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(71) Applicant: **Askoll Holding S.r.l.**
36031 Povolaro di Dueville (Vicenza) (IT)

(72) Inventor: **MARIONI, Elio**
36031 Dueville (VI) (IT)

(74) Representative: **Botti & Ferrari S.p.A.**
Via Cappellini, 11
20124 Milano (IT)

(54) DISCHARGE PUMP FOR HOUSEHOLD APPLIANCE PROVIDED WITH A FILTER FOR MICROPLASTICS AND RELATED CONTROL METHOD

(57) Control method for a variable speed discharge pump of a large household appliance for washing and/or drying clothes, wherein a filter for collecting microplastics is placed downstream of said discharge pump, said control method comprising the following steps:
- operating the discharge pump at an initial rotational speed to which an initial flow rate through the filter (100) corresponds;
- increasing the rotational speed of the discharge pump over time until the filter is replaced or cleaned, in order to compensate for the decrease in the flow rate due to the progressive clogging of the filter (600).

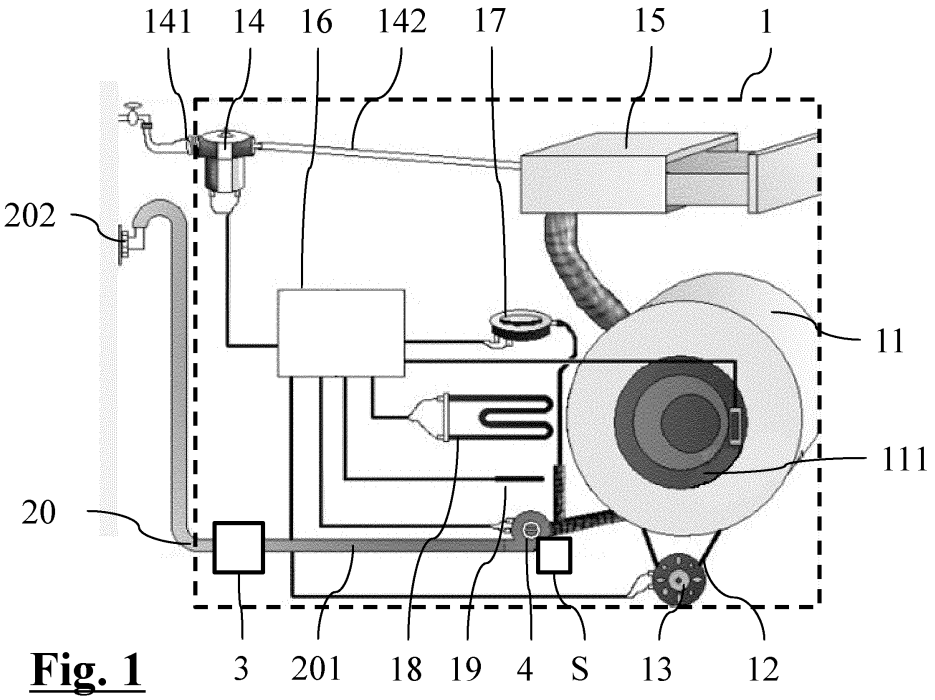

Fig. 1

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Description

Field of application

[0001] The present invention relates to a discharge pump for a large household appliance such as a washing machine, a clothes dryer, a washer dryer or another appliance dedicated to the treatment of linen. In particular, the discharge pump according to the present invention finds useful application if mounted on household appliances equipped with a filter for the collection of microplastics.

[0002] The invention also relates to a control method for the discharge pump and to the household appliance as a whole.

[0003] Therefore, the invention addresses the industrial field of large household appliances, in particular of washing machines, and the related components.

Prior art

[0004] Currently, it is now known that microplastic pollution is a global environmental emergency. Actually, the clothing items currently in use are particularly rich in synthetic fibers, such as polyester, nylon, acrylic and the like. During machine washing, these fibers can release tiny plastic fragments with each wash, which reach the drain and are then released into water and soil, thus entering the food chain.

[0005] To contain this phenomenon, filters are being spread to be coupled with household appliances in order to capture the microplastics released in the washing cycle prior to being discharged into waste water.

[0006] In particular, mechanical filters placed on the drain line of a washing machine are known, in order to incorporate microplastic particles before the water is released into the drain: these mechanical filters may be installed between the washing machine drain and the wall connection or, if originally provided by the manufacturer, directly integrated into the casing of the appliance.

