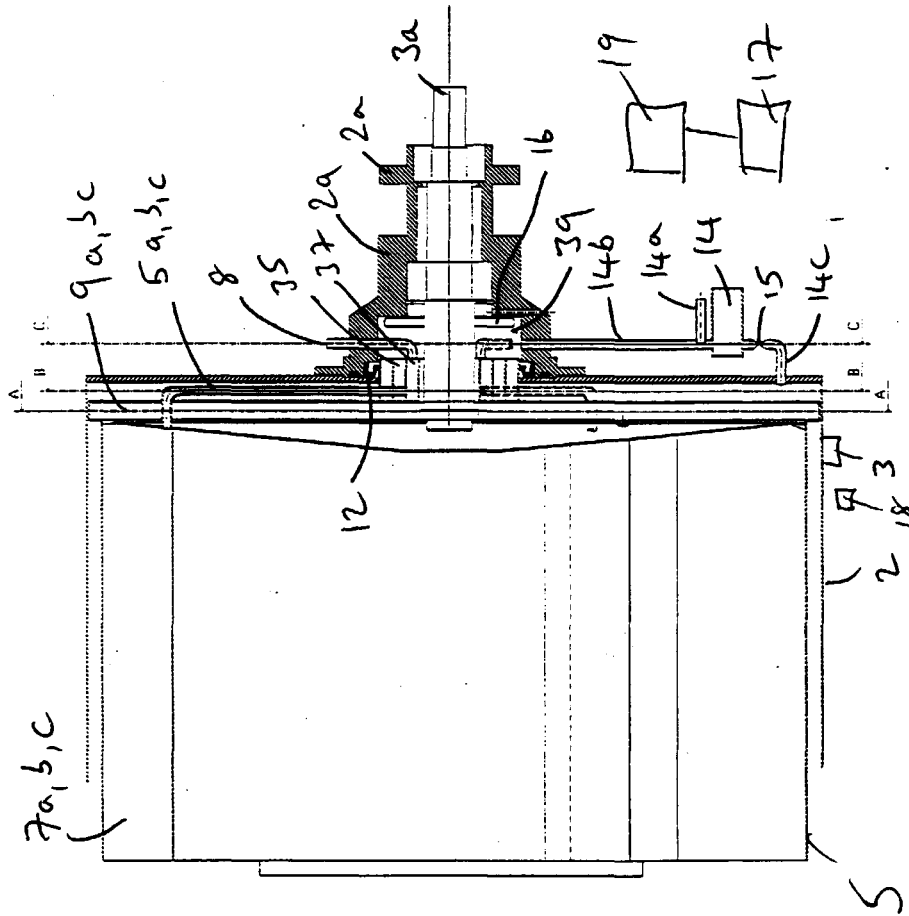
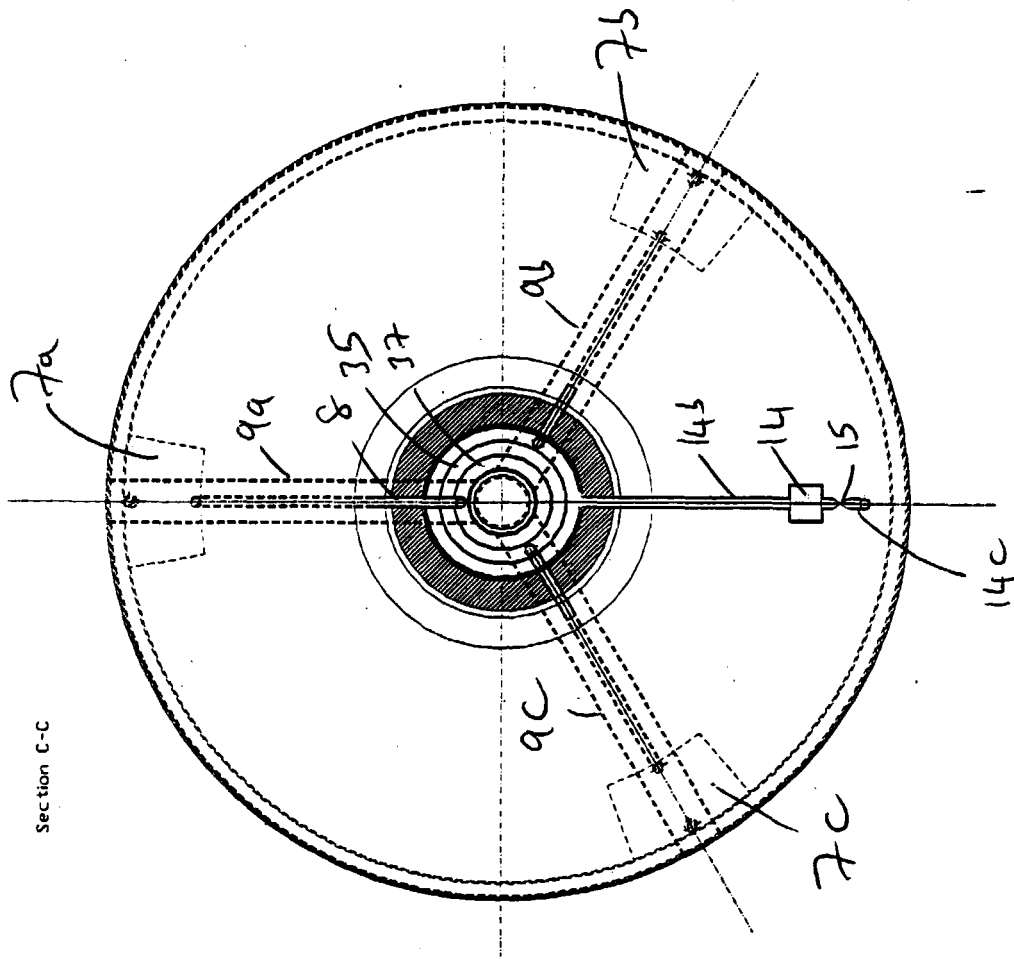


Fig. 8



