



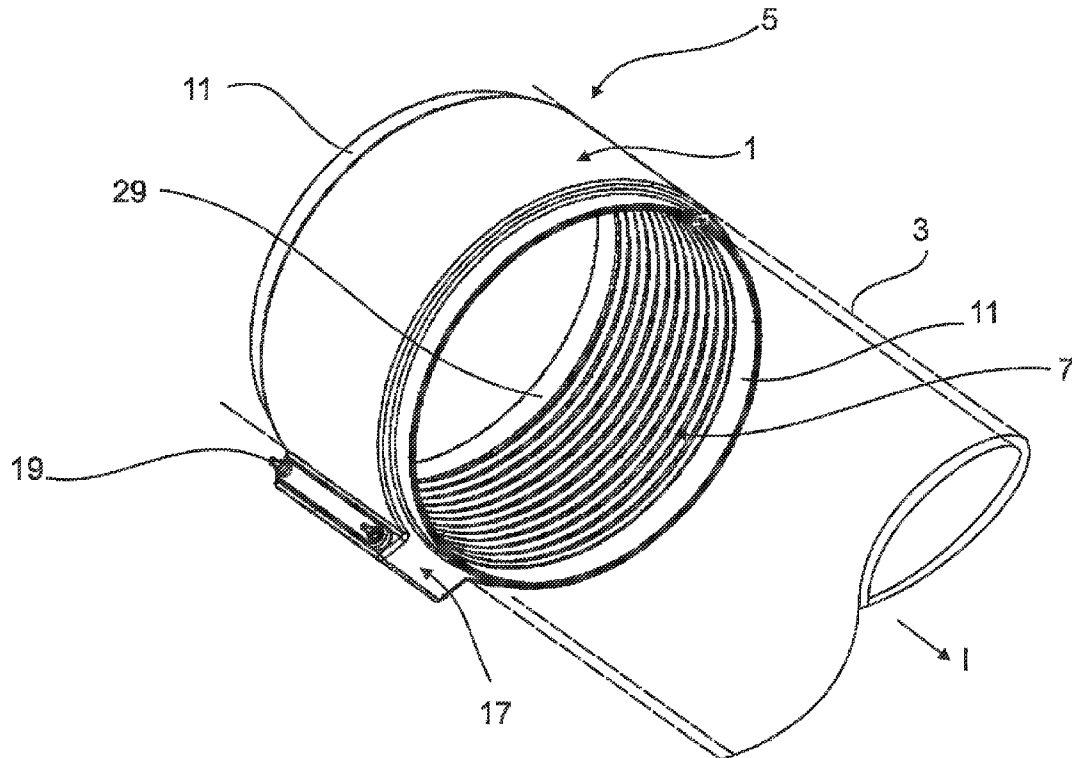
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DOMESTIC APPLIANCE**(30) **Foreign Application Priority Data**

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The invention relates to a heating device for heating a liquid flow (I) in a water-bearing domestic appliance. According to the invention, the heating device has a heat pipe having a heat-absorbing evaporator section and a heat-outputting condenser section that is in thermal connection with the liquid flow (I).



