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(54) Title: AN ULTRASONIC CLEANING UNIT AND A FILTER APPARATUS COMPRISING THE ULTRASONIC CLEAN-
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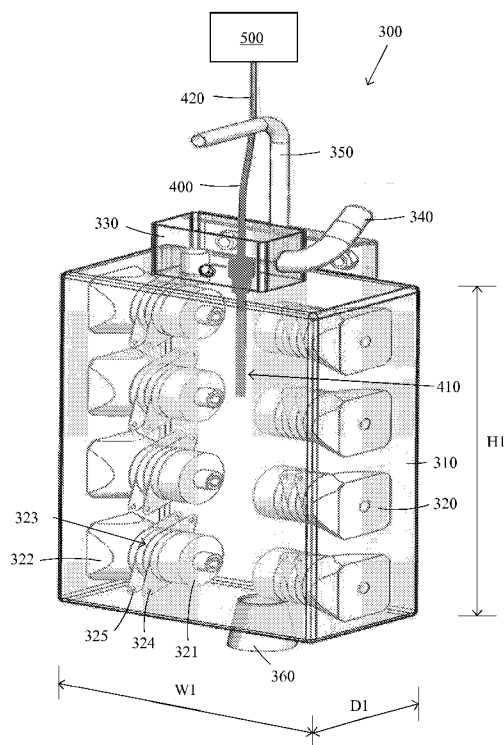


FIG. 6

(57) Abstract: The ultrasonic cleaning unit comprises ultrasonic trans-
ducers (320) being positioned within a casing (310). The ultrasonic clean-
ing unit (300) comprises further at least one sensor (400) located within
the casing (310). The at least one sensor (400) measures an indirect para-
meter that indicates whether one or several ultrasonic transducers (320)
does not work in a proper way.



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AN ULTRASONIC CLEANING UNIT AND A FILTER APPARATUS COMPRISING THE ULTRASONIC CLEANING UNIT

5 FIELD OF THE INVENTION

The present invention relates to an ultrasonic cleaning unit, to a filter apparatus comprising the ultrasonic cleaning unit, to a method for monitoring the ultrasonic cleaning unit and to the use of the ultrasonic cleaning unit in a filter disc apparatus.

10 BACKGROUND OF THE INVENTION

Filtration is a widely used process whereby a slurry or solid liquid mixture is forced through a media, with the solids retained on the media and the liquid phase passing through. Examples of filtration types include depth filtration, pressure and vacuum filtration, and gravity and centrifugal filtration.

15 Both pressure and vacuum filters are used in the dewatering of mineral concentrates. Pressure filtration is based on the generation of an overpressure within a filtration chamber. Consequently, solids are deposited onto the surface of the filter medium and the filtrate flows through the filter medium into the filtrate channels. Pressure filters often operate in batch mode
20 because continuous cake discharge is more difficult to achieve. Vacuum filtration is based on producing a suction within the filtrate channels in the filter medium and thereby forming a cake of mineral on the surface of the filter medium. The most common used filter medium in vacuum filters are filter cloths and ceramic filter plates. There exists several types of vacuum filters,
25 ranging from belt filters to drum filters.

BRIEF DESCRIPTION OF THE INVENTION

The present invention relates to an ultrasonic cleaning unit according to the claim 1.

30 The present invention relates also to a filter apparatus comprising an ultrasonic cleaning unit according to claim 13.

The present invention relates further to a method for monitoring an ultrasonic cleaning unit according to claim 16.

The present invention relates further to the use of the ultrasonic cleaning unit according to claim 17.

The ultrasonic cleaning unit comprises ultrasonic transducers being positioned within a casing. The ultrasonic cleaning unit comprises further at least one sensor located within the casing, whereby said at least one sensor measures an indirect parameter that indicates whether one or several
5 ultrasonic transducers does not work in a proper way.

It is not possible to directly measure the electric power supplied to the ultrasonic cleaning unit e.g. with a normal current meter due to the high frequency of the electric power supplied to the ultrasonic cleaning unit. The frequency of the electric power supplied to the ultrasonic cleaning unit is in the
10 range of 10 kHz to 400 kHz. The voltage of the electric power supplied to the ultrasonic cleaning unit is in the range of 100 V to 1000 V. This voltage might also pose some problems on a direct measurement of the power supplied to the ultrasonic cleaning unit. It is thus necessary to measure some indirect parameter that correlates somehow with the electric power that the ultrasonic
15 cleaning unit consumes.

An indirect parameter that could be measured is the temperature or the sound level within the casing of the ultrasonic cleaning unit. The ultrasonic transducers produce heat and sound when they are working. The temperature and the sound level within the casing will be affected when one or several
20 ultrasonic transducers are not working properly. The temperature and the sound level will start increasing along a respective pattern when the ultrasonic cleaning unit is turned on. A deviation in this pattern will indicate problems in one or several ultrasonic transducers. Tests can be done in order to determine how the pattern changes when one, two, three etc. ultrasonic transducers are
25 out of order i.e. disconnected during start-up of the ultrasonic cleaning unit. The test results can then be used to set up thresholds for the pattern in order to be able to determine when one, two, three or more ultrasonic transducers are not working properly or are completely out of order.

The reference temperature or reference sound level representing a
30 situation where all ultrasonic transducers within the casing of the ultrasonic cleaning unit work properly can be determined in advance. Tests can further be done in advance in order to determine the temperature drops or the sound level drops within the casing of the ultrasonic cleaning unit when one ultrasonic transducer, two ultrasonic transducers etc. are disconnected i.e. they are not
35 working. The results of the tests can then be used to determine a threshold for the temperature or the sound level below the reference temperature or

reference sound level, whereby a temperature or a sound level below the threshold indicates that at least one of the ultrasonic transducers within the casing of the ultrasonic cleaning unit is not working properly. The results can further be used to determine steps for the temperature drop or the sound level drop in situations where two ultrasonic transducers, three ultrasonic transducers etc. are not working.

