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(54) **TWO-STAGE WASTEWATER FILTER FOR WASHING MACHINE**

(57) The invention refers to a washing machine (10), comprising
- a water inlet (16) for receiving clean water,
- a washing drum (12),
- a water outlet (18) for discharging wastewater;

the washing machine (10) further comprising a two-stage filter (20) having a first filter element (22) and a second filter element (24), wherein the two-stage filter (20) is fluidicly arranged between the washing drum (12) and the water outlet (18).

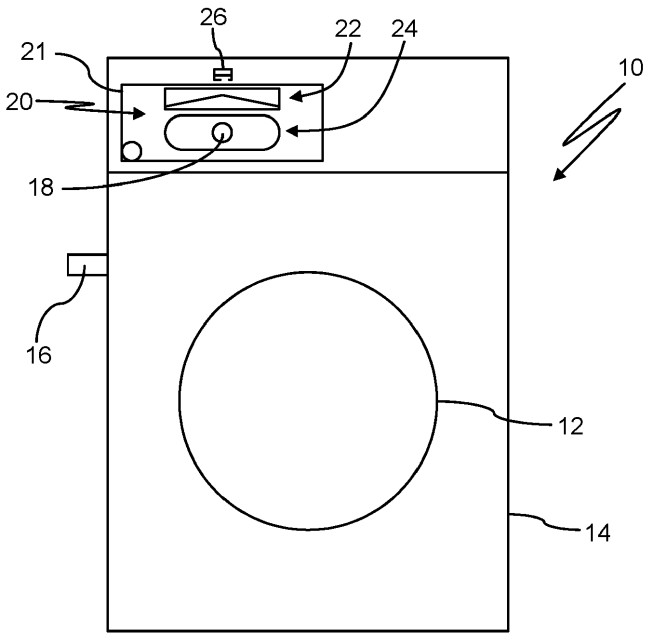

Fig. 1

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Description

Technical field

[0001] The present invention refers to a washing machine, comprising a water inlet for receiving clean water, a washing drum, and a water outlet for discharging wastewater.

Background

[0002] Washing machines of this kind are well known.
[0003] When clothing is being washed, fibers and debris are released. Since clothing is frequently made with synthetic fibers, a certain amount of microplastics is generated during each washing cycle. Nowadays, microplastics emission is frequently considered as a severe ecological problem.
[0004] It is an object of the invention to reduce the ecological impact of washing machines.
[0005] This is achieved by a washing machine according to claim 1 and use of a two-stage filter according to claim 14. Advantageous embodiments are given in the subclaims and the description.

Disclosure of the invention

[0006] In accordance with the invention, a washing machine is provided. The washing machine comprises a water inlet for receiving clean water, e.g. from a water supply, in particular a domestic water supply. The washing machine further comprises a washing drum. The washing drum is supplied with clean water from the water inlet for washing operation. The washing machine also comprises a water outlet for discharging wastewater. I.e., after being used to wash clothing inside the washing drum, the wastewater is fed to a sewer, which is connected to the water outlet of the washing machine. The washing machine may be a washer-dryer.
[0007] According to the invention, the washing machine further comprises a two-stage filter having at least a first filter element and a second filter element, wherein the two-stage filter is fluidicly arranged between the washing drum and the water outlet. In other words, wastewater from the washing drum is fed through the two-stage filter before being purged through the water outlet of the washing machine. The two-stage filter comprises at least two filter stages. In the two-stage filter, the wastewater consecutively passes through the first and second filter elements. In the first filter element, in particular fibers are captured, which have been released from clothing being washed. The second filter element and, optionally any further filter element, collects smaller particles, in particular microplastics. Consequently, the emission of potentially harmful fibers or micro-particles from the washing machine into the environment is reduced or preferably avoided.
[0008] It is understood, that the two-stage filter comprises at least two filter elements arranged in series, namely the first and second filter element. Further filter elements may be provided in the two-stage filter as third or additional filter stages. Likewise, the first and/or second filter stage may comprise several first or second filter elements, wherein the filter elements of the first or second filter stage are arranged for parallel operation.
[0009] Preferably, the two-stage filter is arranged in a drawer compartment of a machine housing. The filter elements of the two-stage filter need to be cleaned or replaced from time to time. By opening the drawer compartment, which simply can be pulled out, this can be facilitated. The drawer compartment may also provide a container for the two-stage filter. Thus, the construction of the washing machine with added wastewater filtration is simplified. In particular, the drawer compartment may form a water basin.
[0010] Preferably, the drawer compartment is arranged above the washing drum. An existing drawer compartment used for dispensing, e.g., washing detergent, may be adapted for the disclosed purpose. In this way, washing machines can be equipped with the two-stage filter with limited adaption of an existing design.
[0011] Indications of directions or positions, such as above or below, generally refer to the washing machine being setup in an operation configuration.
[0012] A wastewater manifold may be provided above the drawer compartment. The wastewater manifold allows feeding wastewater from the washing drum into the drawer compartment with the two-stage filter for filtration of the wastewater prior to its release into the sewer. Typically, the wastewater manifold is fixedly mounted in a machine housing of the washing machine.
[0013] The drawer compartment may comprise a plughole for purging of water from the drawer compartment and a lever operated plug mechanism for opening and closing the plughole. This design avoids that water is spilled during maintenance of the two-stage filter. During regular use of the washing machine, the plug mechanism closes the plughole. The lever may lock the drawer compartment in its closed position. By operating the lever, the plughole is opened by the plug mechanism. Thus, water contained in the drawer compartment is purged into a sewer through the plughole. Further, the drawer compartment may be unlocked. After the drawer compartment has been closed, the plughole is closed by the plug mechanism upon reset of the lever, and the drawer compartment may be locked.
[0014] The two-stage filter may comprise a wiper for cleaning the first filter element. The wiper may scrape fibers from a mesh or other filter medium of the first filter element. By operation of the wiper, the filter surface of the first filter element is freed to further perform filtration and the fibers may be pressed in a storage area.
[0015] Additionally or alternatively, it may be provided that first filter element can be pulled from and pushed into a filter housing of the two-stage filter. This allows cleaning the first filter element, e.g. by rinsing it or by