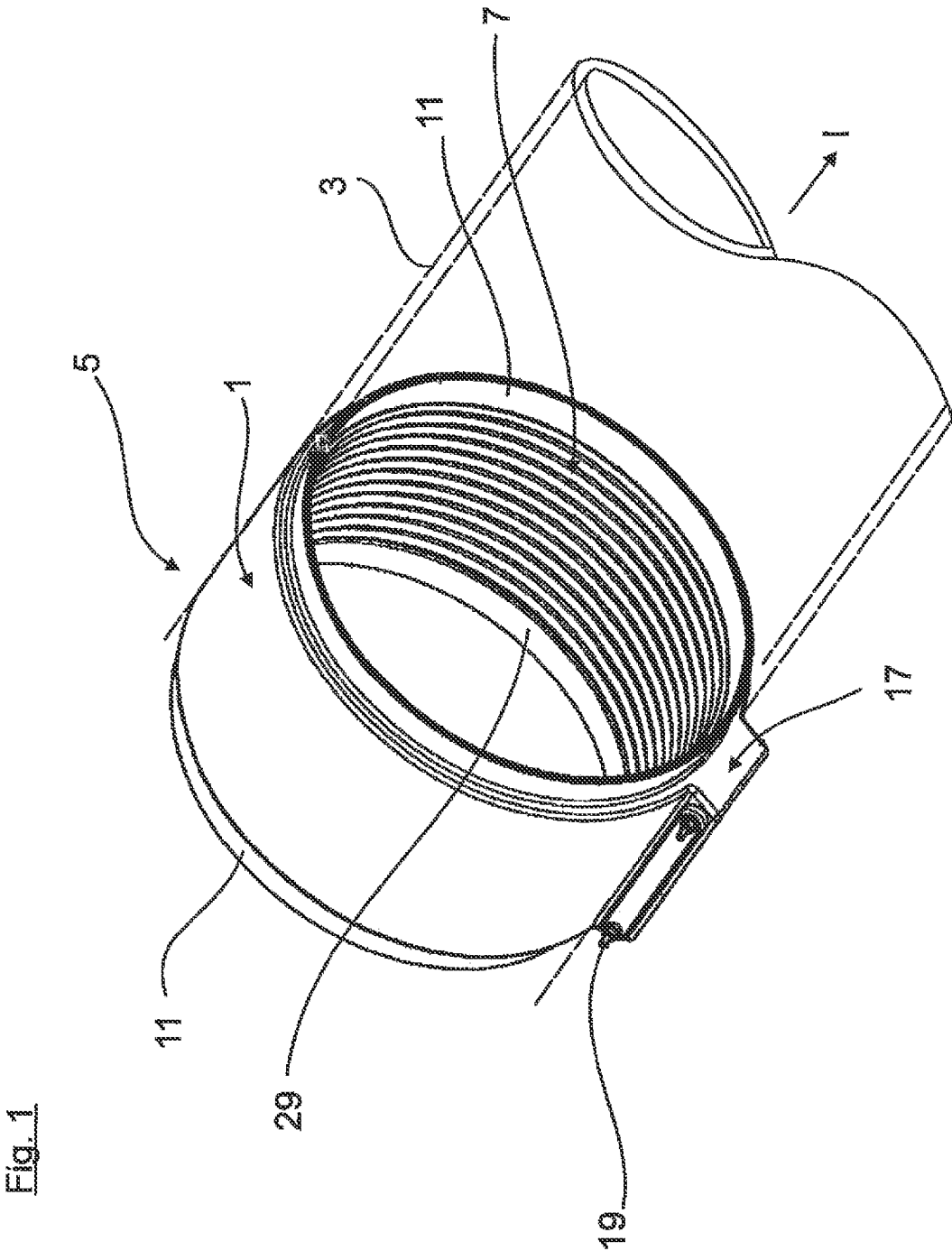


Fig. 2

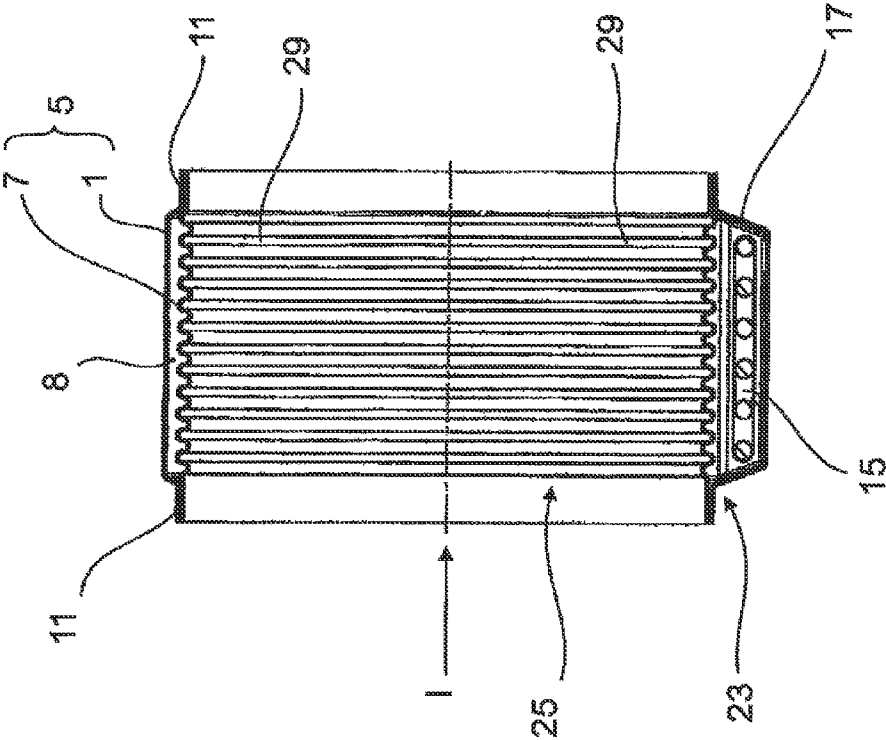