The temperature or the sound level within the casing is thus continuously measured when the ultrasonic unit is operating. An indication of problems in the ultrasonic unit is then given when the measured temperature goes below the threshold temperature or the measured sound level goes below the threshold sound level. This indication of problems means that at least one ultrasonic transducer is not working properly within the casing of the ultrasonic cleaning unit. The measured steps for the temperature drop or the sound level drop in situations where two ultrasonic transducers, three ultrasonic transducers etc. are not working could be used to directly indicate the amount of ultrasonic transducers that are not working in the ultrasonic cleaning unit.

It is important to have real time information of whether the ultrasonic cleaning unit is working properly or not. The capillary ducts in the filter plates might become clogged in a situation where one or several ultrasonic units do not work properly for some time. It might be impossible thereafter to clean said clogged filter plates during the normal cleaning operations of the filter apparatus. Said clogged filter plates will then have to be changed to new filter plates in advance i.e. before the life span of these filter plates actually terminates. This will involve additional costs as otherwise functioning filter plates have to be changed in advance.

The indication of problems in the ultrasonic unit could e.g. be done by a voice signal or by a visual signal on a screen or by lamps etc.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of example embodiments with reference to the accompanying drawings, in which

Figure 1 is a perspective top view of a disc filter apparatus,
Figure 2 is a perspective top view of the drum of figure 1,
Figure 3 is a perspective top view of a drum filter apparatus,

Figure 4 is a perspective view of an ultrasonic cleaning unit, which can be used in the disc filter apparatus shown in figure 1,

Figure 5 is a perspective view of a sensor which can be used in the ultrasonic cleaning unit,

5 Figure 6 is a perspective view of the ultrasonic cleaning unit provided with the sensor.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Figure 1 is a perspective top view of a disc filter apparatus. Figure 2 is a perspective top view of the drum of figure 1.

10 The disc filter apparatus 200 comprises a cylindrical drum 100 having a shaft 15 that is supported by bearings 11, 12 on a frame 8. The shaft 15 has a longitudinal centre axis X-X. A lower portion of the drum 100 is submerged in a slurry basin 9 located below the centre axis X-X. The drum 100 is rotated by a motor e.g. an electric motor through a gear box connected
15 to the shaft 15 of the drum 100. The drum 100 comprises a plurality of ceramic filter discs 110 arranged in line co-axially around the centre axis X-X of the drum 100. Each filter disc 110 is formed of a number of individual ceramic filter plates 120 having essentially the form of a truncated sector in a circle having the centre at the longitudinal centre axis X-X of the drum 100. The filter plates
20 120 are mounted circumferentially in a radial plane to form an essentially continuous and planar disc surface.

 The number of the ceramic filter discs 110 in the disc filter apparatus 200 may be in the range of 2 to 20. The diameter of each filter disc 110 may be in the range of 1,5 to 4 m. The number of filter plates 120 in one
25 filter disc 110 may be in the range of 12 to 15. The filtering area of one filter plate 120 in the filter disc 110 is in the range of 0.1 to 1.0 m², preferably in the range of 0.2 to 0.8 m². The filtering area of one filter disc 110 is in the range of 1 to 10 m². The filtering area of the whole disc filter apparatus 200 is in the range of 1 to 200 m², preferably in the range of 10 to 200 m².

30 Each filter plate 120 comprises a pair of opposite outwardly facing major faces interconnected by one or more edge faces. The major faces of the filter plate 120 are parallel and form planar suction walls through which water is sucked into the interior of the filter plate 120. The lower portion of each filter plate 120 is provided with fastening points for attaching the filter plate 120 to
35 the drum 100. Each filter plate 120 is also provided with a fluid duct from the

interior of the the filter plate 120 to a collector piping 20 provided in the drum 100. The outer surface of the filter plate 120 has a microporous structure so that water can enter into the filter plate 120. The interior of the filter plate 120 is porous so that water can travel within the filter plate 120. The edge surfaces of the filter plate 120 are impervious to water. This means that water can penetrate into the filter plate 120 only through the major faces of the filter plate 120.

The collector pipes 20 are connected to a distributing valve 30 disposed on the shaft of the drum 100. The distributing valve 30 transmits vacuum or overpressure to the filter plates 120. The vacuum system comprises a filtrate tank 7, a vacuum pump 6 and a filtrate pump 5. The vacuum pump 6 maintains vacuum in the collector piping 20 and the filtrate pump 5 removes the filtrate from the collector piping 20. It is possible to arrange reverse flushing or backwash so that some of the filtrate or clean water from an external water source is led back to the collector piping 20 by means of a backwash system, such as a backwash pump.

As the row of the filter discs 110 rotate, the filter plates 120 of each disc 110 move into and through the basin 9. Each filter plate 120 goes through different process phases during one revolution of the disc 110. In a cake forming phase, the liquid is passing through the outer surfaces of the filter plate 120 into the interior of the filter plate 120 when it travels through the slurry, and a cake is formed on the opposite outer surfaces of the filter plate 120. The filter plate 120 enters the cake drying phase after it leaves the basin 9. If cake washing is required, it is done in the beginning of the drying phase. In the cake discharge phase the cake is scraped off from the outer surfaces of the filter plate 120 by ceramic scrapers so that a thin cake is left on the outer surfaces of the filter plate 120. There is thus a small gap between the scraper and the outer surface of the filter plate 120. In the backflush or backwash phase of each rotation, water (filtrate) is pumped in a reverse direction from the inside of the filter plate 120 through the filter plate 120 to the outside of the filter plate 120. The backflush water washes off the residual cake and cleans the pores of the filter plate 120.

An ultrasonic cleaning unit 300 is situated between each pair of filter discs 110 in the lower portion of the drum 100. The ultrasonic cleaning units 300 are thus situated within the basin 9. The ultrasonic cleaning units 300 are used to clean the outer surfaces and the pores of the filter plates 120 in the

filter discs 110. The cleaning result is naturally dependent on the proper function of the ultrasonic cleaning unit 300. If one or several of the ultrasonic transducers 320 within the ultrasonic units 300 do not work properly, then the cleaning result will suffer. A reduced cleaning capacity of the ultrasonic cleaning unit 300 might lead to a situation where some or all of the pores in the filter plates 120 become gradually heavily clogged. It might then be impossible to clean the pores even with the help of acids, which means that the clogged filter plates 120 have to be changed. This will involve extra costs. It is thus important to be able to monitor the proper function of the ultrasonic cleaning units 300 in the disc filter apparatus 200. It is not possible to measure directly the electric power supplied to the ultrasonic cleaning units 300 e.g. with a normal current meter due to the high frequency of the electric power.