[0007] These mechanical filters have an increasing hydraulic resistance over their life, since they are progressively saturated by the collected particles. Therefore, by working with a constant speed discharge pump, there is a reduction in the water flow rate through the filter over time based on the level of clogging. In particular, we go from an initial condition, in which the filter is new and therefore the water flow flows freely through the filter itself with nominal flow rate, to a final condition, in which the filter is completely saturated, thus reducing and almost canceling the passage of water. In this final condition, it is necessary to replace or clean the filtering element depending on whether the filter used is of a cartridge type or a reusable one.

[0008] On the other hand, the variable hydraulic resistance of the filter often leads to the need of replacing or cleaning the filter itself before it is completely saturated. Indeed, the progressive decrease in the flow rate, in addition to being potentially unwanted since it lengthens the washing cycle times, conflicts in many cases with the control electronics, which can diagnose a clogging in the drain or a malfunction of the pump due to the lengthening of the water evacuation time.

[0009] It should also be noticed that in many cases the filtering systems proposed on the market are not able to signal the condition of complete saturation to the user, so that the replacement or cleaning often occurs early at the first signs of lengthening of the discharge time.

[0010] Document WO 2022/203217 A1 shows a control method for a variable speed discharge pump according to the prior art.

[0011] In light of the drawbacks and unsolved problems of the prior art, the technical problem underlying the present invention is to devise a control method for the discharge pump which allows an optimal use of the filters for microplastics.

[0012] An object of the method according to the present invention is to ensure an extended life cycle of the filter for microplastics, thus allowing for less frequent replacement or cleaning of the filter.

[0013] A further object of the present invention is to provide a feedback to the user when replacing or cleaning the filter.

Summary of the invention

[0014] The idea underlying the present invention is to adapt the speed of the discharge pump over time, so as to keep the flow rate through the filter substantially constant despite the progressive clogging thereof.

[0015] The above defined technical problem is thus solved by a control method for a variable speed discharge pump of a large household appliance for washing and/or drying linen, wherein at least one filter for collecting microplastics is placed downstream of said discharge pump, said control method comprising the steps of:

- operating the discharge pump at an initial rotational speed which an initial flow rate through the filter corresponds to;

characterized in that it further comprises the step of:

- increasing the rotational speed of the discharge pump over time until the filter is replaced or cleaned, in order to compensate for the decrease of the flow rate due to the progressive clogging of the filter.

[0016] Preferably, the household on which the discharge pump operates is a washing machine, a clothes dryer or a washer dryer.

[0017] The discharge pump comprises an electric motor, preferably a three-phase direct current electric motor, such as a BLDC motor.

[0018] Preferably, the method according to the present

invention may comprise a step of obtaining an electric parameter that is indicative of the power input of the discharge pump in order to indirectly monitor the decrease in the flow rate. In the step of increasing the rotational speed of the discharge pump over time, said speed is thus increased with the decrease in the power input.

[0019] Preferably, the electric parameters obtained may comprise electric current and voltage and/or back electromotive force.

[0020] Preferably, the control method according to the present invention further comprises the steps of identifying a condition of exhausted filter (i.e. clogged to the point of needing replacement or cleaning) for said filter and of signaling said condition of exhausted filter to the user, for instance through communication to the control unit of the household appliance.

[0021] The condition of exhausted filter may be identified upon reaching a pre-set maximum rotational speed. In this case, previous laboratory tests may have been performed to determine this maximum rotational speed.

[0022] Alternatively, the condition of exhausted filter may be identified in an iterative manner until the moment when the increase in the rotational speed does not allow any longer to restore the power input above a value of minimum threshold.

[0023] Indicatively, the initial rotational speed may be comprised between 500 and 1500 rotation per minute and be increased up to a maximum rotational speed comprised between 3000 and 4000 rotation per minute.

[0024] In an embodiment, in the control method the increase in the rotational speed of the pump occurs by discrete steps each time a control value crossing a threshold is detected. As previously mentioned, said control value may be the power input, case in which the speed is increased by a discrete step each time the detected power input is below a minimum threshold.

[0025] Alternatively, the control method may operate a continuous adjustment of the feedback rotational speed with respect to the acquired value of the control parameter, for instance the power input.

[0026] The technical problem previously cited is also solved by a discharge pump comprising a control board configured to operate said discharge pump according to the control method previously discussed.