Fig. 3

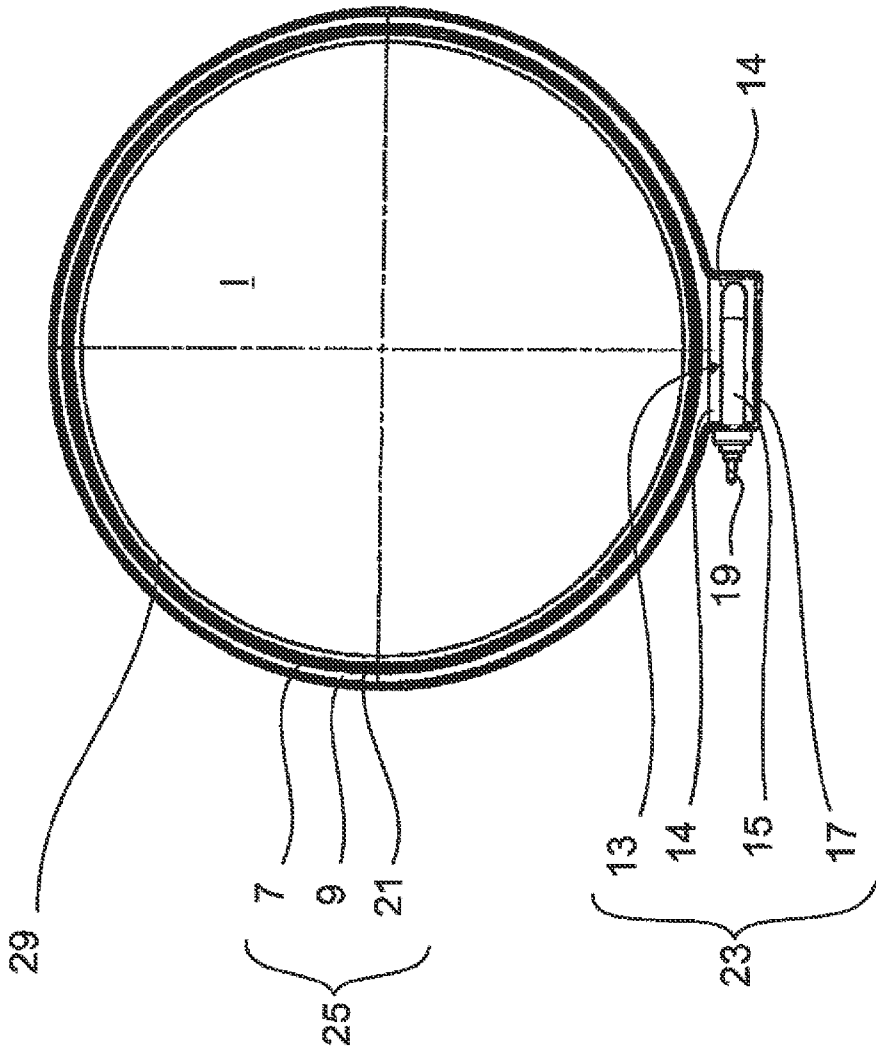
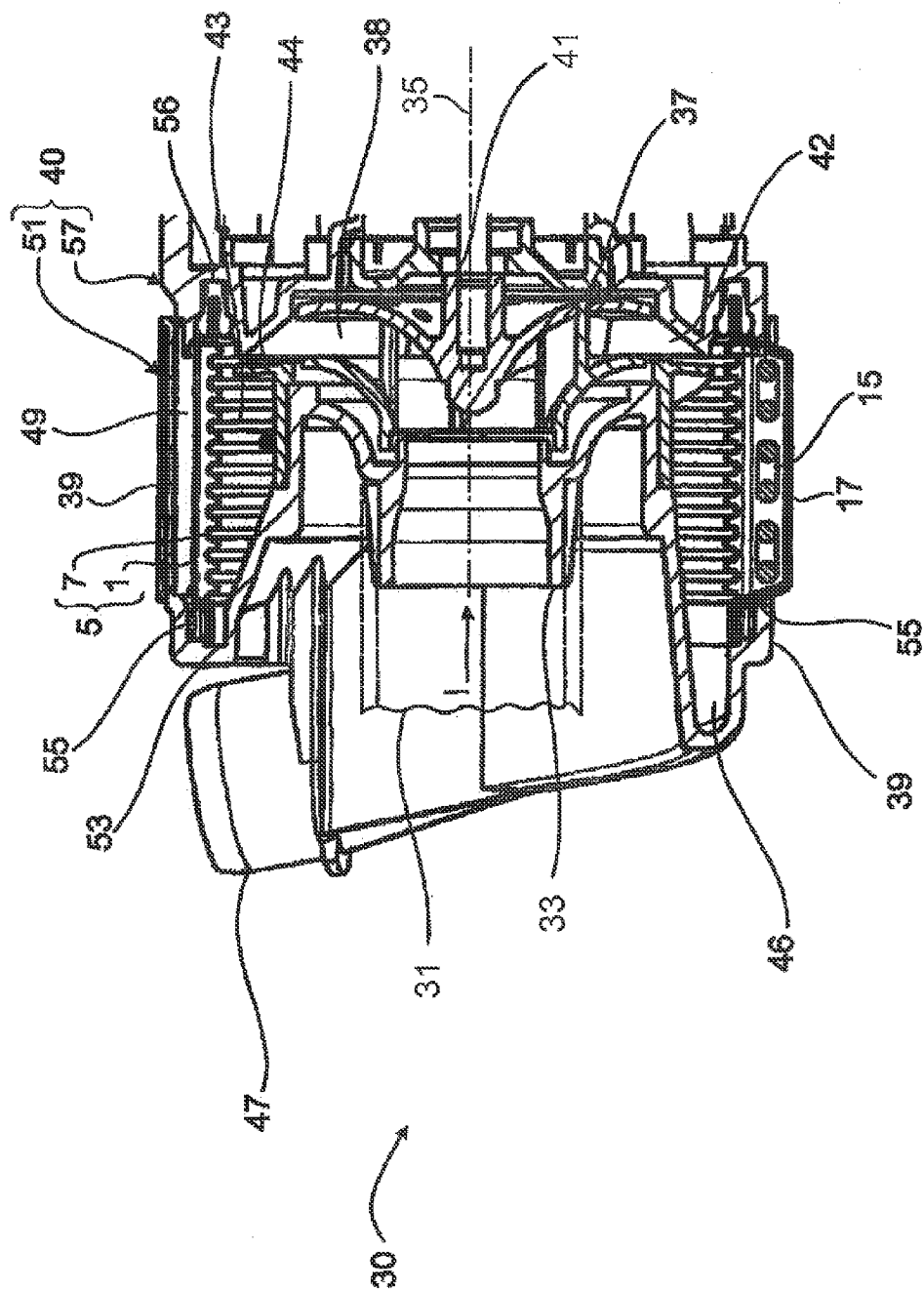


