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(54) Steam cleaning apparatus

(57) A boiler for a steam cleaning device comprises a thermal heat store; an electrical heating element for heating the thermal heat store; a water cooling circuit comprising a water input for receiving water from a water tank and a steam output. The electrical heating element

and the water cooling circuit are embedded in the thermal heat store and an outer surface of the electrical heating element is closer to an outer surface of the thermal heat store than an outer surface of the water cooling circuit.

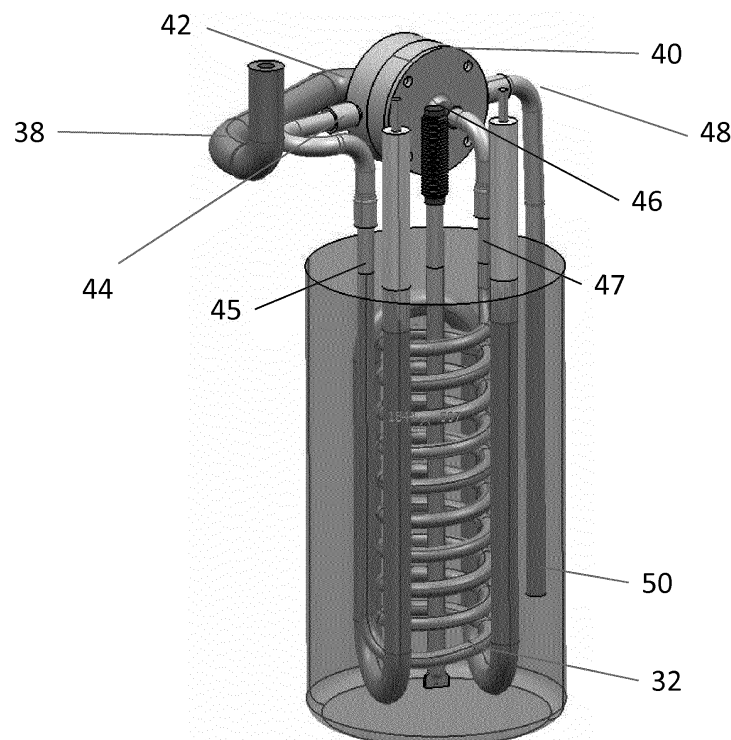


Figure 3

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Description

[0001] The present invention relates to a steam cleaning apparatus. In particular the present invention relates to a steam cleaning apparatus which can be used for cleaning when disconnected from an external source electrical power.

[0002] Steam cleaning appliances having become increasingly popular over the last few years. An example of such a steam cleaning apparatus is a steam cleaning mop for cleaning tiled or hardwood floors. Handheld steam cleaning appliances can be used for cleaning work surfaces such as in the kitchen.

[0003] A steam cleaning apparatus comprises a boiler which transfers sufficient heat energy to water in order to convert it into steam. The steam is then directed via a steam cleaning head to the surface which is to be cleaned. Many steam cleaning appliances are powered by an external source of electricity which supplies energy to an electrical heating element in a boiler. A problem with using an external source of electricity is that the steam cleaning apparatus must be connected by an electrical cord to the electricity power supply. This means that the steam cleaning apparatus is tethered to the electricity socket and the user can only use the steam cleaning apparatus within a certain distance of the electricity socket.

[0004] CN102087019 discloses a steam generator for steam mop with an electric heater which requires an external power supply for supplying AC electricity to the steam generator. The steam generator comprises a heat exchange body in which the electric heater is embedded and an external sleeve for covering the heat exchange body. Water flows between a gap between the heat exchange body and the external sleeve and is turned into steam. A problem with the steam generator is that it is not configured for cordless use. This means that if the steam generator is used with a battery to supply power to a steam generator, the energy that is required to raise the ambient temperature of the water and required to change the phase of water from liquid to steam is significant. Typically the energy stored in a battery is limited and this will mean that there may be a very short runtime when the electric heater is on and solely running on a battery.

[0005] Embodiments of the present invention aim to address the aforementioned problems.

[0006] According to an aspect of the present invention there is a boiler for a steam cleaning device comprising: a thermal heat store; an electrical heating element for heating the thermal heat store; a water cooling circuit comprising a water input for receiving water from a water tank and a steam output; wherein the electrical heating element and the water cooling circuit are embedded in the thermal heat store and an outer surface of the electrical heating element is closer to an outer surface of the thermal heat store than an outer surface of the water cooling circuit.

[0007] This means that a more even thermal distribution across the thermal heat store can be achieved. This means that the thermal energy is distributed more efficiently across the thermal store and less time is required for the heating element to heat the thermal heat store so that all parts are at an operating temperature. This is particularly useful when the thermal heat store material is made of a poor thermal conductor.

[0008] Preferably the electrical heating element comprises a plurality of elongate portions each of which are parallel to a longitudinal axis of the thermal heat store. By providing elongate portions of the heating element in the thermal store, the entire height of the boiler is efficiently warmed.

[0009] Preferably the elongate portions are each equidistant from the longitudinal axis of the thermal heat store. Preferably the elongate portions are centred on the circumference of a circle having a first radius, the circle being concentric with the longitudinal axis of the thermal heat store. Preferably the first radius is equal to approximately 60% of the distance from the centre of the thermal heat store to the outer surface of the thermal heat store.

[0010] Preferably the water cooling circuit comprises a helical coil having a longitudinal axis parallel to a longitudinal axis of the thermal heat store. Preferably helical coil has a second radius and the second radius is smaller than the first radius. Preferably the second radius is equal to approximately 40% of the distance from the centre of the thermal heat store to the outer surface of the thermal heat store. Preferably the helical coil of the water cooling circuit does not substantially overlap with the elongate portions of the electric heating element.