[0027] The technical problem previously cited is also solved by a household appliance for washing and/or drying linen, comprising:

a water inlet circuit, a drum for washing or drying clothing items, a water outlet circuit;

a variable speed discharge pump for discharging water through said outlet circuit;

at least a filter (3) for collecting microplastics placed along said water outlet circuit (20) downstream of said variable speed discharge pump (4);

a control board, operatively connected to said discharge pump; characterized in that said control board (S) is configured to operate said discharge pump according to the control method previously discussed.

Brief description of the drawings

[0028] In these drawings:

- figure 1 shows a schematic view of the internal components of a washing machine, among which a discharge pump according to the invention is visible;
- figure 2 shows a flow chart of the control method for a discharge pump according to the present invention;
- figure 3 shows a flow rate-head graph for the pump according to the present invention, which illustrates, in addition to the head H, power input Pass, hydraulic power Pidr and efficiency η for a determined rotational speed ωi of the pump.

Detailed description

[0029] With reference to figure 1, reference number 1 globally indicates a household appliance for washing and/or drying linen, in particular a washing machine, comprising a discharge pump 4 according to the present invention.

[0030] In a per se known manner, the washing machine 1 comprises a tank 11 inside which a drum 111 rotates, which is dragged in rotation due to a belt 12 moved by a pulley that is integral with the rotor of an electric motor 13. In alternative also known embodiments, the drum is dragged in rotation by the electric motor, without the interposition of a belt.

[0031] The washing machine 1 may also comprise, in a per se known manner, a selector 16 of washing programs, a pressure switch 17, a resistor 18 and a temperature probe 19, which will no further be described since irrelevant to the purposes of this invention.

[0032] As known, the washing machine 1 is provided with a water inlet circuit 14 into the drum 111 through said detergent drawer 15 and with a related outlet circuit 20.

[0033] The inlet circuit 14 comprises a valve or electrovalve 141 and a duct 142.

[0034] The electrovalve 141 enables the passage of water from the connection connected to the water mains into the duct 142, up to the detergent drawer 15 and from here into the drum 111.

[0035] Said outlet circuit 20 comprises a discharge duct 201 through which the waste water from the washing machine 1 passes and on which a discharge pump 4, placed downstream of a lower well of the tank 11, acts.

[0036] Relevant to the understanding of this invention, at the outlet circuit 20 a filter 3 for collecting microplastics

is provided. Said filter 3 may be integrated into the washing machine casing, as illustrated in the figure; alternatively, it may be mounted outside the washing machine, hydraulically interposed between the output of the discharge duct 201 and a wall connection for the discharge into the waste water 202.

[0037] The filter 3 comprises an external closing body and an internal filtering body, able to contain and block the microplastic particles present inside the clothing items. The internal filtering body may be advantageously integrated in a cartridge, replaceable by the user. Alternatively, the filter may be reusable after cleaning the filter element by the user.

[0038] The discharge pump 4 is a variable speed pump; preferably, it comprises a three-phase direct current electric motor, for instance a BLDC motor; however, without departing from the scope of protection of the present invention, the motor may also be of other types, provided that the possibility of speed control is contemplated.

[0039] Onboard said discharge pump 4 a control board S is provided, which is configured to operate said pump according to a control method described hereinafter.

[0040] Without departing from the scope of protection of the present invention, it is possible for the control board to be external to the discharge pump 4, or even to be integrated in a main control unit of the washing machine 1.

[0041] The operation of the washing machine 1 provided with the discharge pump 4 is hereinafter described.

[0042] When the washing machine 1 is operated by a user, by selecting the washing program by means of the selector 16, the electrovalve allows the passage of water inside the inlet circuit 14, toward the detergent drawer 15.

[0043] The rotor of the electric motor starts rotating, setting the drum 111 in rotation by means of the belt 12, moved by the pulley 13.

[0044] During a washing program, the resistance 18 heats the water, bringing it to the temperature required by the selected washing program, the probe 19 measures the temperature of the water, whereas the pressure switch 17 adjusts the quantity of water during washing.

[0045] When the washing program is about to end, or any time when it is necessary to evacuate water from the drum 111, the water used must be expelled through the outlet circuit 20 by means of the discharge pump 4.

[0046] The discharge pump 4 is thus operated by following the control method of the invention, which is schematically illustrated in figure 2 and described in detail hereinafter.