Fig. 4



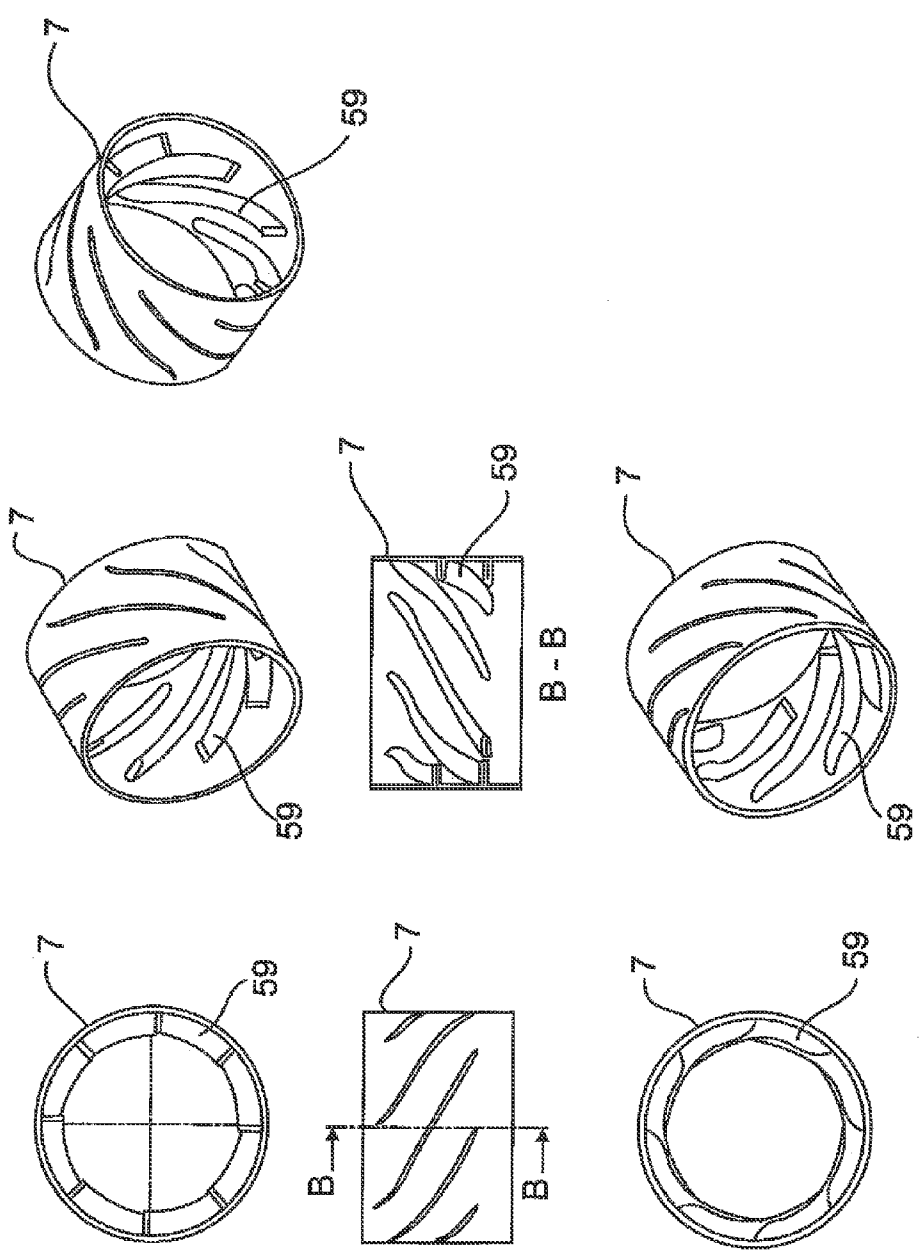


Fig. 5

HEATING DEVICE IN A WATER-BEARING DOMESTIC APPLIANCE

[0001] The invention relates to a heating device for heating a liquid flow in a water-conducting domestic appliance as claimed in the preamble of claim 1 and a water-conducting domestic appliance of this type as claimed in claim 14.

[0002] The use of heat pipes is generally known in many fields. Such a heat pipe contains a hermetically encapsulated volume filled with a working medium (for example water). The working medium fills the volume to a minor degree in a liquid state and to a greater degree in a vaporous state. When heat is input into the heat pipe, the working medium starts to evaporate. This raises the pressure in the vapor space above the liquid level locally. The resulting vapor therefore flows in the direction of a heat transfer surface of the heat pipe, where it condenses due to low temperatures. This causes the previously absorbed heat to be emitted again. The liquid working medium can then be guided back to the evaporator by gravity and/or by a capillary force.

[0003] A generic heating device for heating a liquid flow in a water-conducting domestic appliance is known from DE 10 2007 060 193 A1. The heating device here is arranged for example in the manner of a thick film element on the outer face of a cylindrical housing wall of the pump housing. The cylindrical housing wall delimits a pressure chamber in a radially inward direction, through which the liquid conveyed by a pump impeller is guided to a pressure connector on the outlet side subject to pressure. The application of the thick film heater to the outer face of the pump housing is associated with a high level of manufacturing outlay here. Also the thermal resistance of the metal pump housing which has to be overcome is considerable, with the result that heat losses occur in heating mode.