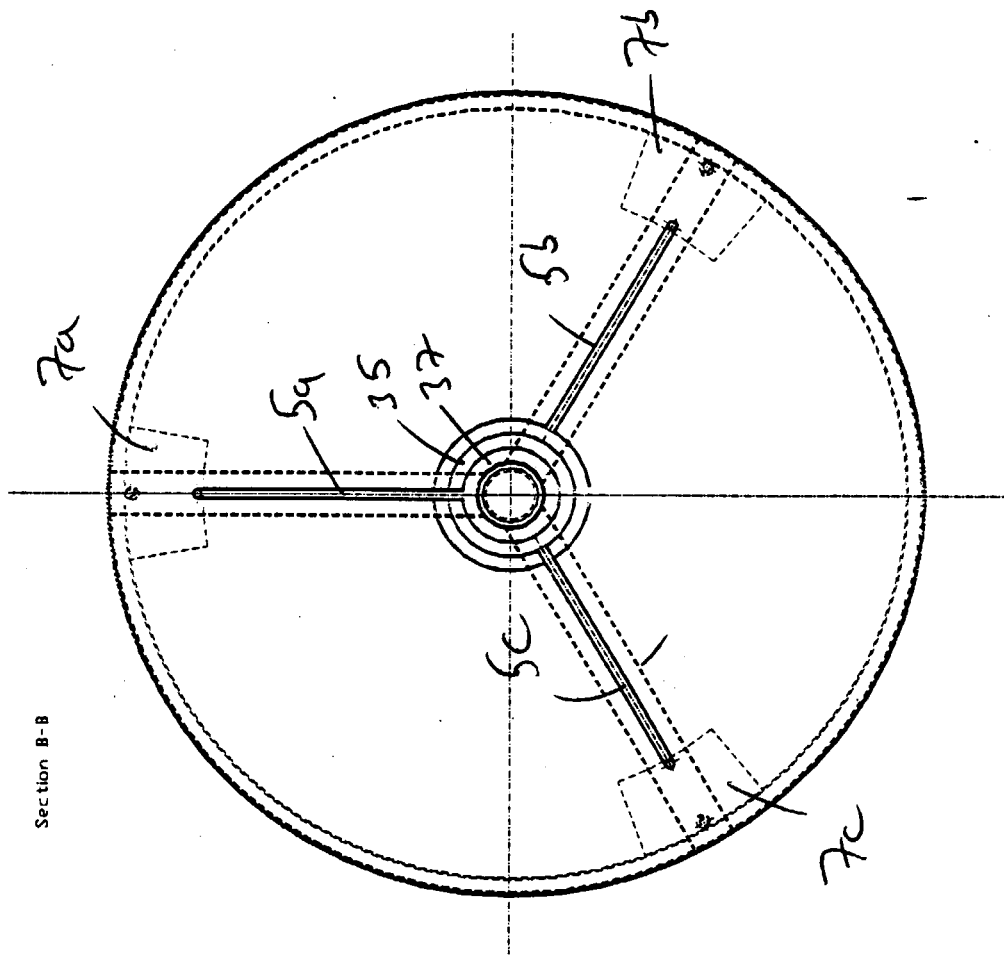


Fig 10

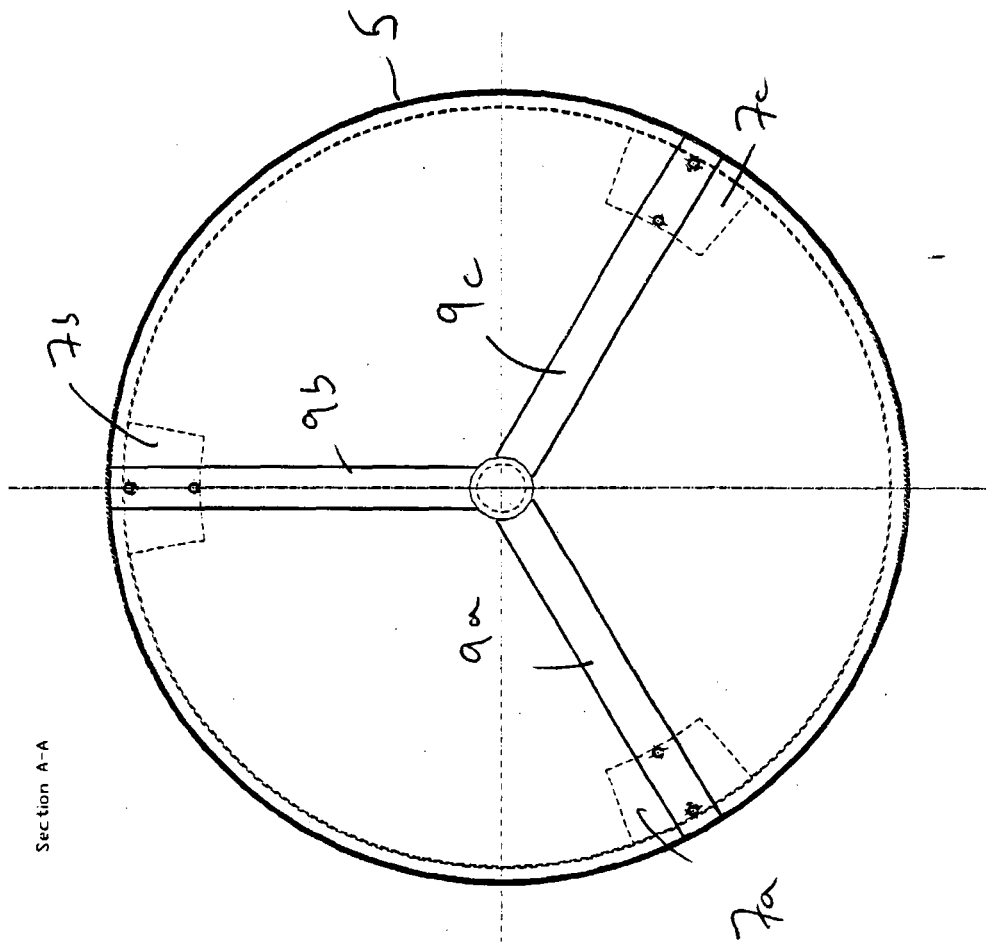