frictional movement against the filter housing. Removal and installation of the first filter element generally do not require any tools or disassembly of the filter housing.

[0016] The first filter element may comprise a filter mesh. This kind of filter media is particularly useful for retaining fibers. The filter mesh may be configured as a flat mesh. A flat mesh can easily be cleaned, e.g. by a wiper or by rinsing.

[0017] Preferably, the filter mesh of the first filter element is inclined with respect to the horizontal plane by at least 5°, particularly preferably by at least 10°. The inclination to the horizontal plane may be at most 40°, preferably at most 30°. A slight inclination of the filter mesh spreads the water over its surfaces. This contributes to use of the complete area of the filter mesh. Furthermore, water flowing along the surface of the filter mesh automatically carries fibers to the lower parts of the filter mesh. Thus, a self-cleaning effect is obtained; manual cleaning of the first filter element is required less often.

[0018] Preferably, the filter mesh comprises two sections with different inclinations. The filter mesh may be roof-shaped. In other words, the mesh sections may adjoin one another along a common ridgeline at top of the filter mesh. The ridgeline may be curved or pointed. This design enhances the self-cleaning effect and reduces overall height of the first filter element.

[0019] Preferably, the first filter element is arranged above the second filter element. Thus, after passing through the first filter element, water is automatically fed to the second filter element. Consequently, effort for guiding water through the two-stage filter is reduced.

[0020] A deflector plate may be arranged between the first filter element and the second filter element. The water, which has passed through the first filter element, in particular its filter mesh, partially splashes back from the deflector plate and hits the first filter element from the other side. Thereby, fibers that are stuck in the first filter element are freed. A self-cleaning effect is achieved or enhanced in this way.

[0021] A filter medium of the second filter element may annularly surround an interior space. A compact filter element with high accumulation capacity can be obtained by this design. In this embodiment, water generally passes through a filter medium of the second filter element from radially outside towards the radial inside. A cross section of the second filter element may be circular or preferably oval. A filter medium of the second filter element may be pleated. An outlet of the second filter element is typically provided at an axial end face, in particular an end cap of the second filter element.

[0022] Preferably, a central axis of the second filter element is oriented in the horizontal direction. A horizontal flow of water towards the water outlet of the washing machine can be established in this way. This contributes to a compact design of the two-stage filter.

[0023] The two-stage filter may be provided as a filter cartridge with a cartridge housing having a cartridge inlet and a cartridge outlet, in which cartridge housing the first filter element and the second filter element are arranged. This allows for an integrated design with low space requirements. Further, maintenance of the filter is facilitated in that the complete cartridge can be easily replaced when required. The first filter element of the cartridge may comprise a flat filter mesh. Preferably, a depth filtration medium is employed for the second filter element. For operation of the washing machine, the cartridge outlet is generally connected to the water outlet. The cartridge inlet serves to receive wastewater from the washing drum.

[0024] Preferably, a filter medium of the second filter element is recyclable. In this way, the environmental impact of disposing the second filter element is reduced.

[0025] A filter medium of the second filter element may have

- an air permeability between 600 l/(m^{2*}s) and 2000 l/(m^{2*}s) at 200 Pa (according to ISO 9237), and/or
- a thickness between 1 mm and 4 mm at 0.5 kPa (according to DIN EN ISO 9073-2), and/or
- a specific weight between 200 g/m^2 and 400 g/m^2 (according to DIN EN 29 073-1).

[0026] It was found by the inventors that a filter medium with these properties is particularly effective for capturing microplastics.

[0027] The invention also refers to a two-stage filter with a first filter element and a second filter element for filtering wastewater of a washing machine. The two-stage filter may have further features as described above.

[0028] The invention further relates to a use of a two-stage filter having a first filter element and a second filter element for filtering wastewater of a washing machine. The two-stage filter is preferably used in a washing machine according to the invention, as described above. The two-stage filter may have further features as described above.

[0029] Preferably, the first element is periodically cleaned, in particular after at least 5 and/or at most 15 washing cycles. This ensures that the first filter element, in particular a filter mesh thereof, is not blocked by fibers or the like.

[0030] The second filter element may be periodically replaced, in particular after at least 30, preferably at least 40, and/or at most 100, preferably at most 60, washing cycles. This ensures that the second filter element is capable to retain microplastics. In particular, it is avoided that previously captured microplastics are released from the second filter element, which might happen when the second filter element is used after its accumulation capacity has been completely utilized.