[0011] Preferably the boiler comprises a temperature sensor embedded in the thermal heat store and the temperature sensor is aligned with the longitudinal axis of the thermal heat store. This means the hottest portion of the boiler can be accurately monitored.

[0012] Preferably the thermal heat store is a metal, metal alloy or an intermetallic compound cast around the water cooling circuit and the electric heating elements.

[0013] Preferably the boiler comprises a thermally insulating jacket surrounding the outer surface of the thermal heat store. This reduces thermal energy escaping from the thermal heat store. At the same time the insulating jacket prevents the outer housing of the steam cleaning device to overheat.

[0014] Preferably the electric heating element is U-shaped having a 180 degree bend therein. This means a simple structure of a single heating element can be used whilst heating a large volume of the thermal heat store. The bent U shaped heating element means that four elongate portions are heating the entire length of the thermal heat store in operation.

[0015] Preferably the thermal heat store comprises a substantially cylindrical shape. This reduces the thermal heat loss because the cylinder has a good surface area to volume ratio.

[0016] In another aspect of the invention there is a

steam cleaning device comprising: a water tank; a boiler according to the above mentioned aspect in fluid communication with the water tank; and a steam outlet in fluid communication with the steam output of the boiler.

[0017] Various other aspects and further embodiments are also described in the following detailed description and in the attached claims with reference to the accompanying drawings, in which:

Figure 1 shows a perspective view of the steam cleaning apparatus according to an embodiment;
Figure 2 shows a partial cross sectional view of the steam cleaning apparatus according to an embodiment;

Figure 3 shows a partial perspective view of the steam cleaning apparatus according to an embodiment;

Figure 4 shows a schematic block diagram of the steam cleaning apparatus according to an embodiment;

Figure 5 shows a hidden line side view of the boiler according to an embodiment;

Figure 6 shows a plan view of the boiler according to an embodiment;

Figure 7 shows a side cross section and thermal gradients of a boiler in operation not according to an embodiment; and

Figure 8 shows a side shows a side cross section and thermal gradients of a boiler in operation according to an embodiment.

[0018] Figure 1 shows a perspective view of a steam cleaning apparatus 10. The steam cleaning apparatus can be any appliance for generating steam for cleaning surfaces. Figure 1 shows an exemplary steam mop 10 which is a non-limiting example of a steam cleaning appliance. Hereinafter the term steam mop will be used to describe the steam cleaning appliance, but the present invention can be applicable to steam cleaning appliances other than steam mops.

[0019] The steam mop 10 comprises a steam head 12 for delivering steam to a surface to be cleaned. Typical surfaces are tiled floors or hardwood floors, but other surfaces may be cleaned with the steam mop 10. The steam head 12 may comprise a pad or cloth (not shown) fixed to the underside of the steam head 12 to pick up dirt dislodged by the steam cleaning action.

[0020] The steam head 12 is coupled to a body 14 by an articulated joint 16. The articulated joint 16 may comprise a universal joint for allowing at least two degrees of freedom between the steam head 12 and the body 14. The articulated joint 16 is hollow and comprises a steam duct (not shown) for delivering steam to the steam head 12.

[0021] The body 14 of the steam mop may comprise a clam shell construction. The two halves of the clam shell are fixed together with screws and encase a steam generating apparatus 24. The steam generating appara-

tus 24 is not shown in Figure 1, but will be described in further detail in the subsequent Figures.

[0022] The body 14 is coupled to a water tank 18 for holding a water reservoir. The water tank 18 is in fluid communication with the steam generating apparatus 24. The water tank 18 may be removable for allowing the user to refill with water.

[0023] A handle 20 is coupled to the body 14 and provides a grippable portion for the user to hold during use. The body 14 and the handle 20 may have controls for operating the steam mop. The controls are coupled to an electronic controlling circuit (not shown). The steam mop 10 comprises an electrical heating circuit 60 which may be electrically coupled to a power cord (not shown) for connecting to an alternating current (AC) electricity supply. The AC electricity supply is configured to deliver electrical energy to the steam generating apparatus 24. In some embodiments a power cord is not needed because the steam mop 10 electrically and physically couples with a docking and charging station. In some alternative embodiments, the steam mop may be powered by a DC electricity supply such as a battery (not shown).

[0024] Turning to Figure 2, which shows a schematic cross sectional diagram of the steam generating apparatus 24 will be described in further detail. The steam generating apparatus in some embodiments is a boiler 24 and will be referred to hereinafter as a boiler. The boiler 24 comprises a resistive electrical heating element 26. The ends 28 of the resistive heating element 26 are electrically coupled to the electric heating circuit 60 which is shown in more detail in Figure 4. The electric heating circuit 60 comprises an electrical circuit breaking device 70.

[0025] The resistive heating element 26 is embedded in a solid thermal mass 30. The thermal mass 30 is configured to be heated by the resistive heating element 26. By heating the thermal mass 30 with the resistive heating element 26, electrical energy is converted to thermal energy and the thermal energy is stored in the thermal mass. The thermal mass 30 is a thermal heat store but will be referred to a thermal mass hereinafter. A portion of a water cooling circuit 32 is also embedded within the thermal mass 30. The water cooling circuit 32 provides a water heating path across the boiler 24 extending from a boiler water input 45 to a boiler superheated steam output 47. As the water flows through the water heating path 32, the water is heated and turned into steam. In some embodiments the water cooling circuit 32 is a helical coil, however in other embodiments the water cooling circuit 32 may have a conduit following a different path through the thermal mass. Ideally the water cooling circuit 32 traces a circuitous route through the thermal mass to heat the water to a sufficient degree. This also aids draining the thermal energy from the thermal mass 30. In some embodiments the thermal mass 30 is integral with the boiler 24. This means that if the thermal mass 30 is not a good thermal conductor, the thermal mass immediately surrounds the water cooling circuit 32 and the resistive

heating element 26.