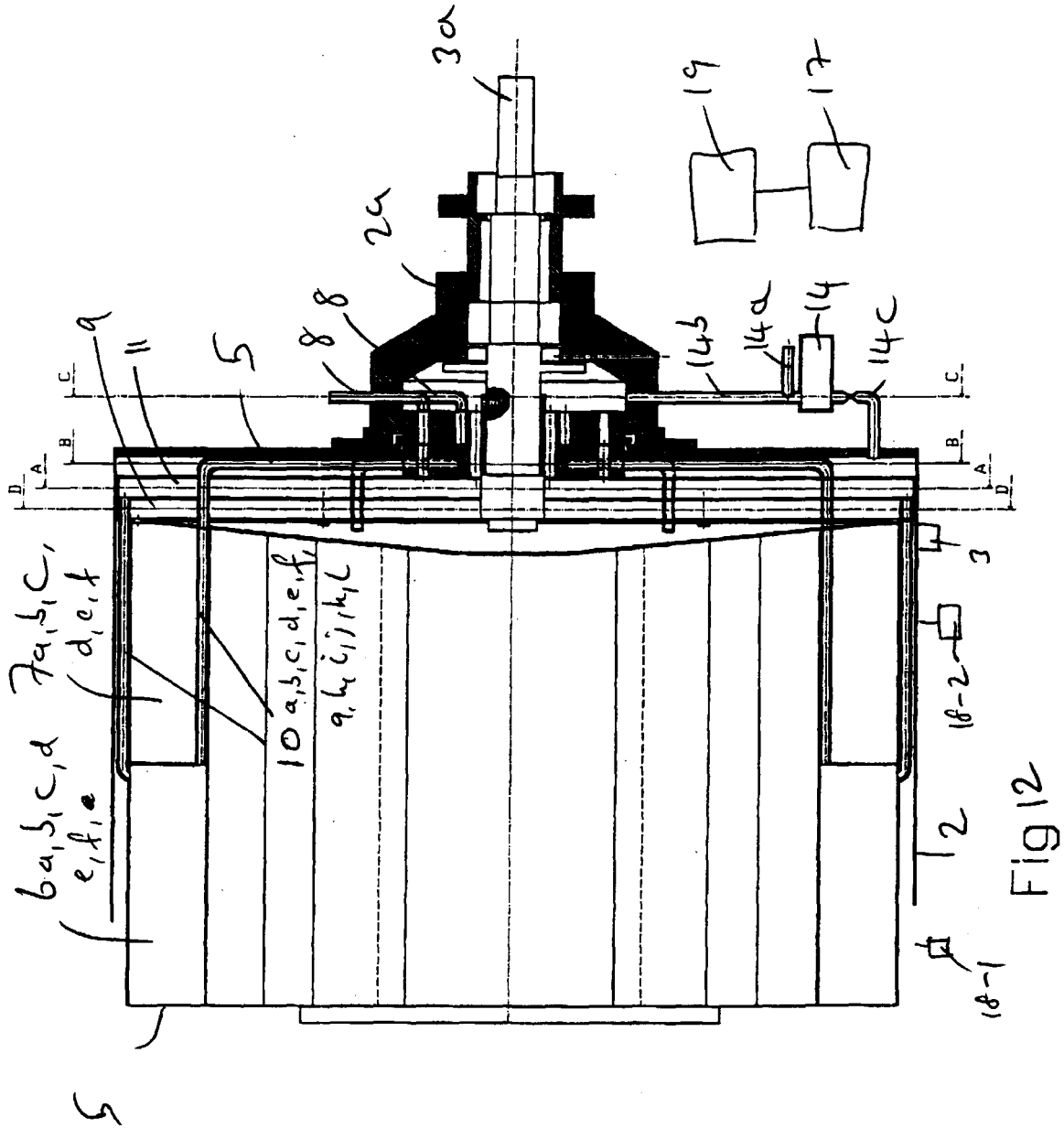
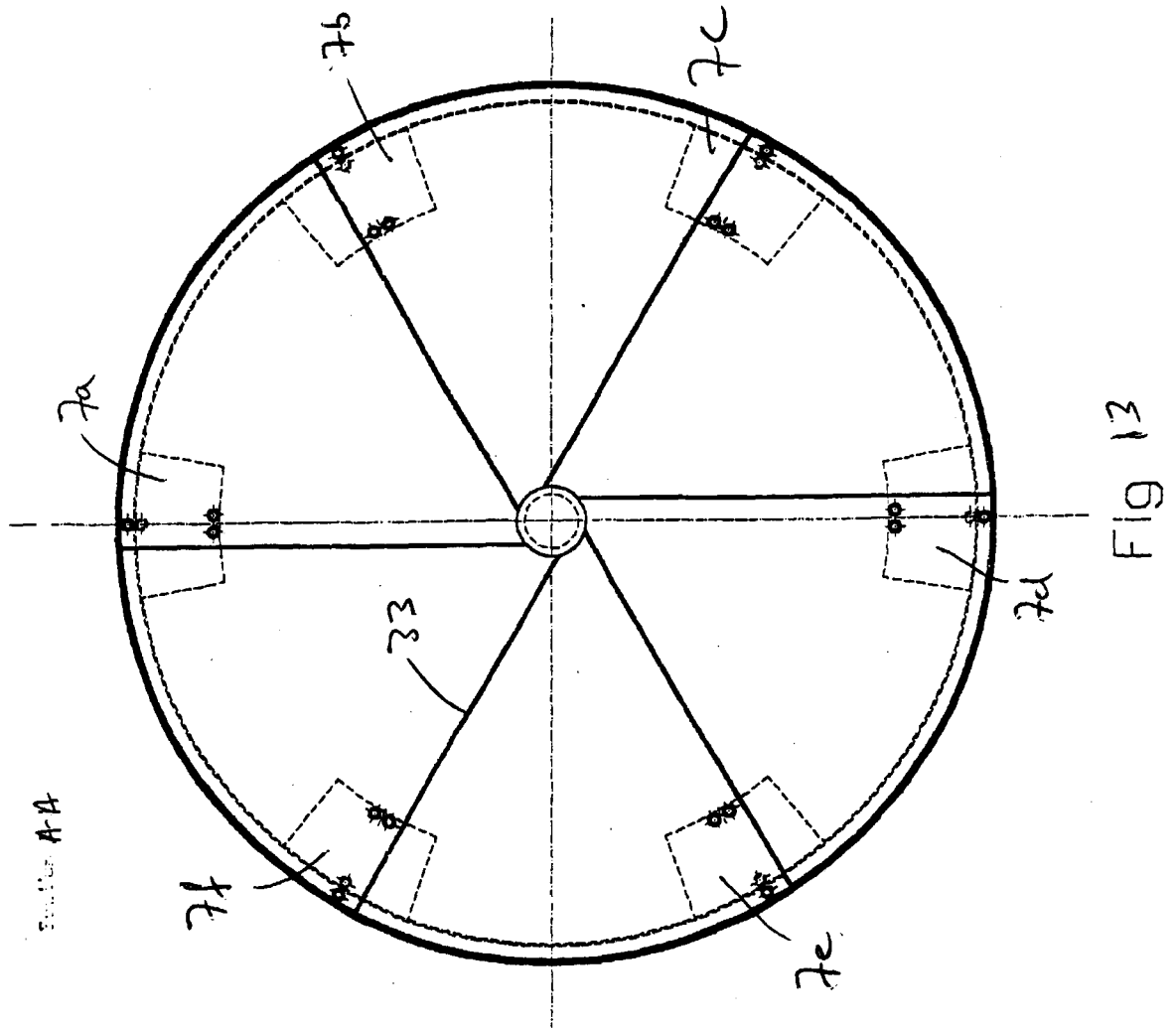
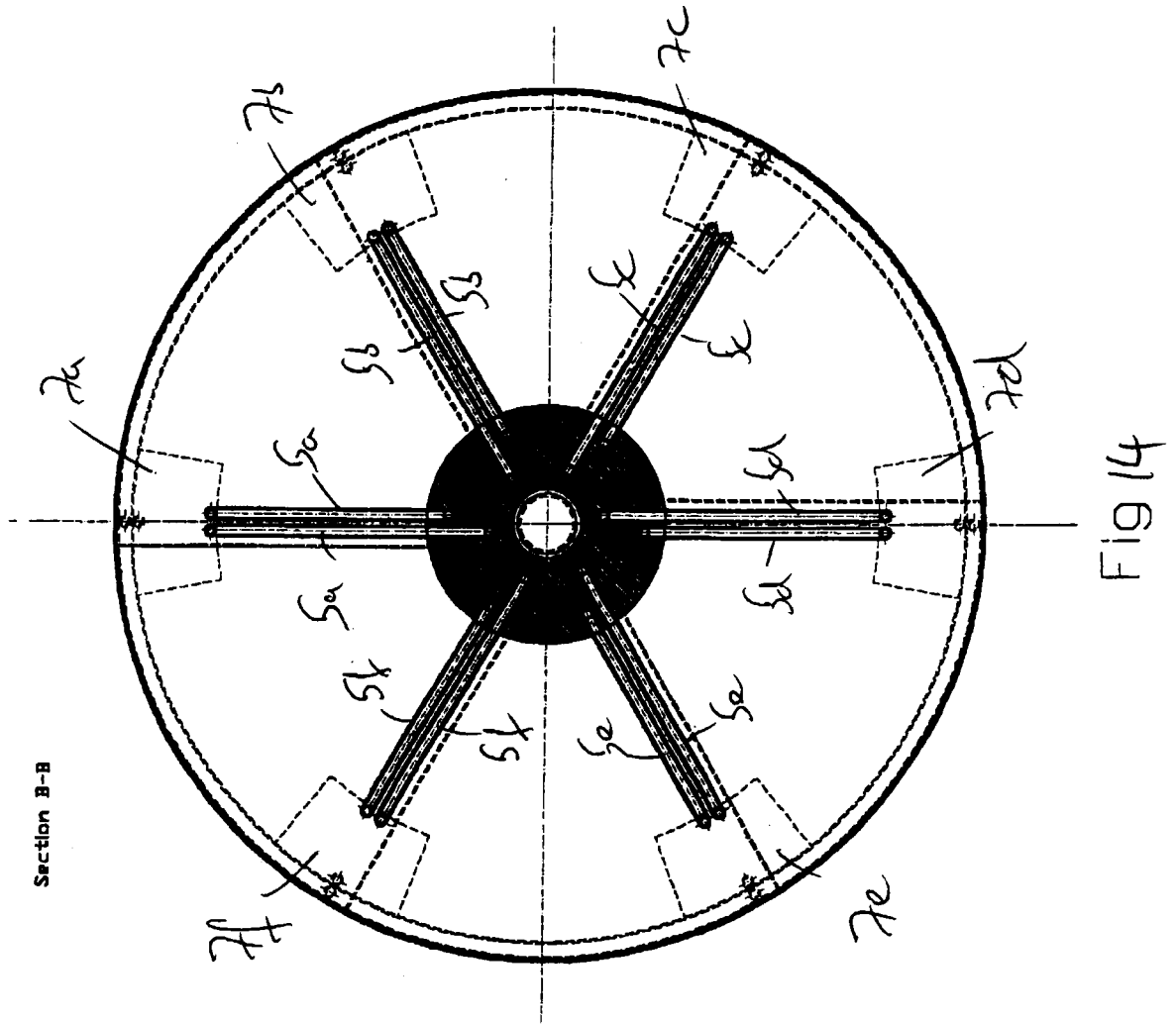