[0031] Preferably, the two-stage filter is arranged in a drawer compartment of a machine housing of the washing machine, wherein the drawer compartment is opened for cleaning of the first filter element and/or for replacement of the second filter element and wherein the drawer

compartment is closed for washing operation of the washing machine. The drawer compartment may also be opened to clean the first filter element and/or to replace the second filter element. The drawer compartment facilitates maintenance of the two-stage filter. This increases the willingness of users to execute the maintenance required to ensure full functionality of the two-stage filter.

Brief description of drawings

[0032] Other advantages and features of the invention will be appreciated from the following description of embodiments of the invention with reference to the figures of the drawing, which show significant details, and from the claims. The individual features, as described above or explained below, may each be implemented individually or implemented together in any useful combination in variants of the invention.

Fig. 1 shows a washing machine according to the invention comprising a two-stage filter, which is arranged in a drawer compartment, in a schematic cross section;

Fig. 2 shows the drawer compartment comprising the two-stage filter of the washing machine of Fig. 1, in an enlarged view;

Fig. 3 shows the drawer compartment and two-stage filter of the washing machine of Fig. 1 in a schematic longitudinal section;

Fig. 4 shows a filter cartridge comprising a filter mesh and a depth filtration medium for use in a washing machine according to the invention, in a schematic sectional view;

Fig. 5 shows a two-stage filter with a first filter mesh and an annular second filter medium, wherein a deflector plate is arranged below the filter mesh, for use in a washing machine according to the invention, in a schematic sectional view;

Fig. 6 shows a perspective view of the two-stage filter of Fig. 5, in the area of the filter mesh and deflector plate.

Detailed description

[0033] **Figure 1** shows a washing machine **10**. The washing machine 10 comprises a washing drum **12**, which is rotatably mounted in a machine housing **14**. Clean water is fed to the washing drum 12 through a water inlet **16**. Wastewater is disposed into a sewer (not depicted) through a water outlet **18**. Before being disposed at the outlet 18, the wastewater, which may be contaminated with dirt, debris and fibers from clothing, is filtered in a two-stage filter **20**.

[0034] In the depicted embodiment, the two-stage filter 20 is arranged in a drawer compartment **21,** which is positioned above washing drum 12. The drawer compartment 21 with two-stage filter 20 is depicted in more detail in **Figures 2** and **3.** The two-stage filter 20 comprises a first filer element **22** and a second filter element **24.** In the depicted embodiment, the first filter element 22 is positioned above the second filter element 24. Both filter elements 22, 24 are releasably held in the drawer compartment 21. For washing operation, the drawer compartment 21 is closed. For maintenance of the two-stage filter 20, in particular for cleaning of the first filter element 22 and/or replacement of the second filter element 24, the drawer compartment 21 can be opened.

[0035] A wastewater manifold **26** is arranged in the machine housing 14 above the drawer compartment 21 and the filter elements 22, 24. Dirty water (wastewater) from the washing drum 12 is fed to the two-stage filter 20 through the wastewater manifold 26. After having been filtered by the two-stage filter 20, the wastewater, which now contains less debris, in particular less or no fibres and less or no microplastics is disposed through the water outlet 18.

[0036] The first filter element 22 comprises a flat filter mesh **28** held in a frame **30,** cf. in particular Figure 2. The filter mesh 28 is arranged at an angle of e.g. 20° with respect to the horizontal plane, wherein two filter sections of the filter mesh 28 may have different orientations of their inclination. In other words, the filter mesh 28 may be roof-shaped. The wastewater is poured on the ridge between the two inclined filter sections. Thus, the water partially flows along the filter mesh 28 prior to passing through the first filter element 22. A permanent self-cleaning may be obtained in this way. In particular fibers are captured by the first filter element 22 and may be collected at the lower ends of filter mesh 28 near frame 30.

[0037] The second filter element 24 comprises a filter medium **32,** which annularly surrounds an interior space **34.** A central axis **36** (see Figure 3) of the second filter element 24 is oriented horizontally in the embodiment of Figures 1 to 3.

[0038] After having passed through the filter mesh 28 of first filter element 22, the water pours onto the second filter element 24 and is collected inside the drawer compartment 21. A certain level of water will build up in the drawer compartment, in particular approximately to the height of the water outlet 18 (which roughly corresponds to the central axis 36 in the present embodiment). The water outlet 18 and the second filter element 24 may be positioned near the bottom of the drawer compartment 21 to minimize water buildup in the compartment 21.

[0039] The water radially passes through the filter medium 32 of the second filter element 24. Water will enter the second filter element 24 in particular directly from above (when dripping onto the second filter element 24) and from below because the water level is higher than the underside of filter element 24.

[0040] In particular microplastics are captured by the filter medium 32 of the second filter element 24. To achieve advantageous filtering properties, the filter medium 32 may have an air permeability of 1000 l/(m^{2*}s) at 200 Pa, a thickness of 3 mm, and/or a specific weight of 300 g/m^2.

[0041] Since water stands in the drawer compartment 21 during washing and filtering operation, the drawer compartment should be emptied from water prior to opening the drawer compartment 21 for maintenance of the two-stage filter 20. To this end, a plug mechanism **38** is provided which allows to open or close a plughole **40** with a plug **42,** see in particular Figure 3.