Figure 3 is a perspective top view of a drum filter apparatus. Corresponding parts in the disc filter apparatus and in the drum filter apparatus have been numbered with the same reference number. The drum filter apparatus 600 comprises a frame 8, a cylindrical drum 100 supported within the frame 8, a slurry basin 9 under the drum 100. The drum 100 comprises a shaft 15 that is supported at both ends with bearings 11, 12 on the frame 8. The shaft 15 and thereby also the drum 100 is rotated by an electric motor 26 through a gear. The drum 100 rotates around a centre axis X-X forming the longitudinal centre axis X-X of the shaft 15. The drum 100 rotates in a counter clockwise direction in the figure. The drum 100 comprises filter plates 120 attached to an outer surface of the drum 100. The axial X-X length of the drum 100 is divided into two sections. A first ring of filter plates 120 is positioned on the first section of the drum 100 and a second ring of filter plates 120 is positioned on the second section of the drum 100. The filter plate 120 comprises a planar inner surface, a curved outer surface and edge surfaces connecting the side edges of the inner surface and the side edges of the outer surface of the filter plate 120. The curvature of the outer surface of the filter plates 120 coincides with the circumference of the outer surface of the drum 100. The filter plates 120 form a cylindrical filter surface on the outer surface of the drum 100. Each filter plate 120 is also provided with a fluid duct from the interior of the filter plate 120 to a collector piping 20 provided in the drum 100.

The number of filter plates 120 in the drum filter apparatus 600 may vary depending on the size of the drum 100 of the drum filter apparatus 600. The diameter of the drum 100 may be in the order of 1 to 5 meter and the length of the drum 100 may be in the order of 1 to 10 meter. The filtering area of one filter plate 120 on the drum 100 is in the range of 1 to 10 m², preferably in the range of 2.5 to 10 m². The filtering area of the drum filter apparatus 600 is in the range of 1 to 200 m², preferably in the range of 10 to 200 m².

A lower portion of the drum 100 is submerged in the slurry basin 9. The outer surface of the filter plate 120 has a microporous structure so that water can enter into the filter plate 120. The interior of the filter plate 120 is porous so that water can travel within the filter plate 120. The inner surface of the filter plate 120 and the edge surfaces of the filter plate 120 are impervious to water. This means that water can penetrate into the filter plate 120 only through the outer surface of the filter plate 120.

As the drum 100 rotate, the filter plates 120 move into and through the basin 9. Each filter plate 120 goes through different process phases during one revolution of the drum 100. In a cake forming phase, the liquid is passing through the outer surfaces of the filter plate 120 into the interior of the filter plate 120 when it travels through the slurry, and a cake is formed on the outer surface of the filter plate 120. The filter plate 120 enters the cake drying phase after it leaves the basin 9. If cake washing is required, it is done in the beginning of the drying phase. In the cake discharge phase the cake is scraped off from the outer surface of the filter plate 120 by ceramic scrapers 27 so that a thin cake is left on the outer surfaces of the filter plate 120. There is thus a small gap between the scraper 27 and the outer surface of the filter plate 120. In the backflush or backwash phase, water (filtrate) is pumped in a reverse direction from the inside of the filter plate 120 through the filter plate 120 to the outside of the filter plate 120. The backflush water washes off the residual cake and cleans the pores of the filter plate 120.

Ultrasonic cleaning units 300 are situated within the basin 9. The ultrasonic cleaning units 300 are used to clean the outer surfaces and the pores of the filter plates 120 on the drum 100.

Figure 4 is a perspective view of an ultrasonic cleaning unit, which can be used in the disc filter apparatus shown in figure 1 and in the drum filter apparatus shown in figure 3. Ultrasonic cleaning units 300 are used in filter apparatuses in order to clean the filter plates 120 after the cake has been

removed with scrapers from the outer surface of the filter plates 120. The ultrasonic cleaning unit 300 comprises a casing 310 having a rectangular form. The casing 310 is formed of a back wall 311, a front wall 312, and four side walls 313, 314, 315, 316 connecting the back wall 311 to the front wall 312.

5 There is further a connection box 330 attached to the upper side wall 315 and a lead in part 340 leading into the connection box 330. There is further a grip part 350 from which the ultrasonic cleaning unit 300 can be carried and a cone part 360 for attaching the ultrasonic cleaning unit 300 on the operation site. There is thus a corresponding cone part on the operation site into which the
10 cone part 360 in the ultrasonic cleaning unit 300 fits. The casing 310 forms a closed space for the ultrasonic transducers 320 (shown in figure 5) that are positioned within the casing 310. The casing 310 is impervious to water. The casing 310 will be surrounded with slurry when it is installed into the basin 9 in the filter apparatus. The casing 310 must be surrounded by a liquid in order for
15 the ultrasonic cleaning unit 300 to work.

Figure 5 is a perspective view of a sensor that can be used in the ultrasonic cleaning unit. The sensor 400 within the ultrasonic unit 300 is used to monitor possible changes in the environment within the ultrasonic unit 300. The sensor 400 comprises a sensor part 410 to be positioned in the casing
20 310 of the ultrasonic unit 300 and a signal cable 420 for transmitting the output signal of the sensor part 410 to an external control and monitor unit. The sensor 400 measures an indirect parameter from the environment within the casing 310. The indirect parameter is a parameter in the environment within the casing 310 that indicates whether one or several of the ultrasonic
25 transducers 320 positioned within the casing 310 do not work in a proper way.

A parameter that can be measured with the sensor 400 is the temperature within the casing 310. The temperature within the casing 310 has a correlation with the power consumed by the ultrasonic transducers 320 within the casing 310. Especially the rise of the temperature during start-up of the
30 ultrasonic unit 300 follows a characteristic pattern and deviations in this pattern indicate that there is or will soon be problems in the proper function of one or several of the ultrasonic transducers 320 within the casing 310. The measurement of the temperature could indicate problems already at the stage when one or several ultrasonic transducers 320 do not work properly although
35 they are not completely broken. Also a deviation in the final temperature level that is reached within the casing 310 after a certain time after the ultrasonic

cleaning unit 300 has been turned on might indicate problems in one or several of the ultrasonic transducers 320.