[0004] The use of a heat pipe in a dishwasher is known from DE 10 2004 055 926 A1. According to this in a drying step that terminates the wash cycle the air to be dried is brought into thermal contact with a heat-absorbing evaporator section of the heat pipe, with the result that water from the air to be dried condenses. The dried air is then brought into thermal contact with the heat-emitting condenser section of the heat pipe to heat the dried air. The air, which is thus dried and heated, is returned to the wash compartment.

[0005] The object of the invention is to provide a heating device for heating a liquid flow in a water-conducting domestic appliance, which has a simple structure and operates with reduced heat losses.

[0006] The object is achieved by the features of claim 1 or 14. Preferred developments of the invention are disclosed in the subclaims.

[0007] The invention relates to a heating device for heating a liquid flow in a water-conducting domestic appliance. According to the invention the heating device has a heat pipe, which has a heat-absorbing evaporator section and a heat-emitting condenser section. To heat the liquid flow, the heat-emitting condenser section is connected thermally to the liquid flow. In contrast to the generic prior art therefore according to the invention the heat pipe is integrated directly in the hydraulic circuit of the water-conducting domestic appliance, for example in the manner of a water heater. The liquid circulated during operation of the appliance is therefore heated directly with the aid of the heat pipe.

[0008] With such a heat pipe energy is emitted almost exclusively at the condensation surface of the heat pipe. In other words a specific energy emission is brought about at the

condensation surface by condensation of the vaporous working fluid. In contrast in the uncooled heat pipe region, where no condensation of the vaporous working fluid takes place, a significantly reduced energy transfer simply takes place. All the available surfaces can optionally be used for condensation purposes for the energy transfer. This can be done either to reduce the space requirement or to reduce the energy density required for the energy transfer.

[0009] The hydraulic circuit of the domestic appliance has liquid lines that are known per se and/or a circulating pump, which the aid of which wash liquid for example is circulated and guided through the wash compartment of a dishwasher. The heating device can be integrated directly in the liquid line in the manner of a water heater. The heat pipe here can preferably have a liquid passage, through which the liquid flows. The heat pipe here delimits a space, which is closed in a fluid-tight manner and in which a working fluid is provided, with which heat is transported from the heat-absorbing evaporator section to the heat-emitting condenser section of the heat pipe. The heat-emitting condenser section of the heat pipe here can be in direct thermal contact with the liquid flow guided through the liquid passage by way of just one heat transfer surface. To improve thermal conductivity between the heat pipe and the liquid flow further, the inner pipe through which the liquid flows can also have a flow contour and/or flow conducting elements on the inside, for example an undulating profile that assists the transfer of heat into the liquid flow.

[0010] The heat pipe also allows a free surface configuration on the inner pipe delimiting the liquid flow. Such a free surface configuration has the following advantages, summarized as follows: on the one hand the area of the heat exchange surface on the inner pipe can be enlarged in a simple manner. It is also possible to achieve an optimum shape for flow mechanism purposes in respect of both increased heat transfer and flow efficiency. Also, as mentioned above, small micro-vortices can be produced in the liquid flow, which increase the heat transfer further without significantly increasing flow resistance. Finally with a corresponding design the flow contour can increase the component rigidity of the inner pipe. The increased component rigidity in turn means that there can be economies of material, for example stainless steel, the material thickness of which can be reduced up to the region of 0.2 or 0.3 mm.

[0011] Instead of the abovementioned undulating profile any other suitable surface structure can be provided as the flow contour. For example the abovementioned undulating profile can be a longitudinally ribbed undulating structure or a transversely ribbed undulating structure or an obliquely ribbed undulating structure. This allows micro-vortices to be produced on the inner wall delimiting the liquid flow, with the aid of which the heat exchange can be increased. The flow contour can optionally also have a for example a lozenge-shaped bulge structure.

[0012] The term domestic appliance is broadly defined within the meaning of the invention, also covering in particular permanently installed flow-through water heaters for example. The invention can also be used with any other water-conducting domestic appliance, for example in washing machines, dishwashers, as well as in automatic coffee makers or coffee machines.

[0013] The heat pipe within the context of the invention is not restricted per se to a pipe geometry. Instead the heat pipe can have any form, as long as adequate thermal contact with

the liquid flow to be heated is ensured. However in respect of reducing the space requirement it is advantageous if the heat pipe is embodied as circular in profile. In one space-saving embodiment the heating device can be embodied as a twin-walled heating pipe. The heating pipe can have an outer pipe forming the heat pipe, an inner pipe forming the liquid passage and an annular gap in between. The annular gap can form the abovementioned space in the heat pipe which is closed in a fluid-tight manner together with a collection space described below. In this way the entire cylindrical outer surface of the inner pipe serves as a heat transfer surface.

[0014] Heat is input into the heat pipe at the heat-emitting evaporator section of the heat pipe. For heat inputting purposes the evaporator section can have an in particular electrically actuable heating element. The heating element, for example a tubular heating unit, can be arranged within the space in the heat pipe which is closed in a fluid-tight manner with a view to reducing heat losses.

[0015] The working fluid condensed on the condensation surface (heat transfer surface) can depending on the design of the heat pipe return to the evaporator section as a result of gravity or for example due to capillary force. In one inventively preferred design the heat pipe is embodied as a so-called two-phase thermosiphon or a gravitation heat pipe. With such a gravitation heat pipe the space which is closed in a fluid-tight manner is divided into a collection space for the liquid working fluid, which is at the bottom when fitted, and a vapor space arranged above this. When heat is input into the collection space, the liquid working fluid is evaporated and thus transferred to the vapor space. The vaporous working fluid condenses and emits heat at a heat transfer surface and then returns to the collection space automatically in liquid form due to gravity. To circulate the working fluid the heat pipe therefore does not require additional auxiliary energy to activate a circulating pump which can be used to return the working fluid. This minimizes both maintenance outlay and operating costs.