[0042] For washing and filtering operation, the plughole 40 is closed by the plug 42. A lever **44,** which is connected to the plug 42, may lock the drawer compartment 22 to the machine housing 14.

[0043] Upon actuation of the lever 44, the plug 42 opens the plughole 40 and the drawer compartment 22 may be unlocked. Water from inside the drawer compartment 21 flows through plughole 40 and is guided into the sewer, to which water outlet 18 is also connected (not depicted in greater detail). In order to release substantially all water from the drawer compartment 21, the drawer compartment 21 has an inclined bottom face **46** with the plughole 40 located at a lower end thereof. To allow all water to drain from the drawer compartment 21, it is advisable that the drawer compartment 21 is not opened immediately when operating lever 44. Rather, one shoud wait for a few seconds before pulling drawer compartment 21 out of machine housing 14.

[0044] For best filtration performance, the filter mesh 28 of first filter element 22 should be cleaned from fibers approximately every 10 washing cycles. Likewise, the second filter element 24 should be replaced after approximately 50 washing cycles. Preferably, the filter medium 32 of the second filter element 24 is recyclable or biodegradeble.

[0045] **Figure 4** shows a two stage filter **50,** which is designed as a filter cartridge **52,** for a washing machine. For instance, the filter cartridge 52 might be mounted in the drawer compartment 21 of washing machine 10 (cf. Figure 1). Other installation options are also conceivable, e.g. below washing drum 12.

[0046] Two filter elements 22 are permanently mounted inside a cartridge housing **54** of filter cartridge 52. From time to time, e.g. after 50 washing cycles, filter cartridge 52 should be replaced, in order to assure best filtration performance.

[0047] Wastewater from the washing drum 12 is guided into filter cartridge 52 through a cartridge inlet **56**. A distributor plate **57** may be provided to spread the water over a, preferably flat, filter mesh 28 of the first filter element 22. Water flowing across the surface of the filter mesh 38 may provide a self cleaning effect and contribute to collect fibres at the perimeter of the first filter element 22 where it is fixed to cartridge housing 54.

[0048] A second filter element 24, which may comprise a depth filtration medium **58**, is provided below the first filter element 22. Both filter elements are sealed against cartridge housing 54. Thus, the water which has been pre-filtered by the first filter element 22 is subject to fine filtration at the second filter element 24. In particular microplastics are captured in the depth filtration medium 58. Wastewater, which has been cleaned from fibers and microplastics by the filter elements 22, 24, is discharged through a cartridge outlet **60** at the lower end of cartridge housing 54. In the installed state, the cartridge outlet 60 is connected to the water outlet of washing machine 10, which leads into a sewer.

[0049] **Figures 5** and **6** show a futher two-stage filter **70** for wastewater filtration at a washing machine. The two-stage filter 70 has a filter housing **72**, which may comprise an upper and a lower housing part **74**, **76**. Two filter elements 22, 24 are received inside filter housing 72 for consecutive filtration of wastewater.

[0050] A (first) housing inlet **78** and optionally an additional housing inlet **80** are formed at upper housing part 74. The first filter element 22, which comprises a flat filter mesh 28, is arranged between the two housing parts 74, 76. Different flow patterns on the first filter element 22 may be established by using either or both of housing inlets 78, 80. Self cleaning can in particular be enhanced by chosing an approriate flow ratio through the housing inlets 78, 80.

[0051] The first filter element 22 may be releasably held in filter housing 70. In particular, it may be possible to pull the first filter element 22 from filter housing 72 for cleaning purposes and to push it back in for filtering operation without disassembly of filter housing 72.

[0052] Additionally or alternatively, a wiper (not depicted in detail) might be provided in order to scrape fibers or other debris off the filter mesh 28 of the first filter element 22 while being installed in the filter housing 72. The wiper may be actuated by a lever from outside the filter housing 72. The lever may be operated by a user to cause the wiper to move across the filter surface of filter mesh 28. The wiper may alternatively be actuated by a motor.

[0053] Lower housing part 76 defines a cavity in which the second filter element 24 is received. In this embodiment, the second filter element 24 comprises a filter medium **82**, in particular pleated filter paper, which annularly surrounds an interior space 34. At its upper end, the annular filter medium 82 is closed by a first end cap **84** and a deflector plate **86**. A central region of deflector plate 86, which spans across an opening of first end cap 84 is completely closed. The deflector plate 86 sealingly rests against first end cap 84. Flow openings **88** are provided in a peripheral region (radially at the outside) of deflector plate 86, cf. in particular Figure 6.

[0054] Water which passes through the first filter element 22 partially splashes back from the closed central region of deflector plate 86 and hits the
filter mesh 28 from below (note that the filter mesh is not depicted in Figure 6 for greater clarity). Thereby, fibers which might block the filter mesh 28, are freed and can be carried towards a radially outer region by water on the upper side of filter mesh 28.

[0055] At its lower end, annular filter medium 82 is sealed by a second end cap **90,** which rests agains a bottom face **92** of filter housing 72, see Figure 5. A housing outlet **94** is provided at the bottom face 92.

[0056] Water, which has passed through the flow openings 88 in the peripheral region of deflector plate 86, is directed through the filter medium 82 of the second filter element 24 in a radially inward direction to enter interior space 34. In particular microplastics are retained in the filter medium 82.