[0047] In a start-up step 100, the discharge pump 4 is initially brought to an initial rotational speed $\omega 1$, indicatively equal to 1000 rpm.

[0048] In an acquisition step 200, the control board S determines the power input Pass of the pump 4, for instance through acquisition of electric parameters, such as current and voltage or current and back electromotive force.

[0049] As visible in the flow rate Q-head H flow chart of figure 3, which illustrates, in addition to head H, power input Pass, hydraulic power Pidr and efficiency η for a determined rotational speed ωi of the pump, the power input Pass decreases with the flow rate Q. Therefore, if the clogging of the filter has caused a decrease in the flow rate, this affects the power input.

[0050] Therefore, the method provides for a first control step 300 in which it is checked whether the power input Pass has decreased below a certain threshold value Pmin.

[0051] If the check is positive, i.e. if the power input Pass is below the minimum value Pmin, the flow rate has significantly decreased and the system must re-adjust the speed, unless a condition of full filter has already been reached.

[0052] Therefore, the method provides for a second control step 400 in which it is checked whether the condition of full filter has been reached. This check may simply identify whether a maximum speed ωmax has been reached. Alternatively, the check may be performed downstream by checking whether the speed increase still determines a re-alignment of the power input above the threshold Pmin.

[0053] Indicatively, the value of maximum speed ωmax may be equal to 3500 rpm. Still indicatively, the lower threshold value for the power input Pmin may be comprised between 20 and 25 W.

[0054] If the previous check of full filter is positive, in a signaling step 500 the control board sends a signal of full filter, which for instance may be sent to the control unit of the washing machine to generate a diagnostic message on a user interface, not shown in the appended figures.

[0055] Instead, if the check establishes that the filter is still not full and that the speed of the discharge pump 4 may thus be adapted to substantially keep the flow rate constant, the control board S provides for increasing the speed ω from its current value to a higher value, according to a pre-set gradual increase table. For instance, if the initial speed $\omega 1$ is equal to 1000 rpm, a subsequently set speed $\omega 2$ may be equal to 1300 rpm.

[0056] The above described incremental method may be alternatively implemented with a continuous feedback control on the power input Pass.

[0057] In both cases, the adaptation of the power input Pass during the filter 3 lifespan allows keeping the flow rate substantially unchanged and, as a result, respecting the nominal drain times of the washing machine 1, thus avoiding inconveniences related to conflict with the internal diagnostic systems of the washing machine 1.

[0058] As it is clear from the above reported description, the advantage of the system S lies in the double function of self-adjustment of the performance of the discharge pump 4 to increase life cycles of the filter 3 and of detecting the status of the filter 3, in particular by signaling the need for replacement or cleaning when it is completely clogged.

[0059] Obviously a person skilled in the art, in order to

meet contingent and specific needs, may make several changes and variants to the support above described, all of them falling within the scope of protection of the invention as defined by the appended claims.

Claims

1. Control method for a variable speed discharge pump (4) of a large household appliance (1) for washing and/or drying clothes, wherein at least a filter (3) for collecting microplastics is placed downstream of said discharge pump (4), said control method comprising the step of:

   - operating (100) the discharge pump (4) at an initial rotational speed which an initial flow rate (Q) through the filter (3) corresponds to;

   characterized in that it further comprises the step of:

   - increasing (600) the rotational speed of the discharge pump (4) over time until the filter (3) is replaced or cleaned, in order to compensate for the decrease in flow rate (Q) due to the progressive clogging of the filter (3).

2. Control method according to claim 1, further comprising a step of obtaining (200) at least one electric parameter indicative of the power input (Pass) of the discharge pump (4) in order to indirectly monitor the decrease in flow rate (Q), wherein in the step of increasing the rotational speed of the discharge pump (4) over time, said speed is increased with the decrease of the power input (Pass).

3. Control method according to claim 2, wherein said at least one electric parameter comprises electric current and voltage and/or back electromotive force.

4. Control method according to any one of the previous claims, further comprising a step of identifying (400) a condition of exhausted filter for said filter (3) and of signaling (500) said condition of exhausted filter to the operator.

5. Control method according to claim 4 when depending on one of claims 2 or 3, wherein the condition of exhausted filter is identified upon reaching a maximum rotational speed.

6. Control method according to claim 4 when depending on one of claims 2 or 3, wherein the condition of exhausted filter is identified when the increase in rotational speed does not allow any longer to restore a value of the power input (Pass) above a minimum threshold.