Another parameter that can be measured with the sensor 400 is the sound intensity pattern within the casing 310. The sound intensity pattern within the casing 310 has a correlation with the power consumed by the ultrasonic transducers 320 within the casing 310. Especially the rise of the sound intensity during start-up of the ultrasonic unit 300 follows a characteristic pattern and deviations in this pattern indicate that there is or will soon be problems in the proper function of one or several of the ultrasonic transducers 320 within the casing 310. The measurement of the sound level could indicate problems already at the stage when one or several ultrasonic transducers 320 do not work properly although they are not completely broken. Also a deviation in the final sound level that is reached within the casing 310 after a certain time after the ultrasonic cleaning unit 300 has been turned on might indicate problems in one or several of the ultrasonic transducers 320.

Figure 6 is a perspective view of the ultrasonic cleaning unit provided with the sensor. There are a number of ultrasonic transducer units 320 located within the casing 310. A first row of ultrasonic transducers 320 is positioned against a first vertical side wall 313 in the casing 310. A second row of ultrasonic transducers 320 is positioned against a second opposite vertical side wall 314 in the casing 310. Each ultrasonic transducer 320 comprises a resonant mass 321, a radiating cone 322, transducers 323 between the resonant mass 321 and the radiating cone 322, and connectors 324, 325 between the transducers 323. A high frequency electrical oscillation signal is connected to the connectors 324, 325 of the ultrasonic transducer 320. The transducers 323 in the ultrasonic transducer 320 will expand and contract controlled by the high frequency electrical oscillation signal. The ultrasonic transducer 320 is tuned to have a resonant frequency equalling to the frequency of the electrical oscillation signal. Pressure oscillations are thus produced in the radiating cone 322 of the ultrasonic transducer 320. These pressure oscillations are transmitted from the side walls 313, 314 of the casing to the fluid in the basin 9 of the disc filter apparatus 200. The connectors 324, 325 of each ultrasonic transducer 320 are connected with a cable to a connection part in the connection box 340. A supply cable for the high frequency electrical oscillation signal can pass through the lead in part 340 into the connection box 340 where it is terminated at the connection part. The

casing 310 is naturally sealed so that fluid cannot penetrate into the casing 310. The connection box 330 is filled with glue in order to prevent fluid from penetrating into the connection box 330 and further into the casing 310.

5 The sensor part 410 of the sensor 400 is positioned in the casing 310 in a space between the first row of ultrasonic transducers 320 and the second row of ultrasonic transducers 320. The sensor part 410 of the sensor 400 should be positioned in a central position within the casing 410 and it should not be in direct contact with the ultrasonic transducers 320 or the walls 311, 312, 313, 314, 315, 316 of the casing 310. An advantageous position for
10 the sensor part 410 of the sensor 400 is in the middle of the casing 310.

The ultrasonic transducers are usually piezoelectric e.g. made with lead zirconate titanate, barium titanate, etc. The ultrasonic transducer will physically change shape when excited by an electrical pulse. The physical mass and shape of the transducer determine the resonant point of the transducer.

15 The ultrasonic transducer units 320 convert high frequency electrical oscillation signals into high frequency mechanical vibrations (sound) in the range of 10 kHz to 400 kHz. The ultrasonic transducers 320 are tuned so that they vibrate with the frequency of the electrical oscillation signal supplied to them. The mechanical vibrations are transmitted into the fluid in the basin 9.
20 The mechanical vibrations propagating in the fluid cause rapid formation and collapse of numerous micro-bubbles within the fluid. This phenomenon is called cavitation. The bubbles travel at high speed within the fluid, causing them to implode against the surfaces of the filter plates 120 within the fluid with an enormous release of energy. As the bubbles implode and cavitation occurs,
25 the fluid rushes into the gap left behind the bubbles. When the fluid makes contact with the surface of the filter plates 120, any rests of cake and possible contaminants on the surface of the filter plates 120 simply fall away. This also applies to rests of cake and possible contaminants deposited in the pores of the filter plates 120. The cleaning effect can be intensified by using suitable
30 solvents and/or chemicals in the fluid.

The ultrasonic cleaning unit 300 comprises further a sensor 400 having a sensor part 410 positioned within the casing 310. The output signal of the sensor 400 is transferred with a signal cable 420 to a control and monitor unit 500 of the disc filter apparatus 200. The ultrasonic transducers 320
35 produce heat and sound when they are in operation. The temperature rise and the rise in the sound level within the casing 310 follows a certain pattern when

the ultrasonic cleaning unit 300 is turned on and all of the ultrasonic transducers 320 within the casing 310 work properly. There is, however, a deviation in this pattern when one or several of the ultrasonic transducers 320 within the casing 310 are not working properly. Also the final temperature and the final sound level that is reached within the casing 310 remain at a constant level when all ultrasonic transducers 320 within the casing 310 are working properly. In a situation where one or several of the ultrasonic transducers 320 within the casing 310 is not working properly there will be a deviation in the final temperature and the final sound level within the casing 310. These deviations in the rising pattern of the temperature or the sound level can be detected with a corresponding sensor 400. The operator can thus follow the situation in each ultrasonic cleaning unit 300 measured by the sensor 400 positioned in the ultrasonic cleaning unit 300 in order to detect whether one or several of the transducer units 320 within an ultrasonic cleaning unit 300 does not work properly.

The ultrasonic cleaning unit 300 has a width W1, a depth D1 and a height H1. The minimum dimensions of the ultrasonic cleaning unit 300 are W1 = 100 mm, D1 = 100 mm, H1 = 100 mm. The maximum dimensions of the ultrasonic cleaning unit 300 are W1 = 300 mm, D1 = 300 mm, H1 = 1000 mm. The weight of the ultrasonic cleaning unit 300 is in the range of 1 to 100 kg. The power of the ultrasonic cleaning unit 300 is in the range of 100 W to 5 kW. The frequency of the electric power supplied to the ultrasonic transducers 320 is in the range of 10 kHz to 400 kHz, preferably in the range of 20 kHz to 50 kHz. The voltage of the power supplied to the ultrasonic transducers 320 is in the range of 100 V to 1000 V, preferably in the range of 300 V to 900 V. The frequency range of 20 kHz to 50 Hz combined with the voltage range of 300 V to 900 V is a preferable combination.