[0057] The filtered wastewater exits two-stage filter 70 at the housing outlet 94. Housing outlet 94 is connected to a water outlet of the washing machine 10 (cf. Figure 1), which in turn may lead into a sewer (not depicted in detail). Two-stage filter 70 may be arranged somewhere inside machine housing 14, for instance beside washing drum 12.

[0058] In summary, the invention relates to a two-stage filter, which is used to filter wastewater of a washing machine before the wastewater is discharged from the washing machine. A first filter element serves to capture larger contaminants, such as fibers. A second filter element, which is arranged downstream the first filter element, serves to capture smaller contaminants, such as microplastics. The two-stage filter may be arranged in a drawer compartment, in order to facilitate maintenance.

List of reference signs

[0059]

Washing machine **10**
Washing drum **12**
Machine housing **14**
Water inlet **16**
Water outlet **18**
Two-stage filter **20**; **50**; **70**
Drawer compartment **21**
First filer element **22**
Second filter element **24**
Wastewater manifold **26**
Filter mesh **28**
Frame **30**
Filter medium **32**
Interior space **34**
Central axis **36**
Plug mechanism **38**
Plughole **40**
Plug **42**
Lever **44**
Bottom face **46**
Filter cartridge **52**
Cartridge housing **54**
Cartridge inlet **56**
Distributor plate **57**
Depth filtration medium **58**
Cartridge outlet **60**
Filter housing **72**
Upper housing part **74**
Lower housing part **76**
Housing inlet **78**
Additional housing inlet **80**
Filter medium **82**
First end cap **84**
Deflector plate **86**
Flow openings **88**
Second end cap **90**
Bottom face **92**
Housing outlet **94**

Claims

1. Washing machine (10), comprising

- a water inlet (16) for receiving clean water,
- a washing drum (12),
- a water outlet (18) for discharging wastewater;

the washing machine (10) further comprising a two-stage filter (20; 50; 70) having at least two filter stages, the two-stage filter (20; 50; 70) comprising a first filter element (22) and a second filter element (24), wherein the two-stage filter (20; 50; 70) is fluidicly arranged between the washing drum (12) and the water outlet (18).

2. Washing machine (10) according to claim 1, wherein the two-stage filter (20; 50) is arranged in a drawer compartment (21) of a machine housing (14), preferably wherein the drawer compartment (21) is arranged above the washing drum (12), preferably wherein a wastewater manifold (26) is provided above the drawer compartment (21).

3. Washing machine (10) according to claim 2, wherein the drawer compartment (21) comprises a plughole (40) for purging of water from the drawer compartment (21) and a lever operated plug mechanism (38) for opening and closing the plughole (40).

4. Washing machine (10) according to any of the preceding claims, wherein the two-stage filter (70) comprises a wiper for cleaning the first filter element (22) or
wherein the first filter element (22) can be pulled from and pushed into a filter housing (72) of the two-stage filter (70).

5. Washing machine (10) according to any of the preceding claims, wherein the first filter element (22) comprises a filter mesh (28).

6. Washing machine (10) according claim 5, wherein the filter mesh (28) of the first filter element (22) is inclined with respect to the horizontal plane by at least 5°, preferably by at least 10°, and/or by at most 40°, preferably by at most 30°.

7. Washing machine (10) according to any of the pre-

ceding claims, wherein the first filter element (22) is arranged above the second filter element (24).

8. Washing machine (10) according to any of the preceding claims, wherein a deflector plate (86) is arranged between the first filter element (22) and the second filter element (24).

9. Washing machine (10) according to any of the preceding claims, wherein a filter medium (32; 82) of the second filter element (24) annularly surrounds an interior space (34), preferably wherein a central axis (36) of the second filter element (24) is oriented in the horizontal direction.

10. Washing machine (10) according to any of the preceding claims, wherein the two-stage filter (50) is provided as a filter cartridge (52) with a cartridge housing (54) having a cartridge inlet (56) and a cartridge outlet (60), in which cartridge housing (54) the first filter element (22) and the second filter element (24) are arranged.

11. Washing machine (10) according to any of the preceding claims, wherein a filter medium (32) of the second filter element (24) has

- an air permeability between 600 l/(m^{2*}s) and 2000 l/(m^{2*}s) at 200 Pa, and/or
- a thickness between 1 mm and 4 mm at 0.5 kPa, and/or
- a specific weight between 200 g/m^2 and 400 g/m^2.

12. Use of a two-stage filter (20; 50; 70) having at least two filter stages, the two-stage filter (20; 50; 70) comprising a first filter element (22) and a second filter element (24) for filtering wastewater of a washing machine (10).

13. Use according to claim 12, wherein the first filter element (22) is periodically cleaned, in particular after at least 5 and/or at most 15 washing cycles.

14. Use according to claim 12 or 13, wherein the second filter element (24) is periodically replaced, in particular after at least 30, preferably at least 40, and/or at most 100, preferably at most 60, washing cycles.

15. Use according to any of claims 12 to 14, wherein the two-stage filter (20; 50) is arranged in a drawer compartment (21) of a machine housing (14) of the washing machine (10), wherein the drawer compartment (21) is opened for cleaning of the first filter element (22) and/or for replacement of the second filter element (24), and wherein the drawer compartment (21) is closed for washing operation of the washing machine (10).