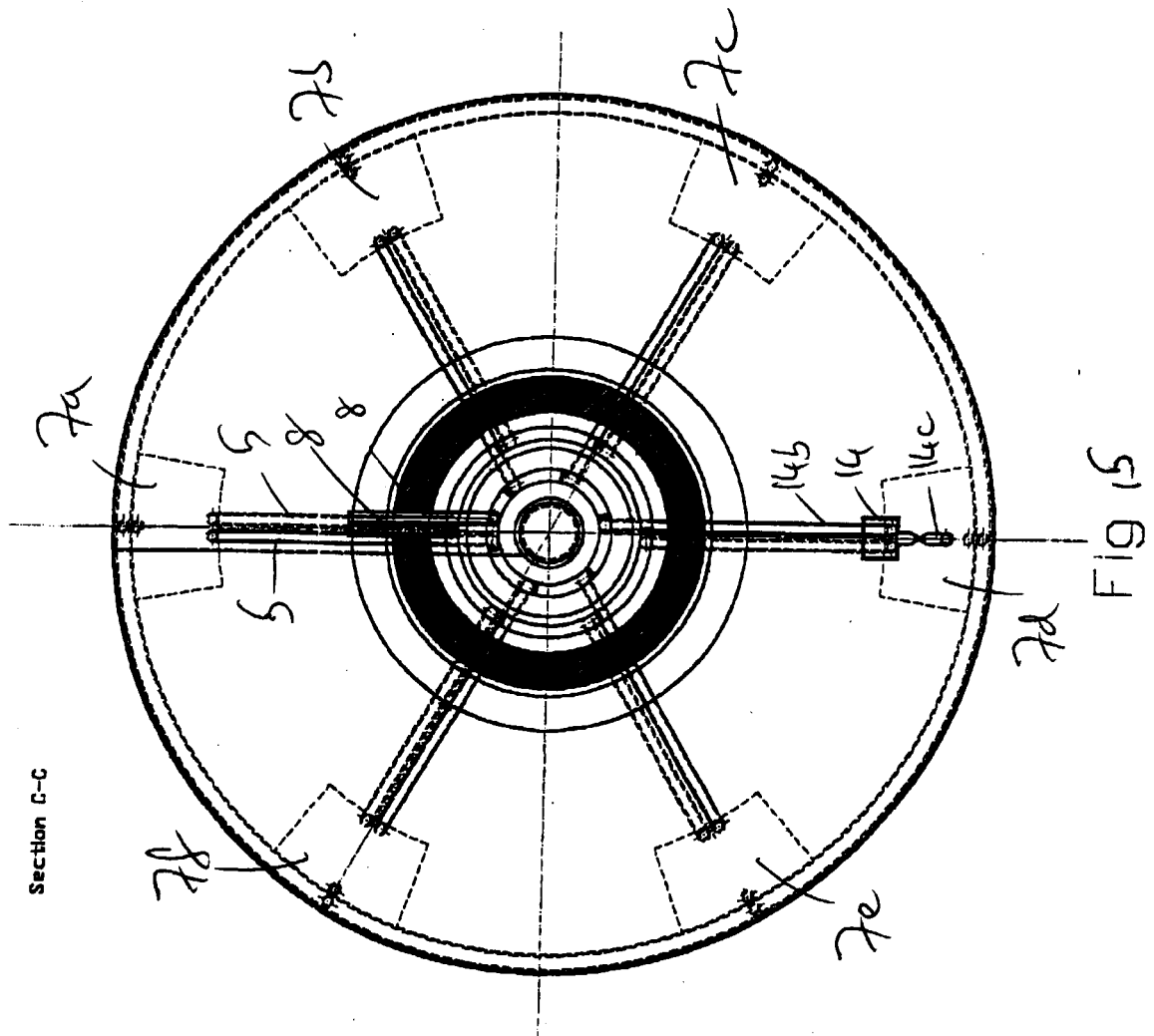


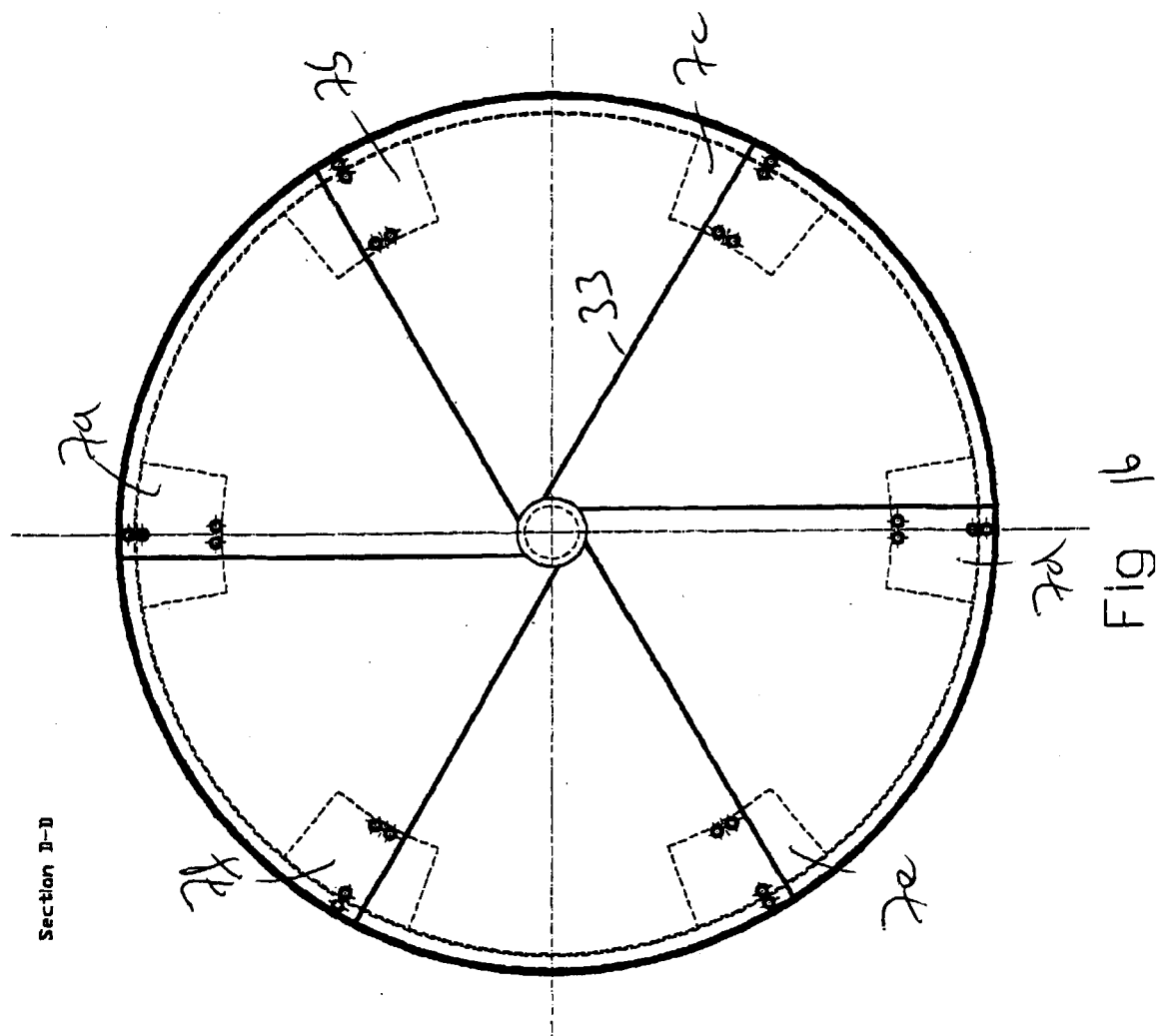