[0026] In some embodiments, the thermal mass is a cylinder or substantially cylindrical. By using a cylinder, the thermal energy density of the thermal mass 30 can be increased over other volumes such as cubes or cuboids. The cylindrical shape has a good ratio of volume to surface area. In another embodiment the thermal mass is spherical in shape. However a cylinder is preferable because the helical coil is easier to manufacture and embed in a cylinder.

[0027] In some embodiments the thermal mass 30 comprises a metal material although the thermal mass can be any material suitable for storing thermal energy.

[0028] The resistive heating element 26 heats the thermal mass 30 up to an initial operating temperature. The initial operating temperature is close but below the melting point, for example at about 400°C, of the material of the solid thermal mass. Preferably in some embodiments the thermal mass is heated between 400 - 425 °C.

[0029] In some embodiments the thermal heat store is a metal alloy or an intermetallic compound. In some embodiments the metal alloy is a eutectic metal alloy. A eutectic metal alloy is advantageous because the melting point of the eutectic metal alloy can be significantly reduced. However, the eutectic mix may have a lower thermal conductivity compared to a pure metal. In one embodiment the thermal mass is made from an intermetallic compound of Aluminium (Al), Magnesium (Mg) and Zinc (Zn) with a melting point of approximately 450°C. In some embodiments the intermetallic compound comprises a composition of Al-34%Mg-6%Zn. Advantageously an intermetallic compound with a composition of a composition of Al-34%Mg-6%Zn is an eutectic intermetallic compound with a melting point lower than each of Magnesium and Aluminium components. A relatively small amount of Zinc is needed and this reduces the melting point of the intermetallic compound by approximately 200°C. However the eutectic intermetallic compound may have a poor thermal conductivity.

[0030] When the thermal mass 30 is heated to its initial operating temperature, the resistive heating element 26 is no longer needed to heat the thermal mass 30. At this point, the thermal mass 30 stores enough energy to heat and power the boiler 24 without an additional heating source. This means that the steam cleaning device 10 can be used remote from an electrical power source. As the water is converted into steam by the boiler 24, the temperature of the thermal mass 30 is reduced as the boiler 24 depletes the thermal energy from the thermal mass 30.

[0031] In order to achieve a useful runtime with the boiler 24 using energy from the thermal mass 30, the thermal mass 30 needs to be heated to a temperature which is significantly higher than the boiling point of water. This means that the boiler will operate at a very high temperature and initially generate superheated steam at the boiler superheated steam output 47 when water flows through the water cooling circuit.

[0032] Turning back to Figure 2, the thermal mass 30 is surrounded with an insulating jacket 34 which limits heat loss from the external surfaces of the thermal mass 30. The insulating jacket 34 comprises two halves which couple together to completely encase the thermal mass. The insulating jacket 34 is made from a ceramic material but the insulating jacket can be made from any suitable insulator.

[0033] A temperature sensor such as a thermostat or thermocouple 36 is also embedded in the thermal mass 30 for determining the temperature of the thermal mass 30. The thermostat 36 is coupled to the electronic controlling circuit 60 (as shown in Figure 4) and the electronic controlling circuit switches off the electrical power to the heating element 26 once the thermal mass reaches a desired operating temperature. The temperature sensor is concentric with the longitudinal axis A-A of the thermal mass 30.

[0034] The desired operating temperature of the thermal mass is selected on the basis that the thermal mass stores sufficient thermal energy to convert a required mass of water to steam without supplying further energy to the thermal mass. In this way the steam mop 10 can be heated up with an AC electricity supply and then used remotely without an electricity supply.

[0035] Since the thermal mass 30 has to be heated in excess of the boiling point of water, the superheated steam initially exits the boiler 24 at the boiler superheated steam output 47. The superheated steam is unnecessary for the application of domestic steam cleaning and the temperature of the superheated steam is reduced until it becomes wet steam. Optionally the temperature of the superheated steam can be reduced such that it is wet steam or reduced enthalpy, the steam cleaning device can be made with conventional plastics material which can withstand the lower temperature of the steam.

[0036] The water cooling circuit 32 will now be discussed in reference to Figure 3. Figure 3 shows a schematic perspective view of the steam generating apparatus 22 without the thermal jacket 34.

[0037] Water is supplied from the water tank 18 to the steam generating apparatus 22 by cold water tube 38. The cold water tube 38 is coupled to an optional steam cooling element 40. The embodiment as described in reference to Figure 3, the optional steam cooling element 40 is also a heat recovery element 40 and the cold water tube is coupled via water inlet 42. The water then flows out of the heat recovery element 40 via water outlet 44. The water outlet is coupled to and in fluid communication with the embedded helical coil 33 via a boiler water input 45. As the water flows through the helical coil 33, the water heats up and is converted into steam. The other end of the helical coil 33 comprises a boiler superheated steam output 47 and the boiler superheated steam output 47 is coupled to and in fluid communication with a steam inlet 46 of the heat recovery element 40. Wet steam or reduced enthalpy steam passes out of the heat recovery element 40 via steam outlet 48. The steam outlet 48 is

coupled to the steam head 12 via conduit 50. As indicated above, the steam cooling element 40 is an optional feature and is not necessary.