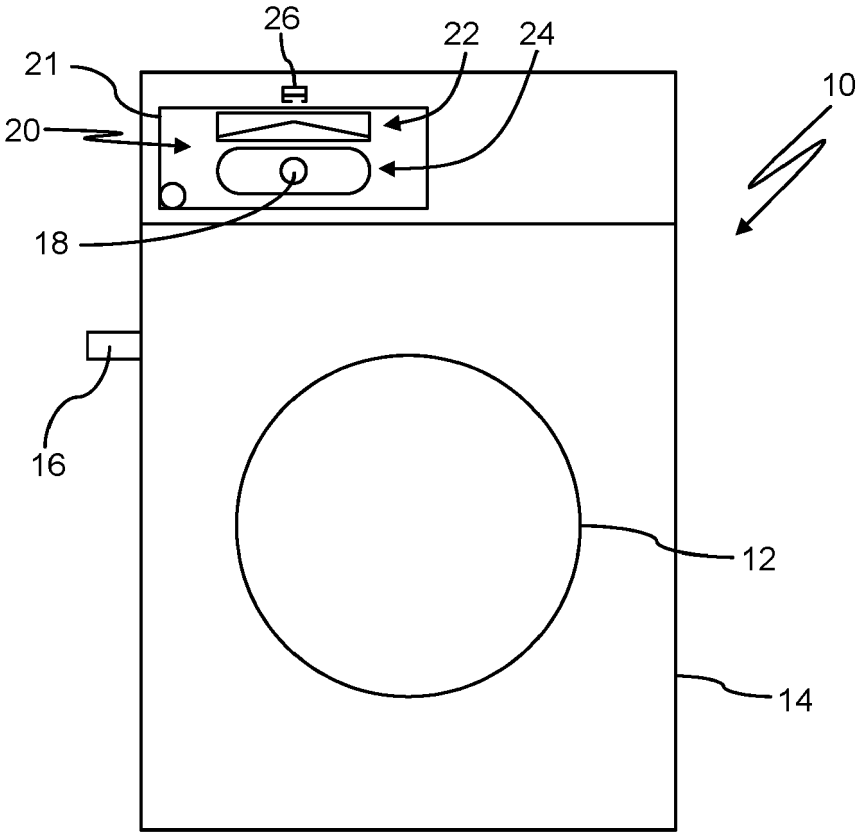

Fig. 1

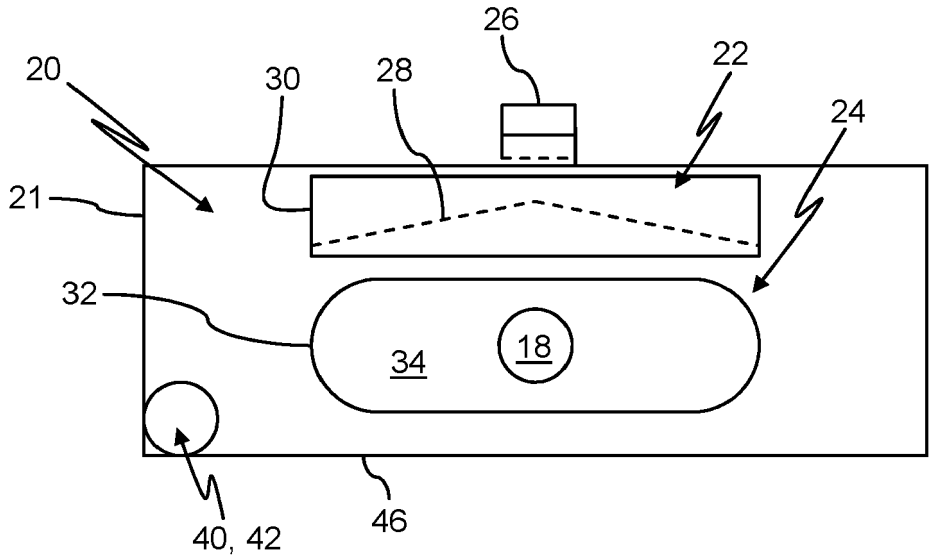

Fig. 2

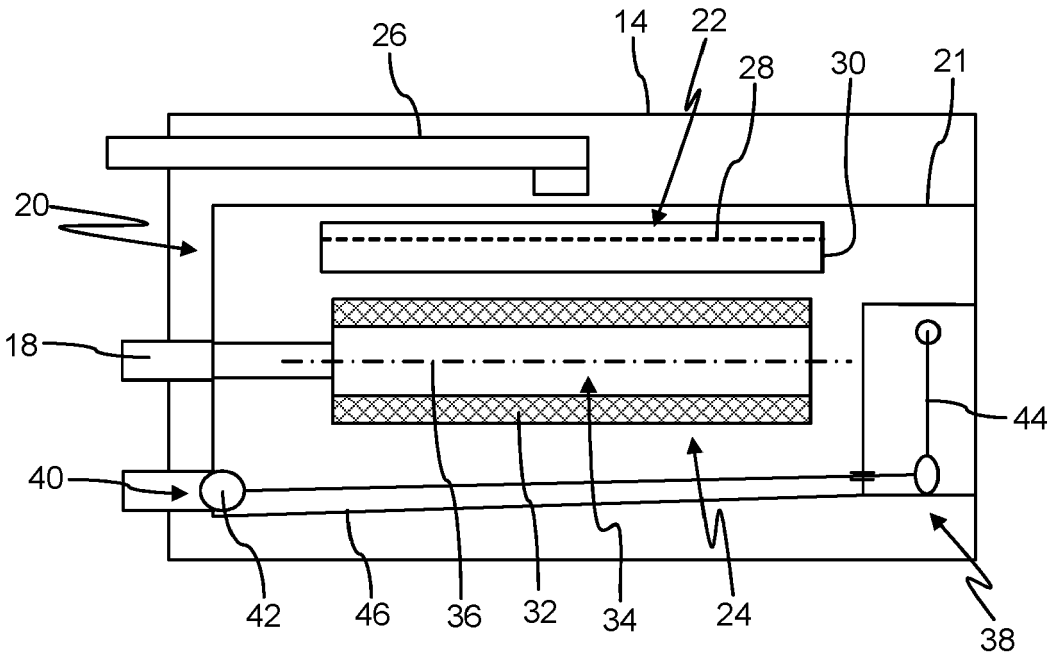