The figures show only one sensor 400 for measuring the indirect parameter within the casing 310 of the ultrasonic cleaning unit 300. There could naturally be several sensors 400 within the casing 310. There could be a sensor 400 at each ultrasonic transducer 320 within the casing 310 in order to measure the indirect parameter associated with each ultrasonic transducer 320. This is, however, not normally necessary as it is enough to know that a specific ultrasonic cleaning unit 300 is not working properly. The whole ultrasonic cleaning unit 300 that is not working properly is then changed to a new one.

The ultrasonic cleaning unit 300 that is shown in figure 5 has two rows of ultrasonic transducers 320. Each row comprises four ultrasonic transducers 320 i.e. there are eight ultrasonic transducers 320 within the casing 310. There can naturally be any number of ultrasonic transducers 320 within the casing 310. The number of ultrasonic transducers 320 and thereby the dimensions of the casing 310 depends on the dimensions of the disc filter apparatus 200. The height H1 of the casing 310 should be such that it covers the corresponding height of the filter disk 120. The ultrasonic transducers 320 should act on the whole height of the filter disk 120 in order to clean the whole filter disc 120 when the filter disc 120 rotates in front of the transducers 320.

The casing 310 of the ultrasonic cleaning unit 300 in figures 4 and 6 has a generally rectangular form. The invention is, however, not limited to a rectangular form of the casing 310 of the ultrasonic cleaning unit 300. The transitions between the walls 311, 312, 313, 314, 315, 316 of the casing 310 could naturally be rounded. The generally rectangular form of the casing 310 is advantageous in view of positioning the ultrasonic transducers 320 in the casing 310.

The filter plates 120 in the disc filter apparatus 200 and the drum filter apparatus 600 are advantageously made of porous ceramic. The pores in the ceramic form a capillary structure through which capillary structure water can propagate. Air will, however, not pass through the capillary structure.

The ultrasonic cleaning can be used in connection with a disc filter apparatus, a drum filter apparatuses and with any filter apparatuses where ultrasonic cleaning is a suitable cleaning method for cleaning the filter surfaces and the pores of the filter plates in the apparatuses.

Upon reading the present application, it will be obvious to a person skilled in the art that the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. An ultrasonic cleaning unit (300) comprises ultrasonic transducers (320) being positioned within a casing (310), **characterized** in that the ultrasonic cleaning unit (300) comprises further at least one sensor (400)
5 located within the casing (310), whereby said at least one sensor (400) measures an indirect parameter that indicates whether one or several ultrasonic transducers (320) does not work in a proper way.

2. An ultrasonic cleaning unit according to claim 1, **characterized** in that the casing (310) forms a closed compartment for the ultrasonic transducers (320) and the at least one sensor (400), the casing (310) being
10 impervious to water.

3. An ultrasonic cleaning unit according to claim 1 or 2, **characterized** in that the casing (310) has a rectangular form being formed of a back wall (311), a front wall (312), a bottom wall (316), a top wall (315) and
15 two opposite side walls (313, 314), whereby the top wall (315), the bottom wall (316) and the two side walls (313, 314) connect the back wall (311) to the front wall (312).

4. An ultrasonic cleaning unit according to claim 3, **characterized** in that at least the two side walls (313, 314) are of metal.

20 5. An ultrasonic cleaning unit according to claim 3 or 4, **characterized** in that a first row of ultrasonic transducers (320) is positioned against a first vertical side wall (313) in the casing (310) and a second row of ultrasonic transducers (320) is positioned against a second opposite vertical side wall (314) in the casing (310).

25 6. An ultrasonic cleaning unit according to any of claims 1 to 5, **characterized** in that the voltage supplied to the ultrasonic transducers (320) in the ultrasonic cleaning unit (300) is in the range of 300 V to 900 V.

7. An ultrasonic cleaning unit according to any of claims 1 to 6, **characterized** in that the frequency supplied to the ultrasonic transducers
30 (320) in the ultrasonic cleaning unit (300) is in the range of 20 kHz to 50 kHz.

8. An ultrasonic cleaning unit according to any of claims 1 to 7, **characterized** in that the power supplied to the ultrasonic transducers (320) in the ultrasonic cleaning unit (300) is in the range of 100 W to 5 kW.

9. An ultrasonic cleaning unit according to any one of claims 1 to 8,
35 **characterized** in that the at least one sensor (400) is a temperature sensor.

10. An ultrasonic cleaning unit according to any one of claims 1 to 8, **characterized** in that the at least one sensor (400) is a sound sensor.

11. An ultrasonic cleaning unit according to any one of claims 1 to 10, **characterized** in that the sensor (400) comprises a sensor part (410) to be
5 positioned within the casing (310) of the ultrasonic unit (300) and a signal cable (420) for transmitting the output signal of the sensor part (410) to an external control and monitor unit (500).

12. An ultrasonic cleaning unit according to any one of claims 5 to 11, **characterized** in that the sensor (400) is located in the casing (310) in a
10 space between the first row of ultrasonic transducers (320) and the second row of ultrasonic transducers (320).

13. A filter apparatus (200, 600) comprises a drum (100, 20) mounted on a rotatable shaft (15) having a centre axis (X-X), the drum (100, 20) being provided with filter plates (120), a lower portion of the drum (100, 20)
15 being submerged in a slurry basin (9) located below the centre axis X-X, **characterized** in that the filter apparatus (200, 600) comprises at least one ultrasonic cleaning unit (300) according to any one of claims 1 to 12 positioned in the basin (9).

14. A filter apparatus according to claim 13, **characterized** in that
20 the filter apparatus (200, 600) is a disc filter apparatus (200) comprising a number of filter discs (110) positioned in the axial direction (X-X) at a distance from each other, each filter disc (110) comprising a number of individual truncated, sector shaped filter plates (120) mounted circumferentially in a radial plane on the filter disc (110), whereby there is an ultrasonic cleaning unit
25 (300) according to any one of claims 1 to 12 positioned in the basin (9) between each pair of two adjacent filter discs (110).