[0016] To configure the collection space at the bottom the outer pipe can have a heat pipe housing that projects radially outward and delimits the collection space. The inner pipe and outer pipe of the twin-walled heating pipe can be connected to one another in a fluid-tight manner at their axially opposing faces. For example the nested inner and outer pipes can be joined together to form a twin-walled composite annular unit at each of the axially opposing end faces.

[0017] In one preferred embodiment the heating device can be integrated in a circulating pump in the manner of a water heater and can be used to force the circulation of the liquid for example in a hydraulic circuit.

[0018] The heat pipe can preferably be arranged within a pump housing in a flow chamber of the circulating pump. The circulating pump can have a blade wheel chamber with a blade wheel conveying the liquid as the flow chamber on the inlet side. On the outlet side the circulating pump can have a pressure chamber, which is arranged downstream of the blade wheel chamber and into which the liquid conveyed by the blade wheel flows at high flow speed. In the flow direction the pressure chamber can transition into a flow channel which guides the liquid to a pressure connector on the outlet side. The heat pipe with its heat transfer surface can preferably face the pressure chamber. The pressure chamber preferably extends in an annular manner around a center axis of the circulating pump. The pressure chamber can also be delimited in a radially outward direction by the inner pipe of the

twin-walled heating pipe. The liquid flow moves in the pressure chamber in a rotational manner here, in other words tangentially to the inner face of the inner pipe. This means that the fluid flow remains in the pressure chamber for a relatively long time.

[0019] As mentioned above, the inner pipe of the heat pipe can delimit the pressure chamber of the circulating pump radially on the outside. In contrast the outer pipe of the heat pipe can be arranged so that it is separated from a cylindrical outer housing wall of the pump housing by an air gap in between. This ensures that the vaporous working fluid largely does not condense on the outer pipe but only on the inner pipe, thereby emitting heat to the liquid flowing through.

[0020] A cutout can be provided in the cylindrical housing wall of the pump housing, through which the heat pipe housing delimiting the collection space of the heat pipe projects. Any connector sockets for the heating element present on the heat pipe housing are therefore accessible from the outside.

[0021] The cylindrical outer housing wall of the pump housing transitions into a radially inner cylindrical pump wall by way of a chamber wall at the end face. The inner cylindrical pump wall delimits the pressure chamber together with the inner pipe of the twin-walled heating pipe.

[0022] The twin-walled heating pipe is preferably fixed to the axially opposing end-face chamber walls of the pressure chamber. To this end each composite annular unit of the twin-walled heating pipe is inserted into an annular groove in the facing chamber wall with a sealing means in between. One of the two axially separated chamber walls forms a transition between the outer and inner pump housing walls, while the other, axially opposing chamber wall can be a removable cover, through which a drive shaft of the blade wheel passes to the electric drive motor of the pump.

[0023] Instead of the abovementioned liquid flow to be heated it is possible to use any type of fluid flow regardless of phase state. The fluid flow can also be cooled by the heat pipe in a departure from the above embodiments. For example the cooling chamber of a refrigeration appliance can be cooled with the aid of the heat pipe. To this end an air flow to be cooled can be guided through the heat pipe with the aid of a fan instead of the liquid flow to be heated. In cooling mode the annular gap in the heat pipe acts for example as the heat-absorbing evaporator section of the heat pipe, while the heat pipe housing acts as the heat-emitting condenser section. In contrast to the above embodiments there is no heating unit in the heat pipe housing, just a suitably embodied cooling element.

[0024] In such a cooling mode heat is extracted from the air flow flowing along the inner pipe and transferred to the working medium present in the annular gap. The working medium is transformed from the liquid phase to the vaporous phase by the energy input from the air flow. The vaporous working medium is in turn condensed on the cooling element.

[0025] The advantageous configurations and/or developments of the invention described above and/or set out in the subclaims can be applied individually or in any combination, except for example in cases of clear dependency or incompatible alternatives.

[0026] The invention and its advantageous configurations and developments as well as their advantages are described in more detail below with reference to drawings, in which:

[0027] FIGS. 1 to 3 each show different views of an inventive heating device alone;

[0028] FIG. 4 shows a side sectional view of a circulating pump used in a hydraulic circuit of a water-conducting domestic appliance; and

[0029] FIG. 5 shows different variants of an inner pipe of the heating device.

[0030] FIGS. 1 to 3 show a heating device for heating a liquid flow I (FIG. 1 or 3) according to a first exemplary embodiment. The heating device can be for example a water heater fitted in the hydraulic circuit of a dishwasher, which is integrated in a liquid line 3 shown in FIG. 1. According to FIGS. 1 to 3 the heating device has a twin-walled heating pipe 5, in which the outer pipe 1 is embodied as a heat pipe. The twin-walled heating pipe 5 also has an inner pipe 7 through which liquid flows and an annular gap 9 (FIG. 3) in between. The two inner and outer pipes 1, 7 are arranged coaxially to one another according to FIGS. 1 to 3, with the result that the annular gap 9 has a constant gap width along the periphery. Together with a collection space 13 (described below) on the bottom the annular gap 9 is part of a space 8, which is closed in a fluid-tight and pressure-tight manner, between the inner and outer pipes 1, 7. For fluid-tight encapsulation the inner and outer pipes 1, 7 are each joined together at their opposing end faces in the axial direction to form a twin-walled composite annular unit 11, as shown in FIG. 1. Each composite annular unit 11 of the heating pipe 5 is connected to the liquid line 3 in a manner not shown in detail.