Fig11

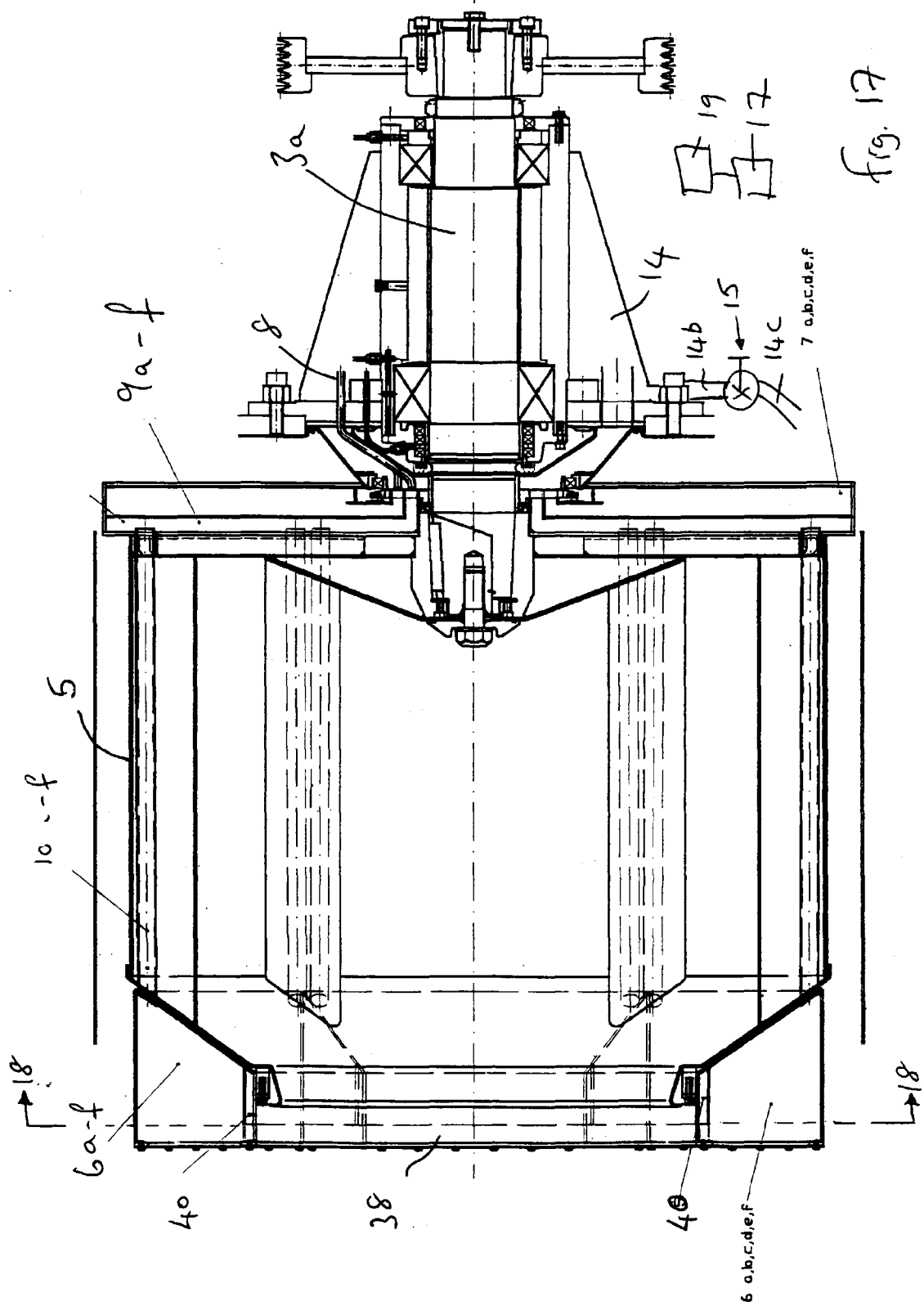












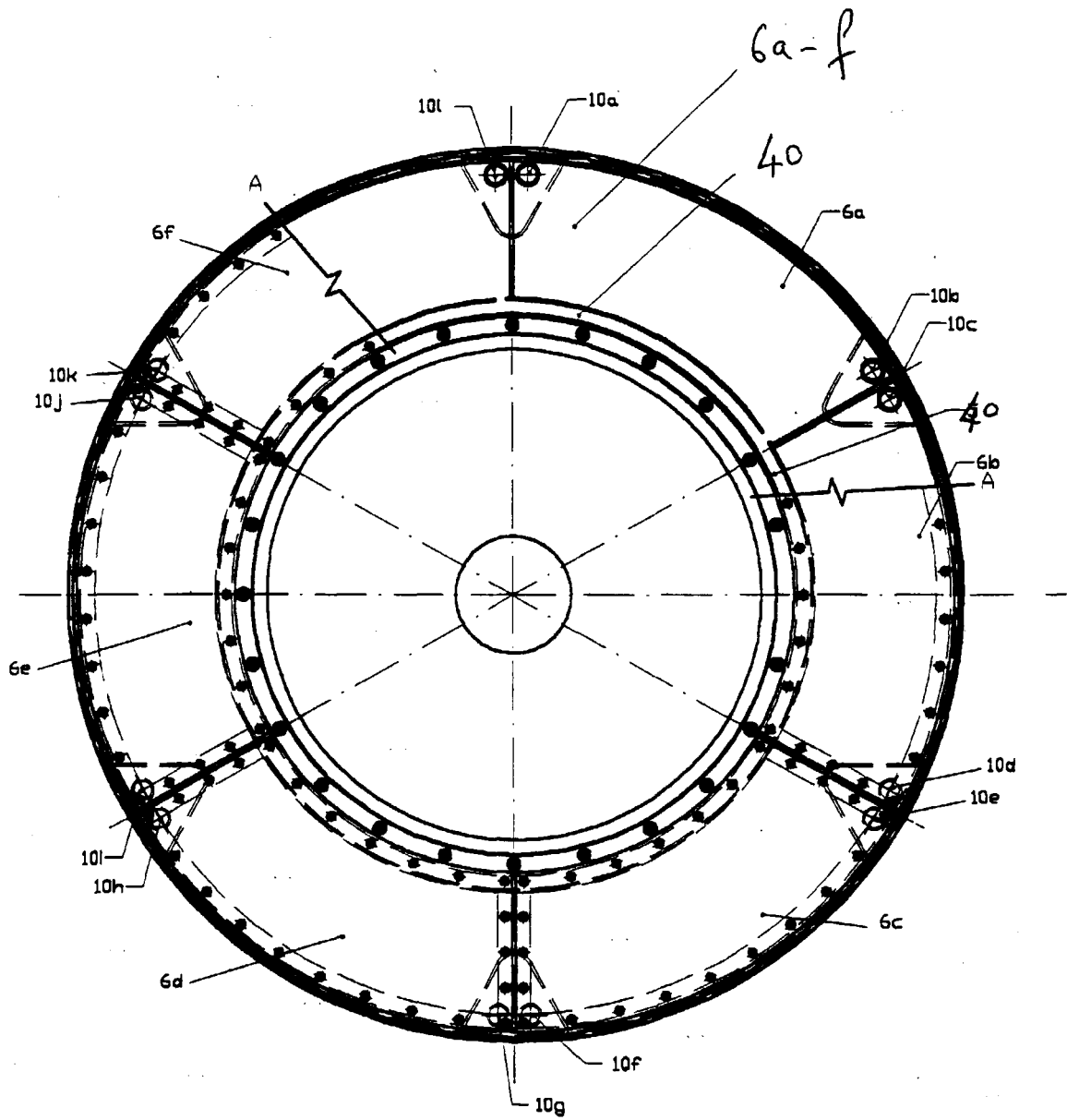


Fig. 18



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 10 4591

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Place of search THE HAGUE		Date of completion of the search 25 August 2000	Examiner Courrier, G
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