15. A filter apparatus according to claim 13, **characterized** in that
the filter apparatus (200, 600) is a drum filter apparatus (600) comprising a number of filter plates (120) positioned on the outer surface of the drum (100)
30 and forming a cylindrical filter surface on the outer surface of the drum (100), whereby there is at least one ultrasonic cleaning unit (300) according to any one of claims 1 to 12 positioned in the basin (9) below the cylindrical filter surface.

16. A method for monitoring an ultrasonic cleaning unit (300)
35 comprising ultrasonic transducers (320) being positioned within a casing (310), **characterized** in that the method comprises the steps of:

measuring an indirect parameter within the casing (310) with at least one sensor (400) located within the casing (310), said indirect parameter indicating whether one or several ultrasonic transducers (320) does not work in a proper way,

5 comparing the measured value of the parameter with a predetermined reference value for the parameter,

 indicating that the ultrasonic cleaning unit (300) is not working properly when the measured value deviates from the predetermined reference value.

10 17. The use of an ultrasonic cleaning unit according to any one of claims 1 to 12 in a disc filter apparatus (200).

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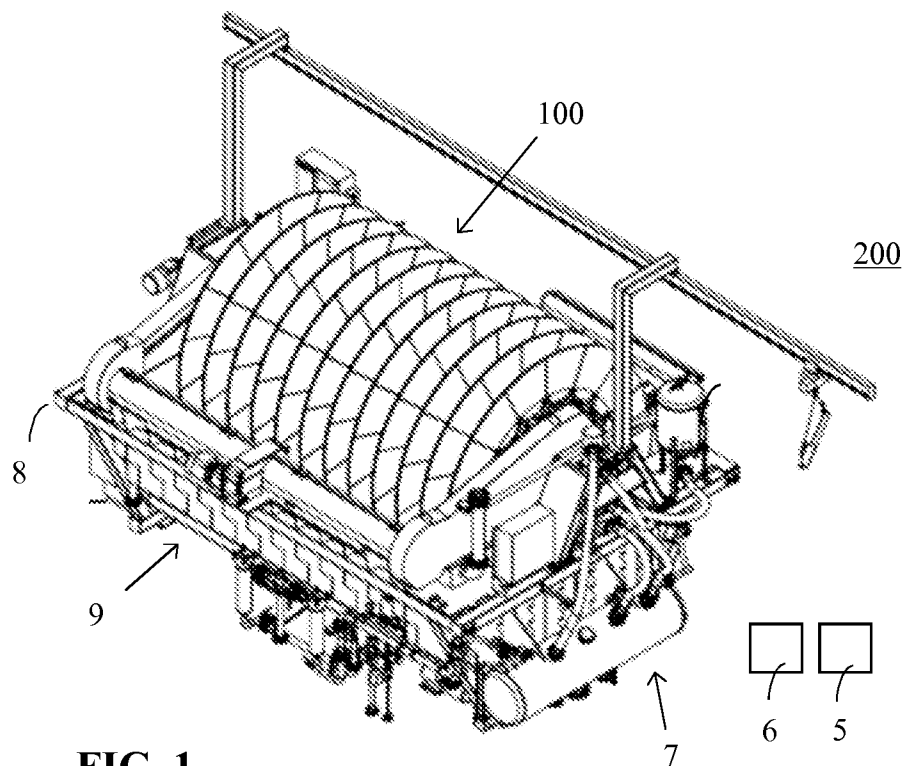