[0038] Operation of the steam mop 10 will now be discussed in reference to Figure 4, which shows a schematic flow diagram of the steam mop 10. First the user turns the steam mop 10 on. This connects the electrical heating circuit 60 to an AC electrical supply 66. The electrical heating circuit 60 is coupled to the resistive heating element 26 via an electrical circuit breaking device 70. The heating element 26 heats the thermal mass 30 of the steam generating apparatus 22 until the thermal mass 30 reaches a desired operating temperature (e.g. approximately 400°C). The thermal mass 30 may not be uniformly at the desired operating temperature. There may be thermal variations over the heating mass and for example hot spots, hotter than the desired operating temperature near the heating element 26 and cold spots cooler than the desired operating temperature near the periphery of the thermal mass 30. As mentioned above, the thermal mass 30 is thermally coupled to the boiler 24 because the thermal mass 30 is integral with the boiler 24. At this point the steam mop 10 is fully charged or heated and the user can use the steam mop 10. A user may then disconnect the steam mop 10 from the electrical supply 66. Due to the low heat loss achieved by the insulation, the user can leave the steam mop 10 disconnected for over an hour and the boiler 24 is still able to produce enough usable steam.

[0039] Water is stored in a water tank 18. When the user operates the steam mop 10 an internal battery 64 powers a pump 62. The pump 62 pumps water from the water tank 18 to the heat recovery element 40 via the water inlet 42. The cold water passes over the heat exchanger 56 and the cold water absorbs the thermal energy from the hot heat exchanger 56. The warm water exits the heat recovery element 40 via the water outlet 44. The warm water then passes through the water cooling circuit 32 comprising the helical coil 33 and is converted into superheated steam in the boiler 24. The superheated steam enters the heat recovery element at steam inlet 46. The superheated steam passes over the heat exchanger 56 and dissipates thermal energy to the heat exchanger 56 which cools the steam. Cooler steam then exits the heat recovery element 40 at steam outlet 48 and the steam is delivered to the steam head 12.

[0040] The boiler 24 will now be discussed in further detail reference to Figures 5 and 6. Figures 5 and 6 show a hidden line side view and a plan view of the boiler 24 respectively.

[0041] The boiler 24 also comprises a heating element 26 which is embedded in the thermal mass 30. The heating element 26 comprises a "U-shaped" element and the U-shape comprises a bend 80 of 180 degrees therein. In some embodiments the outer apex of the bend 80 is located 5mm from the bottom surface of the thermal mass 30. The heating element comprises a plurality of elongate portions 81, 82, 83, 84 which are parallel to the longitu-

dinal axis of the boiler 24. The elongate portions 81, 82, 83, 84 are the straight portions of the U shaped heating element 26. Although only elongate portions 81, 82 can be seen from Figure 5, there are actually four elongate portions as shown in Figure 6.

[0042] The elongate portions 81, 82, 83, 84, of the heating element 26 are equidistant from the axis A-A of the boiler 24. The elongate portions are arranged around a circumference of a first circle 85 having a first radius. In some embodiments the radius of first circle is 48mm. As mentioned above, in some embodiments the thermal mass 30 is cylindrical in shape and the radius of the thermal mass 30, is 79mm. In some embodiments the radius of the first circle is approximately 60% of the radius of the thermal mass 30.

[0043] As mentioned previously the water cooling circuit 32 comprises a coil embedded in the thermal mass 30. The coil in some embodiments can be a helical coil, but alternatively the coil can be any sort of coil with constant or varying pitch and diameter. The helical coil as shown in Figures 5 and 6 comprises a circular cross section which is concentric with a longitudinal axis A-A of the boiler 24. The helical coil has a circular cross section of a second circle having a second radius. The radius of the helical coil portion of the water cooling circuit 32 is smaller than the radius of the first circle. In some alternative embodiments the water cooling circuit 32 can comprise a conduit embedded in the thermal mass 30 whereby the conduit is formed from a void or a helical bore in the thermal mass 30.

[0044] In some embodiments the second radius of the second circle is 32mm. The radius of the second circle is approximately 40% of the radius of the thermal mass 30. In some embodiments the ratio of the radius of the helical coil of the water cooling circuit 32 to the radius of the circle on which portions of the heating element 26 are circumferentially arranged is 2:3. Of course in alternative embodiments the size of the thermal mass 30 and the boiler 24 can vary. For example, different embodiments comprise varying heights of boiler and thermal mass whilst maintaining the relative aforementioned radii.

[0045] The water cooling circuit 32 is wholly contained within the first circle on which the portions 81, 82, 83, 84 of the heating element 26 are arranged. This means that an outer surface 86 of the heating element 26 is closer to the outer surface 87 of the thermal mass 30 than an outer surface of the water cooling surface. In fact the outer surface 86 of the heating element 26 is closer to the outer surface 87 of the thermal mass 30 than any part of the water cooling circuit 32.

[0046] The helical coil portion of the water cooling circuit 32 is completely within a third circle on which the closest point to the axis A-A of outer surface 86 of each of the elongate portions 81, 82, 83 and 84 are located. In this way, the helical coil of the water cooling circuit 32 fits completely within the heating element 26. The helical coil portion of the water cooling circuit 32 is located in

the thermal mass 30 approximately 25mm from the base of the thermal mass 30. The bottom of the U shaped bend 80 of the heating element is located approximately 5mm from the base of the thermal mass 30.