7. Control method according to any one of the previous claims, wherein the initial rotational speed is comprised between 500 and 1500 rotation per minute and is increased up to a maximum rotational speed comprised between 3000 and 4000 rotation per minute.

8. Control method according to any one of the previous claims, wherein the increase in rotational speed of the pump is made by discrete steps every time a control value crossing a threshold is detected (300).

9. Discharge pump (4) comprising a control board (S) configured to operate said discharge pump (4) according to a control method according to any one of the previous claims.

10. Household appliance (1) for washing and/or drying clothes, comprising:

    a water inlet circuit (14), a drum (111) for washing or drying clothes, a water outlet circuit (20);
    a variable speed discharge pump (4) for discharging water through said water outlet circuit (20);
    at least a filter (3) for collecting microplastics placed along said water outlet circuit (20) downstream of said variable speed discharge pump (4);
    a control board (S), operatively connected to said discharge pump (4); **characterized in that** said control board (S) is configured to operate said discharge pump (4) according to a control method according to any one of claims 1-8.

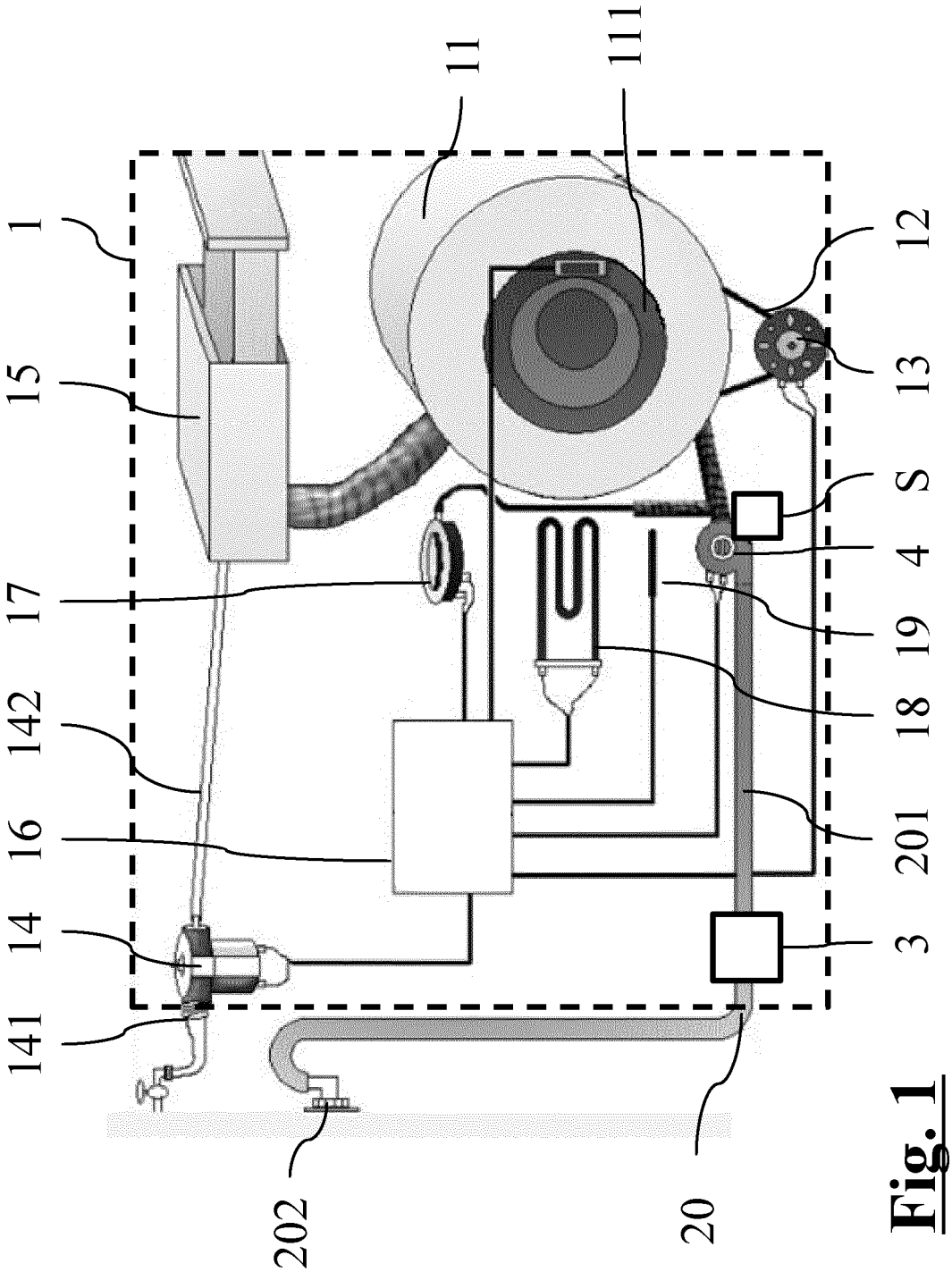

Fig. 1

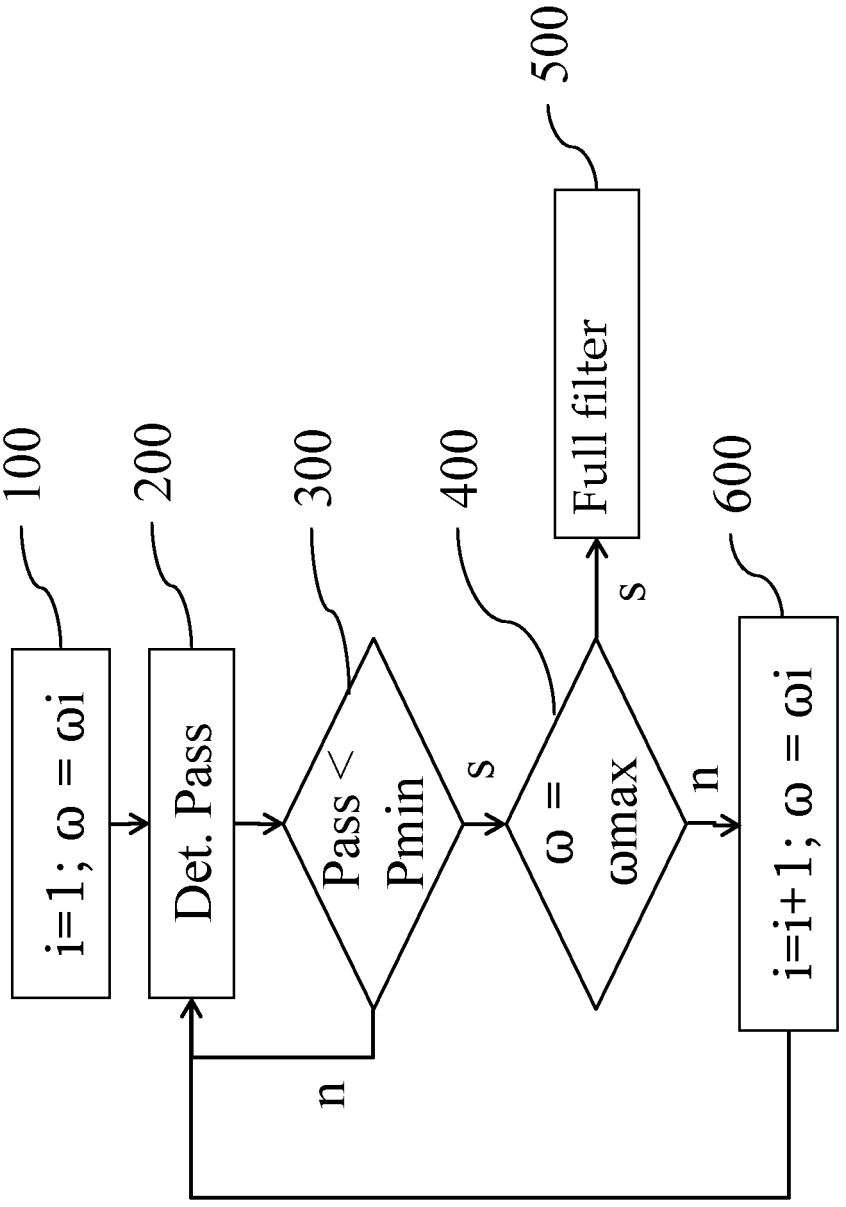
100
i=1; ω = ωi
200
Det. Pass
300
Pass < Pmin
n
s
400
ω = ωmax
s
500
Full filter
n
600
i=i+1; ω = ωi