[0031] FIG. 3 shows the twin-walled heating pipe 5 in the fitted position. According to this its outer pipe 1 has a housing 17 that projects radially outward at the bottom, delimiting a heat pipe sump or the collection space 13 mentioned above. Arranged in the collection space 13 is a tubular heating unit 15, the electrical connectors 19 of which pass outward through the heat pipe housing 13.

[0032] Provided within the space 8 which is closed in a fluid-tight manner is a working fluid 14, which collects at the bottom of the collection space 13 largely in a liquid phase when the heating device is deactivated. A smaller portion of the working fluid is distributed in the vaporous phase in the annular space 9 above, which forms the vapor space of the heat pipe 1. When the heating unit 15 in the collection space 13 is activated, the liquid working fluid evaporates inputting heat into the annular space 9 above. The vaporous working fluid condenses in this process on the outer surface 21 of the inner pipe 7 and is automatically returned to the collection space 13 due to gravity. The collection space 13 therefore forms a heat-absorbing evaporator section 23, while the annular space 9 above with the heat transfer surface 21 forms a heat-emitting condenser section 25 of the heat pipe 1.

[0033] To increase the thermal conductivity from the inner pipe 7 to the liquid I flowing through, the inner pipe 7 has an undulating profile 29 by way of example on the inside. The resulting eddies in the liquid flow I increase the thermal conductivity, particularly in the edge region of the liquid flow I.

[0034] In a second exemplary embodiment in FIG. 4 the twin-walled heating pipe 5 is not arranged in the liquid line 3 but within a pump housing of a circulating pump 30. The structure and mode of operation of the heating pipe 5 are identical to those of the first exemplary embodiment, therefore reference should be made to the description of FIGS. 1 to 3.

[0035] As shown in FIG. 4, the end of a liquid line 31 is pushed onto an intake connector 33 of the circulating pump 30, running coaxially here to a center axis 35 of the circulating

pump 30. The circulating pump 30 has a blade wheel 37 that can be rotated about the center axis 35 and is provided in a blade wheel chamber 38 within the pump housing 40. The blade wheel 37 is connected for drive purposes by way of a drive shaft 40 to an electric motor (not shown). The blade wheel chamber 38 is connected for flow purposes to an annular pressure chamber 43 by way of an annular gap 42 at its radially outer face. The pressure chamber 43 extends with rotational symmetry about the center axis 35 and radially outside by way of the intake connector 33. Provided between the blade wheel chamber 38 and the pressure chamber 43 in the annular gap 42 is a fixed guide wheel 44, which rests in a rotationally fixed manner on a bearing seat of the pump housing 40. The guide walls of the guide wheel 44 are positioned steeply so that the inflowing liquid flow I flows through the pressure chamber 33 at a high flow speed and in a radial peripheral direction. The pressure chamber 33 is delimited in a radially outward direction by the inner pipe 7 of the twin-walled heating pipe 5. In other words the liquid flow flows almost tangentially along the inner pipe 7. This tangential flow is also assisted by the undulating profile 29 on the inner pipe. The liquid flow I also remains for a correspondingly long time within the pressure chamber 43. The guide wheel 44 also imposes a low speed component on the liquid flow I in the axial direction in the direction of the flow channel 46 connected downstream. The liquid flow I is conveyed tangentially through the flow channel 46 into a pressure connector 47 on the outlet side and on into the liquid line 31.

[0036] In the fitted position shown in FIG. 4 the inner pipe 7 of the heat pipe 1 delimits the pressure chamber 43 of the circulating pump 30 radially on the outside. The outer pipe 1 is also separated from the outer cylindrical housing wall 39 of the pump housing 40 in a radially outward direction with an air gap 49 in between. The air gap 49 helps to reduce heat emission by way of the outer pipe 1, in favor of heat emission to the liquid flow I by way of the inner pipe 7.

[0037] The pump housing 40 is embodied in essentially two parts in FIG. 4, a left housing part 51 in FIG. 4 having the cylindrical outer housing wall 39, which transitions as a single piece by way of a vertical chamber wall 53 into a radially inner cylindrical pump wall 54. On the face facing the pressure chamber 43 the chamber wall 53 has an annular groove 55, into which an end-face composite annular unit 11 of the twin-walled heating pipe 5 is pushed with a sealing element in between. In contrast the axially opposing composite annular unit 11 is pushed in a fluid-tight manner into a corresponding annular groove 56 in the second housing part 57, which closes the pressure chamber 43 in a fluid-tight manner on the right in FIG. 4.

[0038] Different variants of the inner pipe 7 are shown in FIG. 5, according to which additional flow guide elements 59 are molded on the inside of the inner pipe 7, with the aid of which a flow pattern that assists the heat transfer can be imposed on the liquid flow I.