[0047] In some embodiments the length of the thermal mass is 143mm. This means that the volume of the cylinder of the thermal mass 30 is approximately 2800 cubic centimetres. This is larger than a typical steam generator as shown in CN102087019 which is relatively small. This means that the small steam generator will cool quickly and the heating element must be permanently on in order to keep the steam generator at a temperature that will convert water into steam. The steam generator of CN102087019 does not have sufficient material surrounding the water flow path to heat the water after the heating element has been turned off for any appreciable period of time.

[0048] Surprisingly by placing the water cooling circuit 32 completely within the heating element 26, the thermal mass 30 is more evenly heated. Initially the inventors thought that the thermal mass 30 would most efficiently transfer heat to the water cooling circuit 32 by embedding the coil of the water cooling circuit 32 at $0.5r$ (where r is the radius of the thermal mass). This would mean that there would be half the volume of the thermal mass 30 outside the water heating circuit 32 and half the volume of the thermal mass 30 inside the water heating coil. However it has been found that the temperature distribution of across the thermal mass 30 has a large variation when the water cooling circuit 32 is located at approximately $0.5r$ which is not conducive for efficient thermal storage.

[0049] Figure 7 shows a cross section through the thermal mass 30 and a temperature variation of the thermal mass 30 when the water cooling circuit 32 is embedded within the thermal mass 30 at approximately $0.5r$. The heating element 26 has been on for 600s at 1500W. Figure 7 shows approximately a 90 degree Celsius variation across the thermal mass. This means that less thermal energy can be stored in the thermal mass if there is a large temperature variation above and below a desired operating temperature and there will be less thermal energy available in the thermal mass to convert water into steam in the water cooling circuit 32. In turn the run time of the steam mop 10 will be reduced if there is a large temperature variation across the thermal mass 30.

[0050] Figure 7 shows different temperature zones. The initial temperature of the thermal mass in a first zone 90 adjacent to the heating element 26 is approximately 400-410C. A second zone 91 adjacent to the first zone 90 has a temperature range of approximately 380-400C. A third zone 92 which is adjacent to the second zone 91 has a temperature range of approximately 350C to 380C. A fourth zone 93, fifth zone 94 and sixth zone 95 has temperature ranges of approximately 340-350C, 330-340C and 320-330C respectively. As can be seen the arrangement in Figure 7 yields an annulus around the top edge of the thermal mass 30, depicted by zone 6, which is 90C cooler than the initial temperature immediately adjacent

to the heating elements 26.

[0051] It is thought that the water cooling circuit 32 acts as a barrier and potentially disrupts the transfer of thermal energy across the thermal mass 30.

[0052] Figure 8 shows a cross section through the thermal mass 30 and a temperature variation of the thermal mass 30 when the water cooling circuit 32 is embedded within the thermal mass 30 according to embodiments of the present invention. It can be seen from Figure 8 that the water cooling circuit 32 is completely within the heating element 26.

[0053] The thermal mass 30 has a more even temperature distribution. This means that less time is required to raise the temperature of the most remote region from the heating element to the desired operating temperature. Indeed in some embodiments, the duration of operation of the heating element 26 can be reduced when heating the thermal mass 30 to a desired operating temperature.

[0054] A first zone 96 which is adjacent to the heating element 26 has a temperature range of approximately 375-380C. The second zone 97 has a temperature range of approximately 370-375C. The third zone 98 has a temperature range of approximately 365-370C. The fourth and fifth zones 99, 100 have temperature ranges respectively of 360-365C and 355 - 360C. In this way the thermal mass 30 of the boiler 24 has an initial temperature variation of approximately 20- 25C. This means more thermal energy can be stored in the thermal mass 30. When only the thermal energy stored in the thermal mass 30 is used to convert water into steam, without an additional electrical power source, the boiler 24 will have a longer run time.

[0055] In another embodiment two or more embodiments are combined. Features of one embodiment can be combined with features of other embodiments.

[0056] Embodiments of the present invention have been discussed with particular reference to the examples illustrated. However it will be appreciated that variations and modifications may be made to the examples described within the scope of the invention.

Claims

1. A boiler for a steam cleaning device comprising:
 - a thermal heat store;
 - an electrical heating element for heating the thermal heat store;
 - a water cooling circuit comprising a water input for receiving water from a water tank and a steam output;
 - wherein the electrical heating element and the water cooling circuit are embedded in the thermal heat store and an outer surface of the electrical heating element is closer to an outer surface of the thermal heat store than an outer surface of the water cooling circuit.