Fig. 2

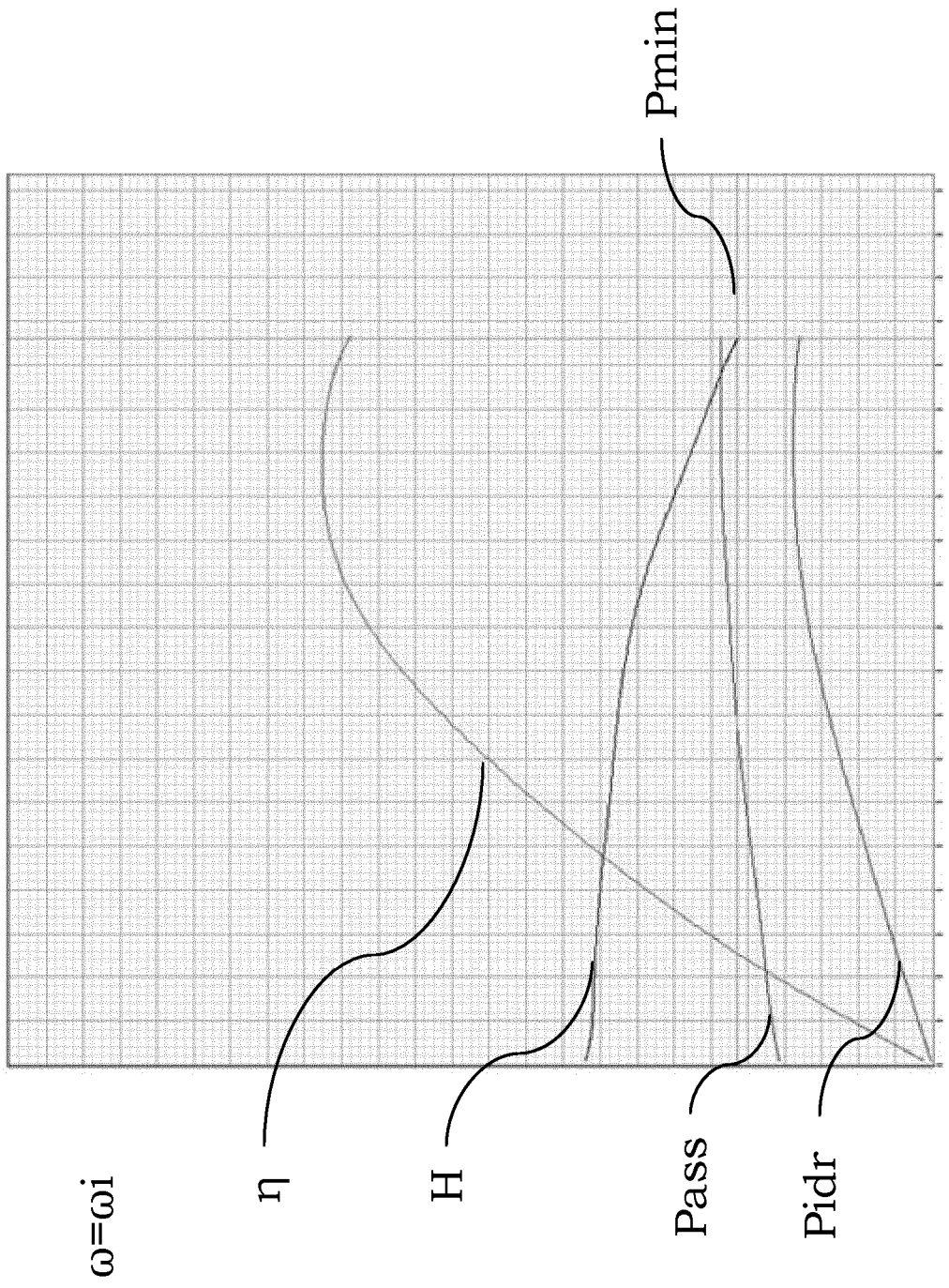

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 24 20 4325

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A	WO 2022/203217 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 29 September 2022 (2022-09-29) * paragraph [0052] - paragraph [0200]; figures *	1-10	INV. D06F39/08 ADD. D06F103/42 D06F103/48 D06F105/00 D06F105/58
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A	US 2021/277562 A1 (PARK JUNHO [KR] ET AL) 9 September 2021 (2021-09-09) * paragraph [0058] - paragraph [0240]; figures *	1-10	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 January 2025	Sangiorgi, Massimo

CATEGORY OF CITED DOCUMENTS

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