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Fig. 3

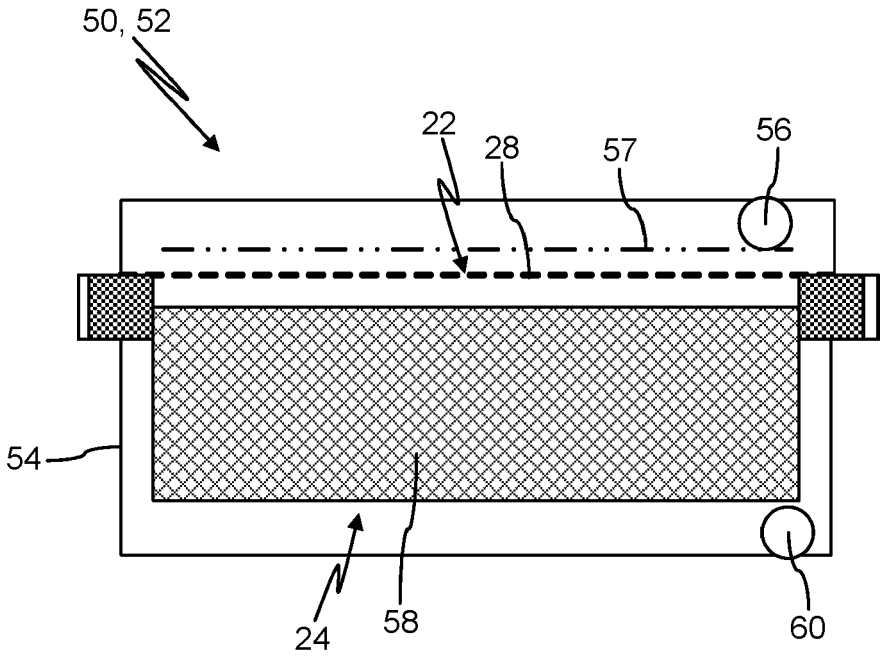
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Fig. 4