2. A boiler according to claim 1 wherein the electrical heating element comprises a plurality of elongate portions each of which are parallel to a longitudinal axis of the thermal heat store.
3. A boiler according to claim 2 wherein the elongate portions are each equidistant from the longitudinal axis of the thermal heat store.
4. A boiler according to claims 2 or 3 wherein the elongate portions are centred on the circumference of a circle having a first radius, the circle being concentric with the longitudinal axis of the thermal heat store.
5. A boiler according to claim 4 wherein the first radius is equal to approximately 60% of the distance from the centre of the thermal heat store to the outer surface of the thermal heat store.
6. A boiler according to any of the preceding claims wherein the water cooling circuit comprises a helical coil having a longitudinal axis parallel to a longitudinal axis of the thermal heat store.
7. A boiler according to claim 6 as dependent on claims 4 or 5 wherein helical coil has a second radius and the second radius is smaller than the first radius.
8. A boiler according to claim 7 wherein the second radius is equal to approximately 40% of the distance from the centre of the thermal heat store to the outer surface of the thermal heat store.
9. A boiler according to claims 7 or 8 wherein the helical coil of the water cooling circuit does not substantially overlap with the elongate portions of the electric heating element.
10. A boiler according to and of the preceding claims wherein the boiler comprises a temperature sensor embedded in the thermal heat store and the temperature sensor is aligned with the longitudinal axis of the thermal heat store.
11. A boiler according to any of the preceding claims wherein the thermal heat store is a metal, metal alloy or an intermetallic compound cast around the water cooling circuit and the electric heating elements.
12. A boiler according to any of the preceding claims wherein the boiler comprises a thermally insulating jacket surrounding the outer surface of the thermal heat store.
13. A boiler according to any of the preceding claims wherein the electric heating element is U-shaped having a 180 degree bend therein.
14. A boiler according to claim 1 wherein the thermal heat store comprises a substantially cylindrical shape.
- 5 15. A steam cleaning device comprising:
 - a water tank;
 - a boiler according to any of claims 1 to 14 in fluid communication with the water tank; and
 - a steam outlet in fluid communication with the steam output of the boiler.