[0039] Any type of fluid flow can be used regardless of the phase state instead of the abovementioned liquid flow I. The fluid flow I is heated by using the heat pipe in the exemplary embodiments set out above. However as an extension to the exemplary embodiments shown the heat pipe can also be used to cool a fluid flow. For example the cooling chamber of a refrigeration appliance can be cooled with the aid of the heat pipe 1. To this end an air flow I to be cooled can be guided through the heat pipe 1 with the aid of a fan instead of the liquid flow I described in FIG. 3. In cooling mode the annular

gap 9 in the heat pipe acts as the heat-absorbing evaporator section of the heat pipe, while the heat pipe housing 17 acts as the heat-emitting condenser section. In contrast to the above exemplary embodiments there is no heating unit 15 in the heat pipe housing 17, just a suitably embodied cooling element.

[0040] In cooling mode heat is extracted from the air flow I flowing along the inner pipe 7 and transferred to the working medium 14 present in the annular gap 9. The working medium 14 is transformed from the liquid phase to the vaporous phase by the energy input from the air flow I. The vaporous working medium 14 is in turn condensed on the cooling element 15.

LIST OF REFERENCE CHARACTERS

[0041]	1 Heat pipe
[0042]	3 Liquid line
[0043]	5 Twin-walled heating pipe
[0044]	7 Inner pipe
[0045]	8 Space closed in a fluid-tight manner
[0046]	9 Annular gap
[0047]	11 Composite annular unit
[0048]	13 Collection space
[0049]	14 Working fluid
[0050]	15 Heating element
[0051]	17 Heat pipe housing
[0052]	21 Heat transfer surface
[0053]	23 Heat-absorbing evaporator section
[0054]	25 Heat-emitting condenser section
[0055]	29 Flow contour
[0056]	30 Circulating pump
[0057]	31 Liquid line
[0058]	33 Connector
[0059]	38 Blade wheel chamber
[0060]	40 Pump housing
[0061]	42 Annular gap
[0062]	43 Pressure chamber
[0063]	44 Guide wheel
[0064]	47 Pressure connector
[0065]	51 Pump housing part
[0066]	53 Chamber wall
[0067]	55, 56 Annular groove
[0068]	57 Pump housing part
[0069]	59 Flow guide elements
[0070]	I Liquid flow

1. A heating device for heating a fluid flow, in particular a liquid flow (I), in a water-conducting domestic appliance, wherein the heating device has a heat pipe with a heat-absorbing evaporator section and a heat-emitting condenser section, which is connected thermally to the liquid flow (I).

2. The heating device as claimed in claim 1, wherein the heat pipe has a liquid passage through which the liquid (I) flows, which extends through the radially outer heat pipe and/or the heat pipe delimits a space which is closed in a fluid-tight manner, in which a working fluid is provided, with which heat is transported from the heat-absorbing section to the heat-emitting section of the heat pipe.

3. The heating device as claimed in claim 1, wherein the heat-emitting section of the heat pipe has a heat transfer

surface for transferring heat from the space in the heat pipe which is closed in a fluid-tight manner to the liquid flow (I).

4. The heating device as claimed in claim 1, wherein that the heating device is embodied as a twin-walled pipe, with an outer pipe forming the heat pipe, an inner pipe forming the liquid passage and an annular gap in between, which is part of the space in the heat pipe which is closed in a fluid-tight manner.

5. The heating device as claimed in claim 1, wherein the heat-absorbing evaporator section of the heat pipe has an in particular electrically actuatable heating element arranged in particular within the space in the heat pipe which is closed in a fluid-tight manner.

6. The heating device as claimed in claim 4, wherein in a free surface configuration the inner pipe through which the liquid flows has a flow contour, in particular for example a bulged profile or undulating profile, and/or flow guide elements.

7. The heating device as claimed in claim 1, wherein the heat pipe is embodied as a two-phase thermosiphon or a gravitation heat pipe, in which the space which is closed in a fluid-tight manner is divided into a collection space for the liquid working medium, which is at the bottom when fitted, and a vapor space into which the liquid working medium evaporates when heat is input and condenses at the heat transfer surface arranged in the vapor space while emitting heat and flows back to the collection space automatically due to gravity.

8. The heating device as claimed in claim 7, wherein, to form the collection space, the outer pipe has a heat pipe housing that projects in a radially outward direction and delimits the collection space.

9. The heating device as claimed in claim 1, wherein the inner pipe and outer pipe are connected to one another in a fluid-tight manner at their axially opposing faces, in particular are each joined at their end faces to form a twin-walled composite annular unit.

10. The heating device as claimed in claim 1, wherein the heat pipe is arranged in a flow chamber of a pump and that in particular the pump has a blade wheel chamber with a blade wheel conveying the liquid as the flow chamber and a pressure chamber arranged downstream thereof.

11. The heating device as claimed in claim 10, wherein the pressure chamber of the pump is delimited radially on the outside by the inner pipe of the twin-walled heating pipe and/or the outer pipe of the heating pipe is arranged within an outer cylindrical outer housing wall of the pump housing with an air gap in between.

12. The heating device as claimed in claim 11, wherein the cylindrical housing wall of the pump housing has a cutout through which the housing delimiting the collection space of the heat pipe projects.

13. The heating device as claimed in claim 11, wherein the cylindrical housing wall of the pump housing transitions into a radially inner cylindrical pump wall, which delimits the pressure chamber together with the inner pipe of the twin-walled heating pipe.

14. A pump having a heating device as claimed in claim 1.

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