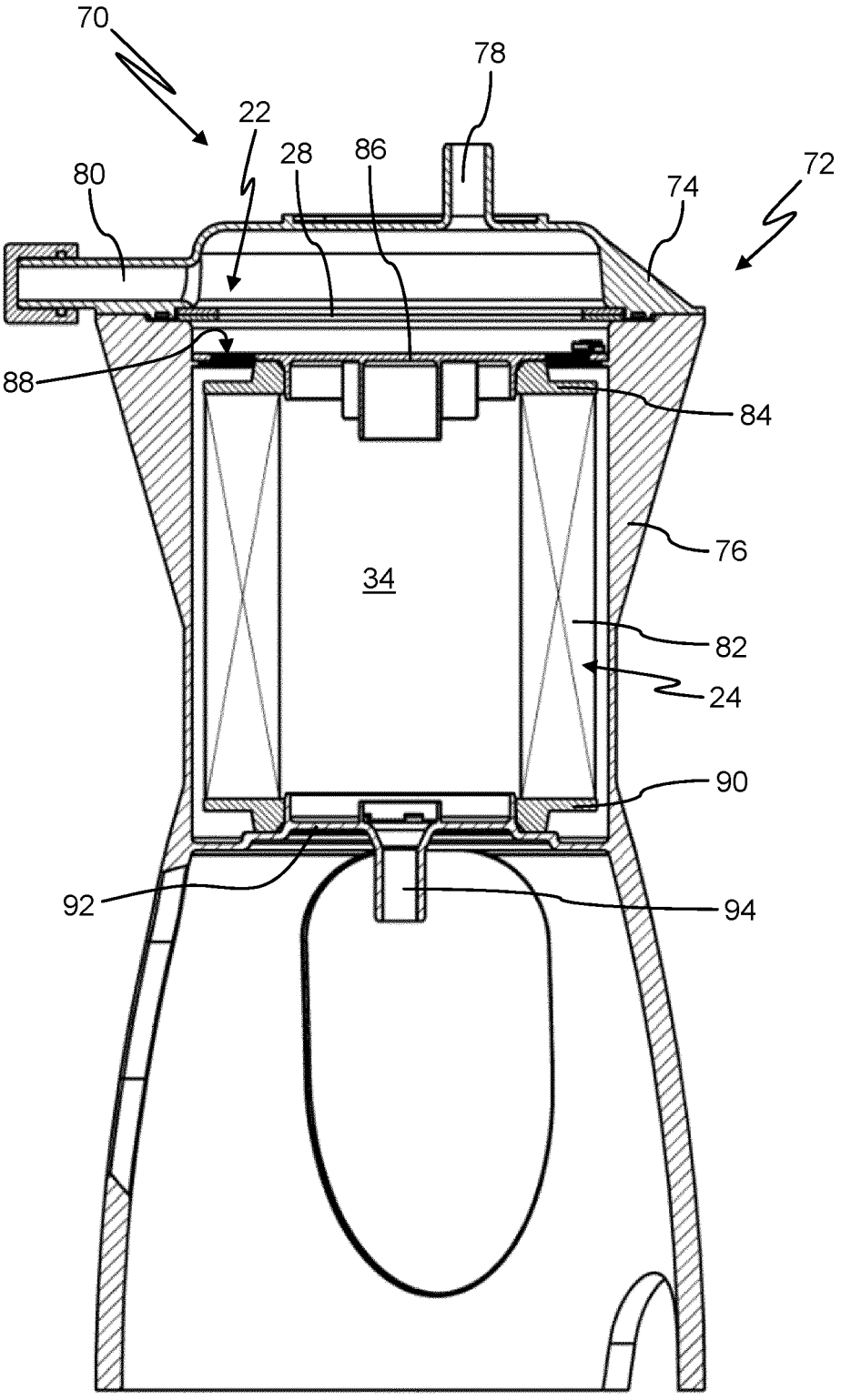

Fig. 5

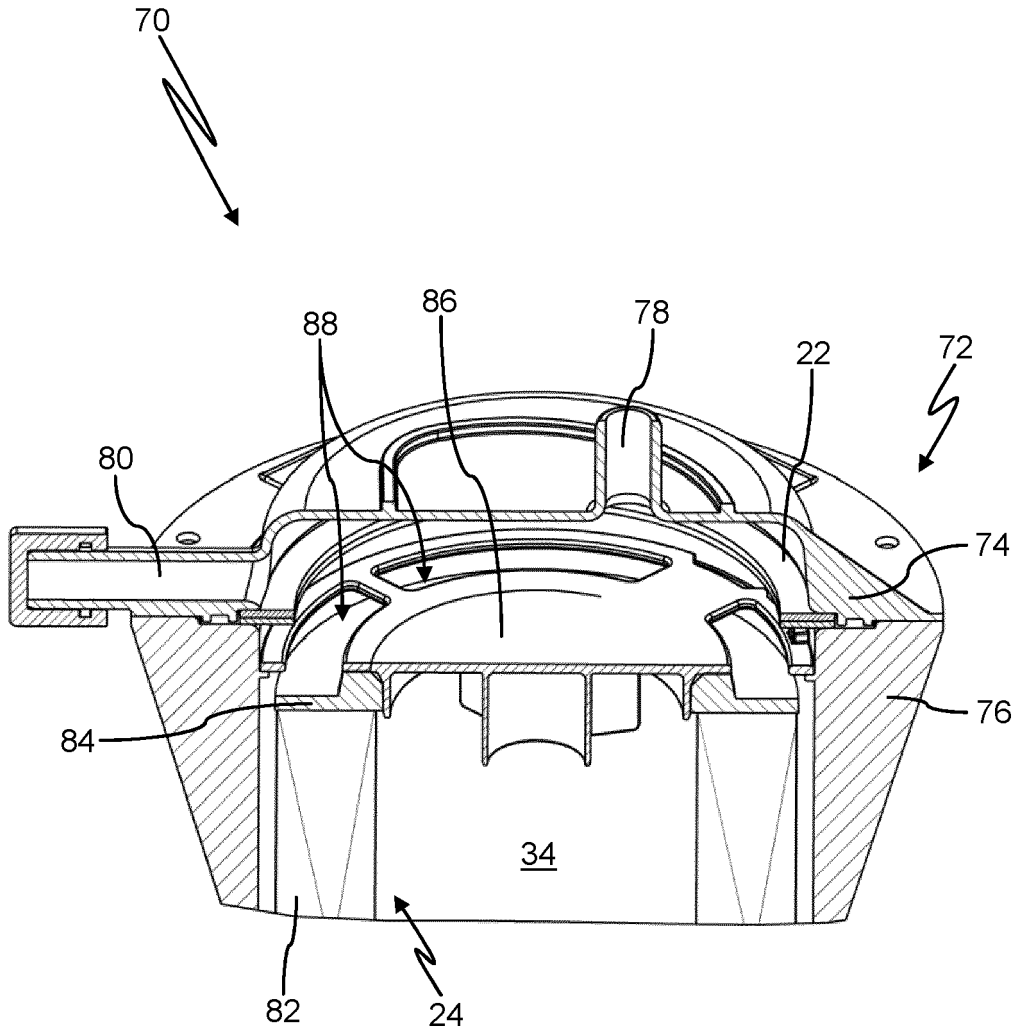

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 16 6453

DOCUMENTS CONSIDERED TO BE RELEVANT

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