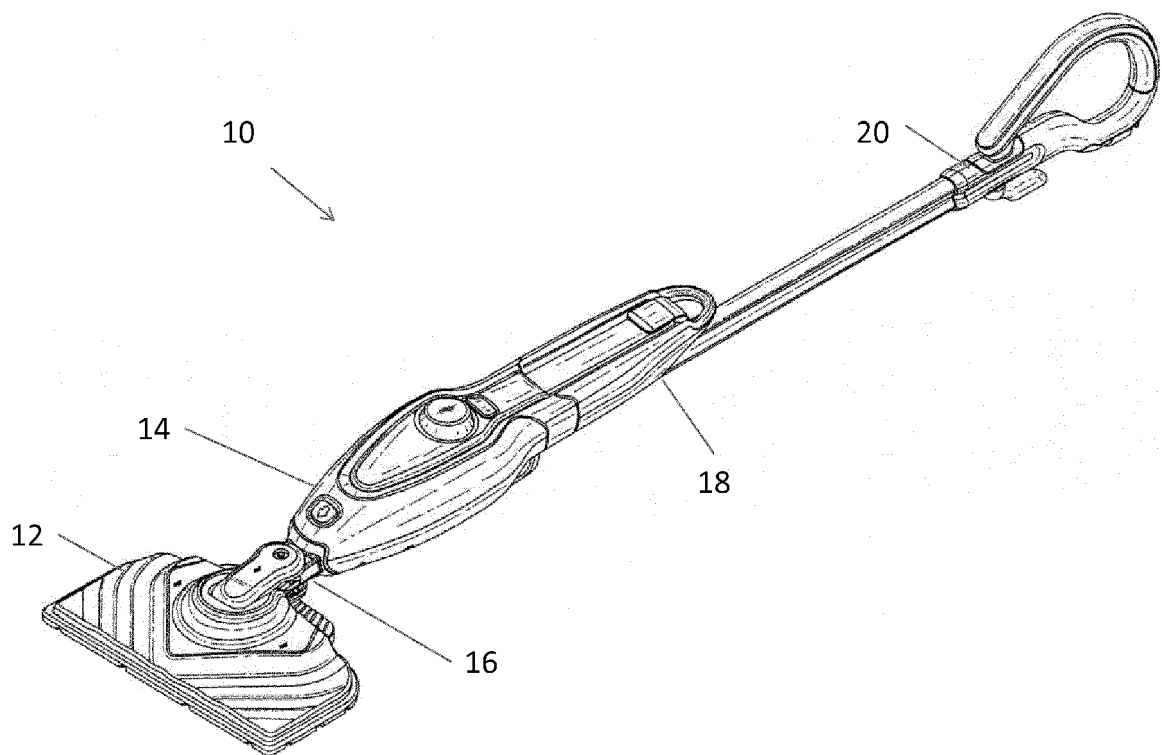


Figure 1

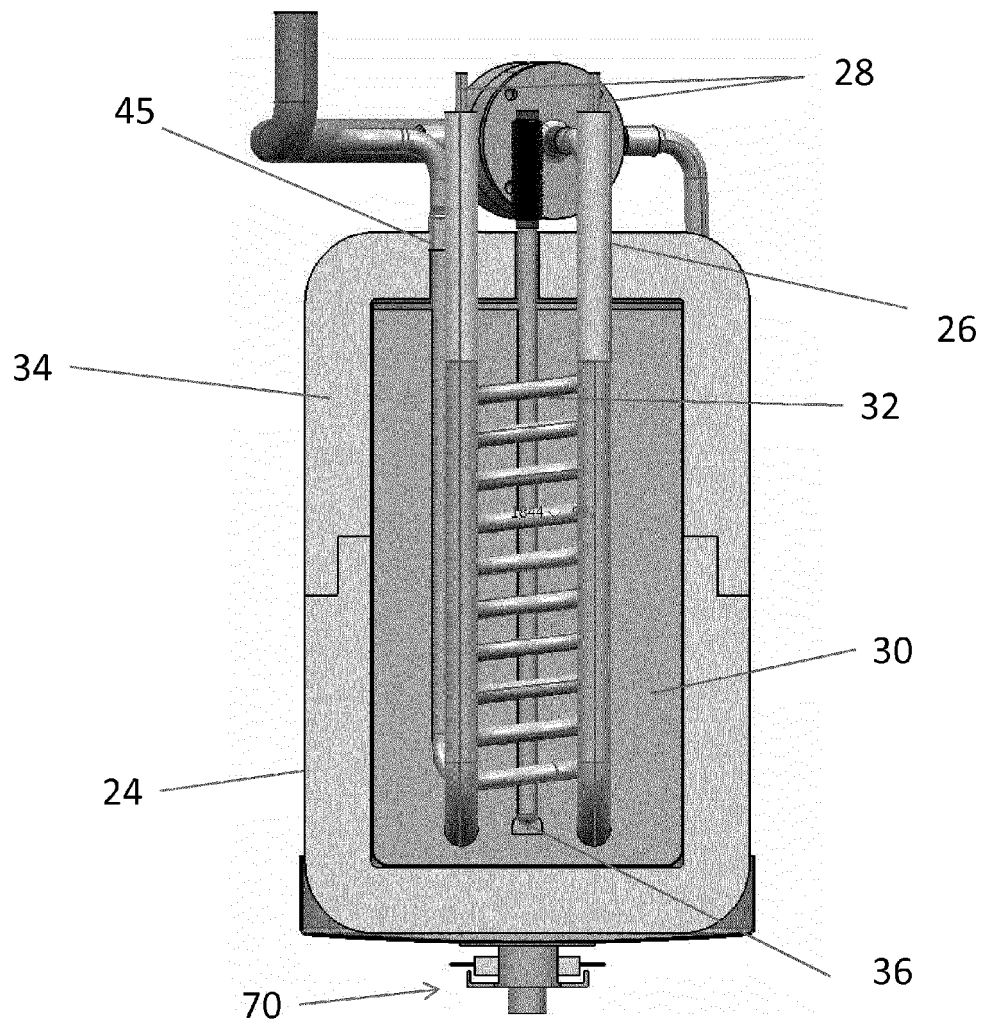


Figure 2

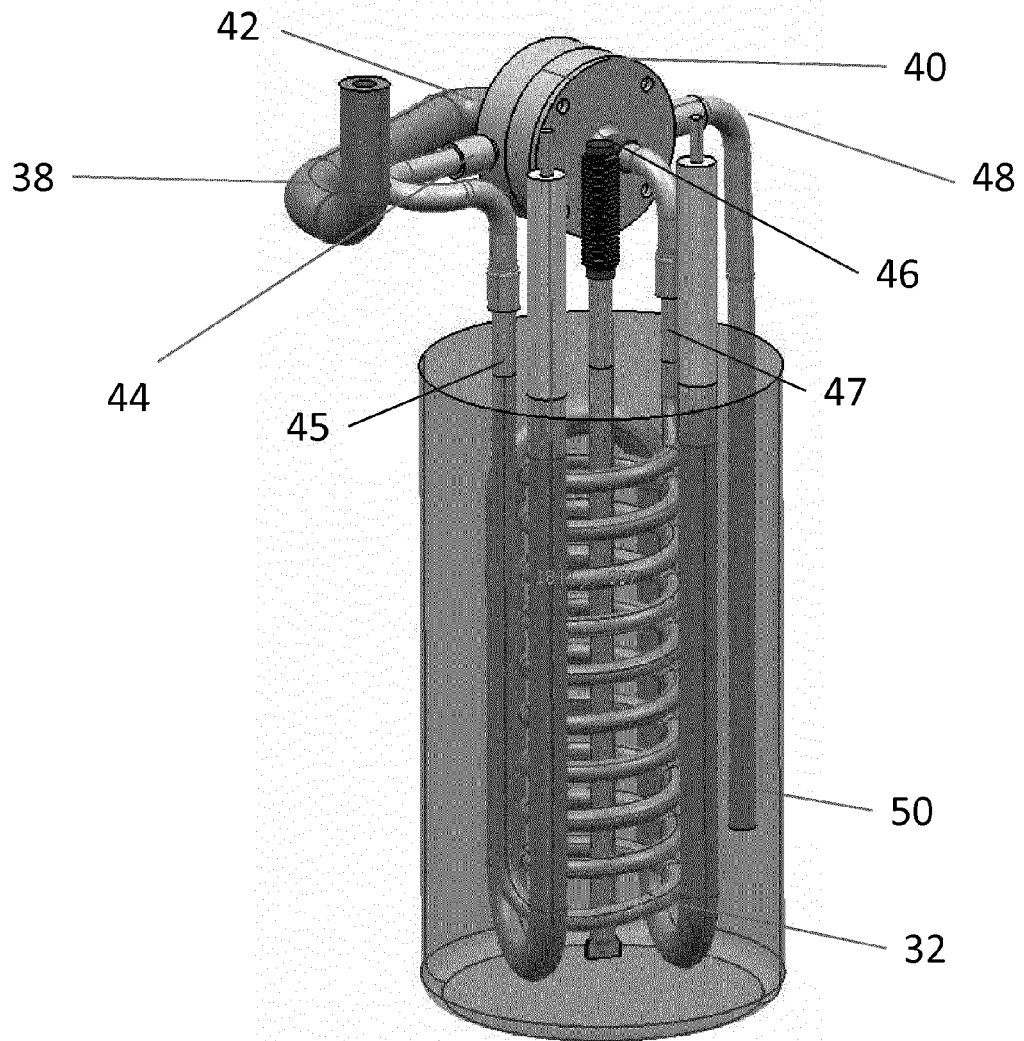


Figure 3