FIG. 1

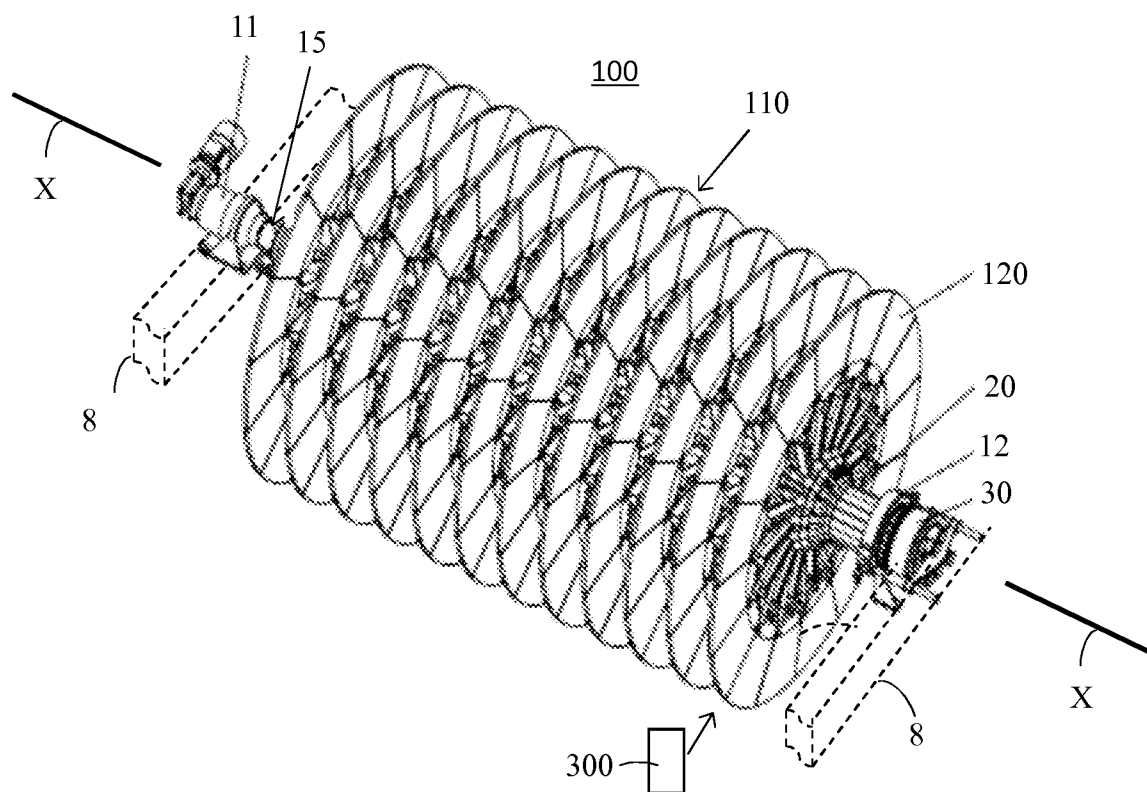


FIG. 2

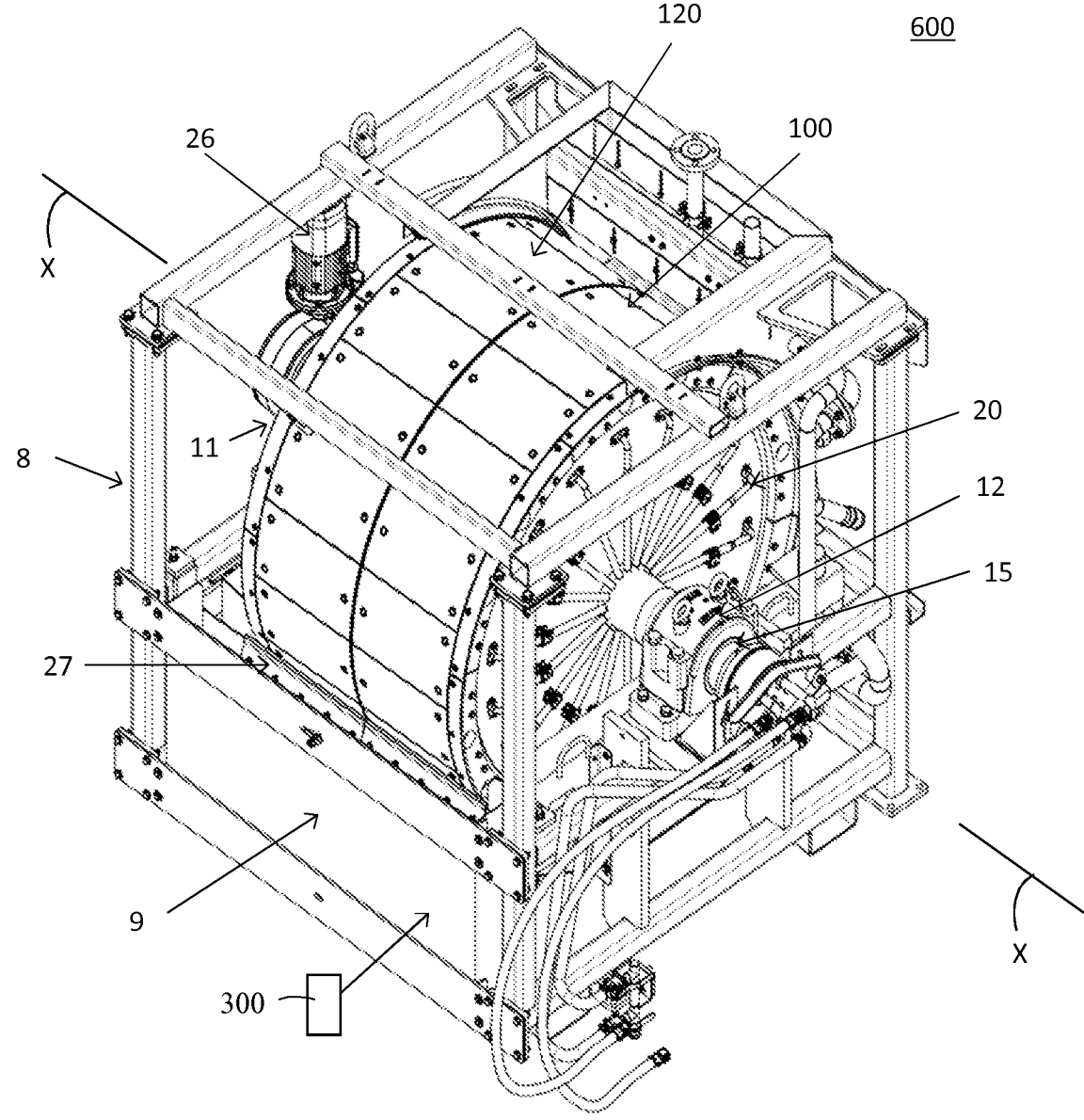


FIG. 3

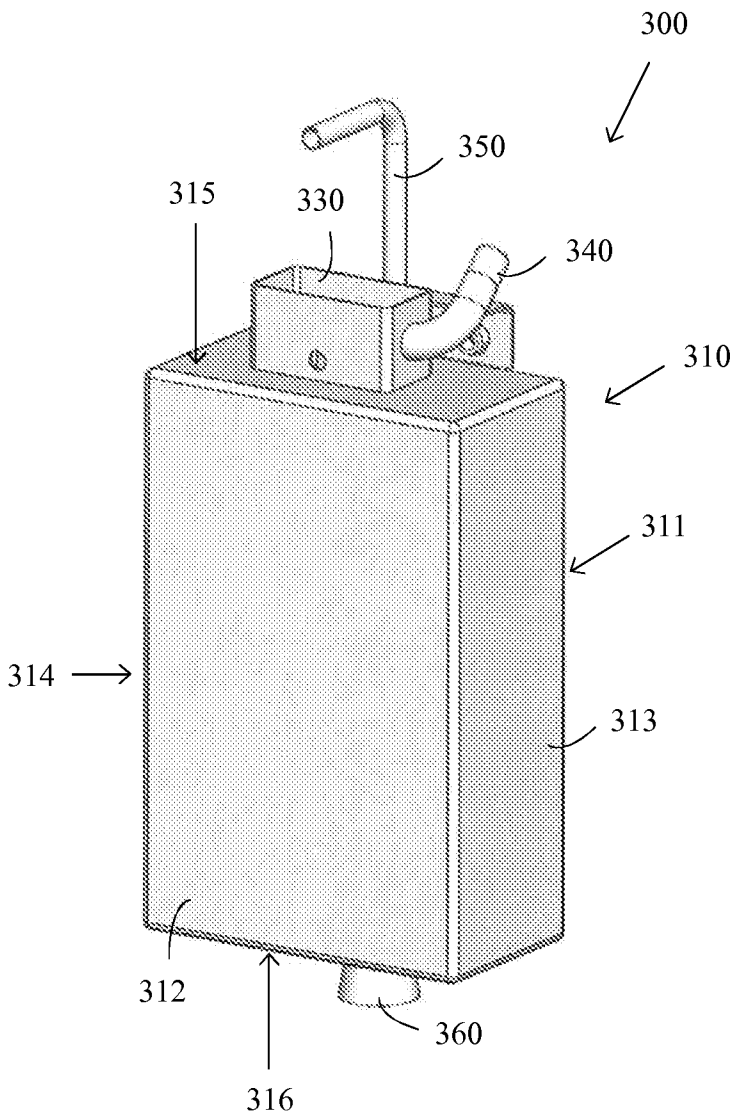


FIG. 4

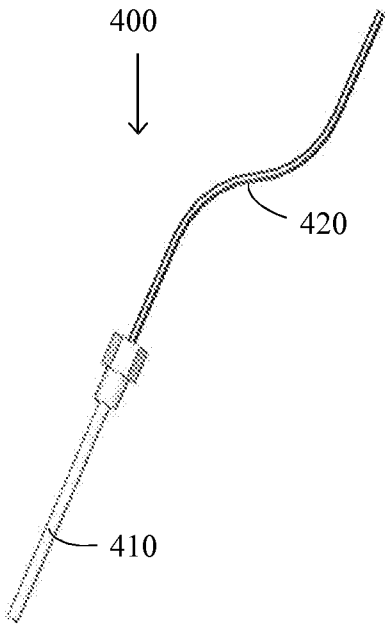


FIG. 5

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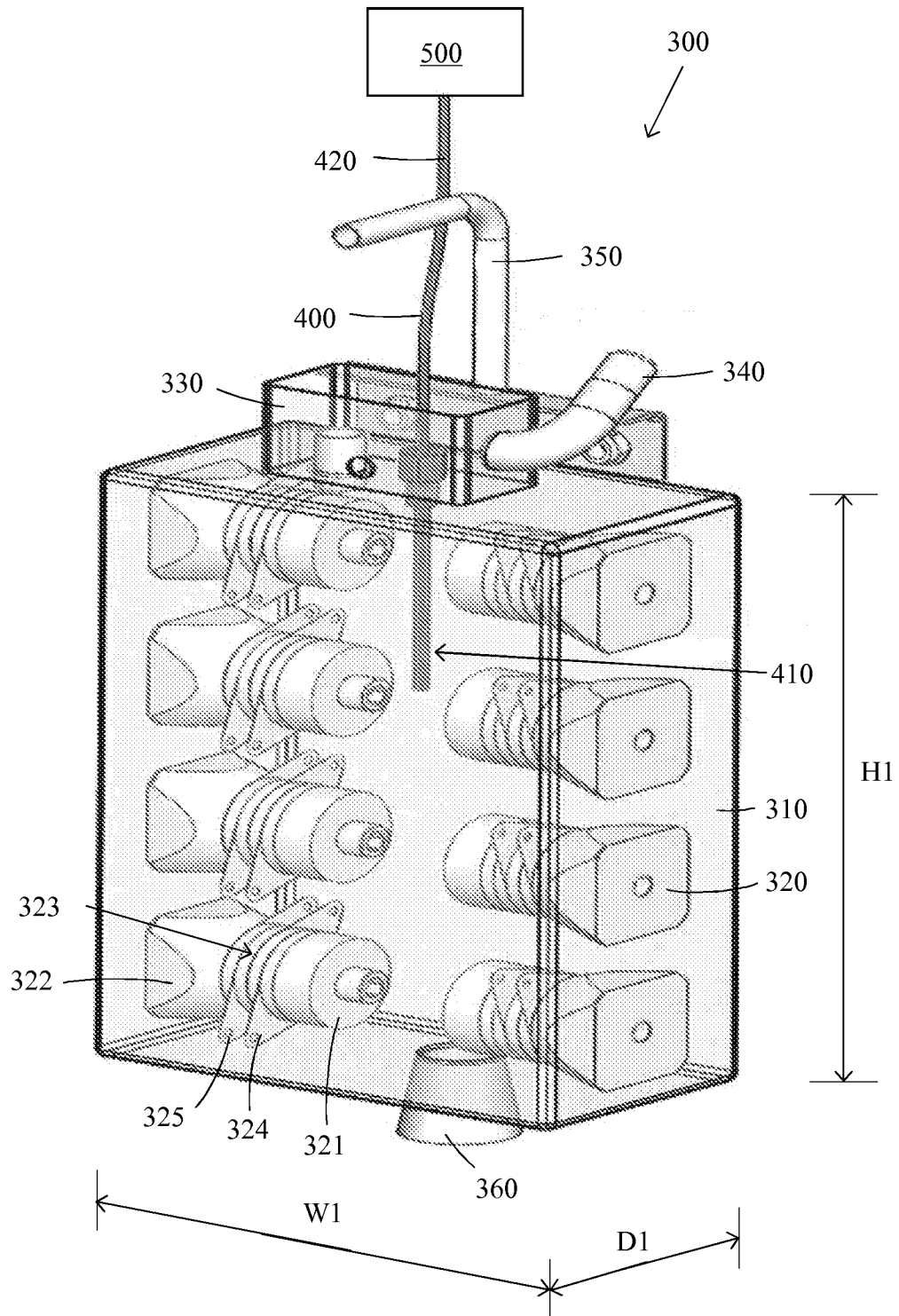


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2015/050883

A. CLASSIFICATION OF SUBJECT MATTER

INV. B01D33/21 B01D33/54 B06B1/02 B08B3/12
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01D B06B B08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 318 578 A (BRANSON NORMAN G) 9 May 1967 (1967-05-09)	1-12,16
Y	column 2, line 43 - column 3, line 16; figures 1-4	13-15,17
Y	----- WO 88/07887 A1 (VALMET PAPER MACHINERY INC [FI]) 20 October 1988 (1988-10-20) the whole document	13-15,17
A	----- US 6 016 821 A (PUSKAS WILLIAM L [US]) 25 January 2000 (2000-01-25) the whole document	1-17
A	----- EP 1 683 466 A1 (ELECTROLUX HOME PROD CORP [BE]) 26 July 2006 (2006-07-26) the whole document	1-17
	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

26 February 2016

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16/03/2016

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INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2015/050883

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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