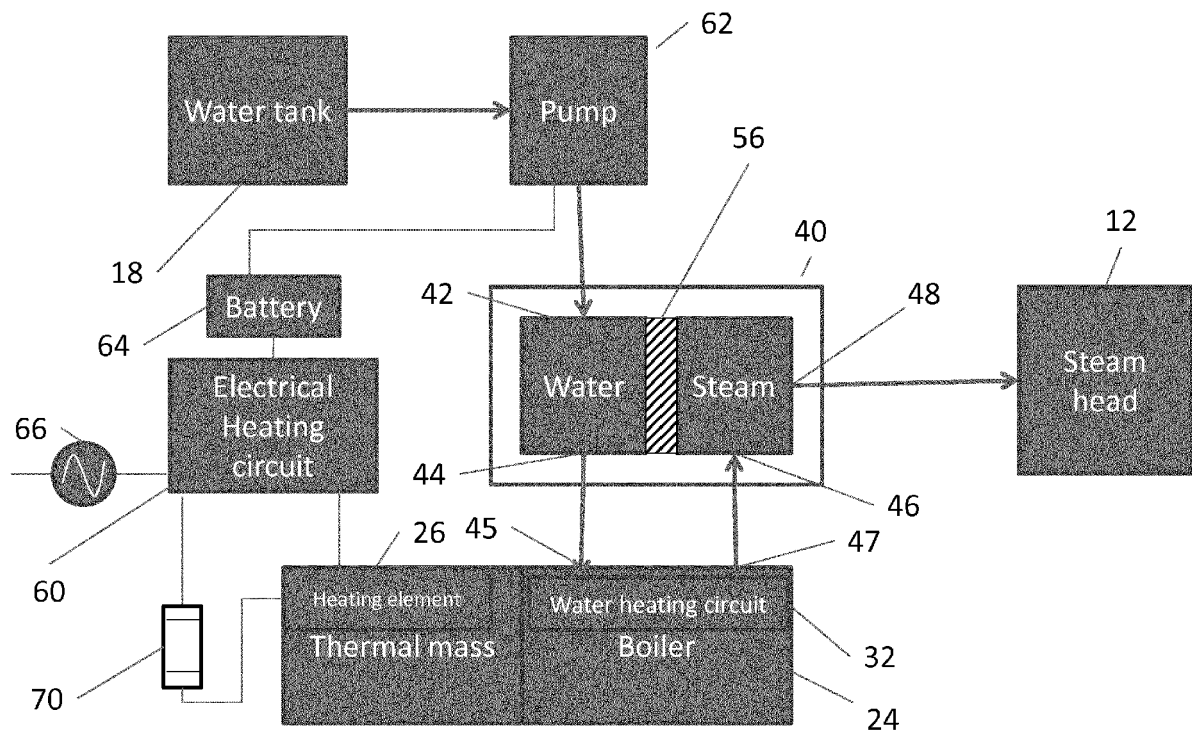


Figure 4

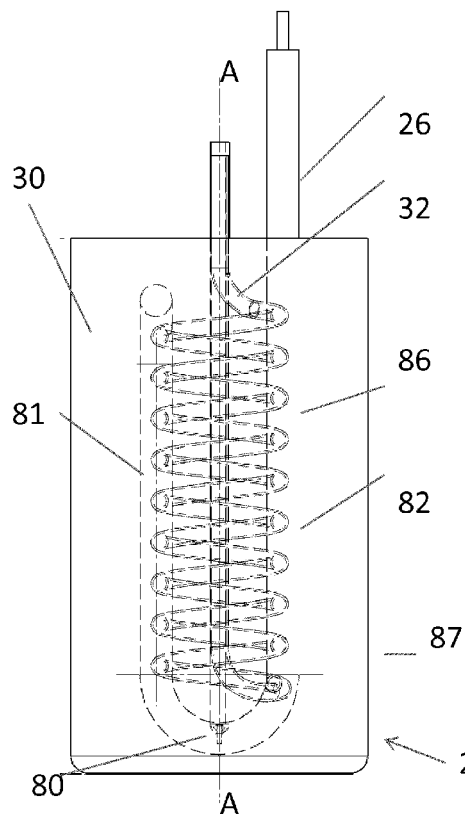


Figure 5

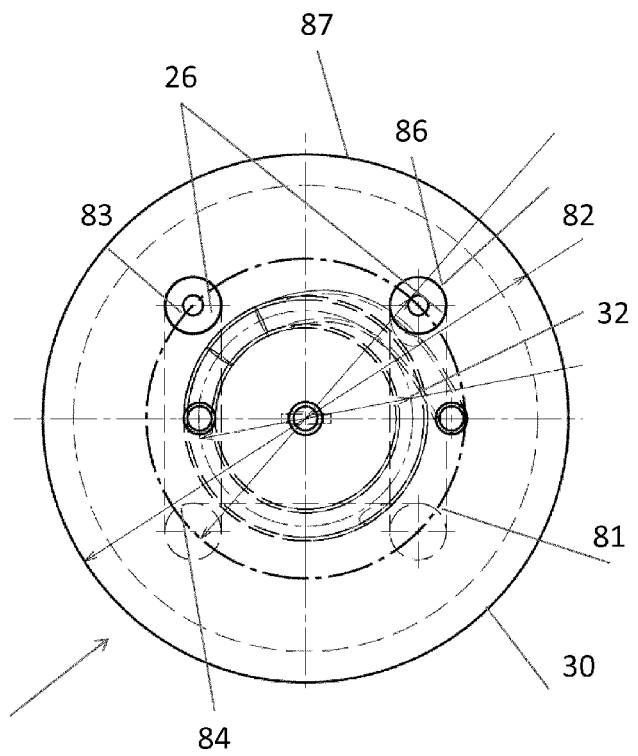


Figure 6

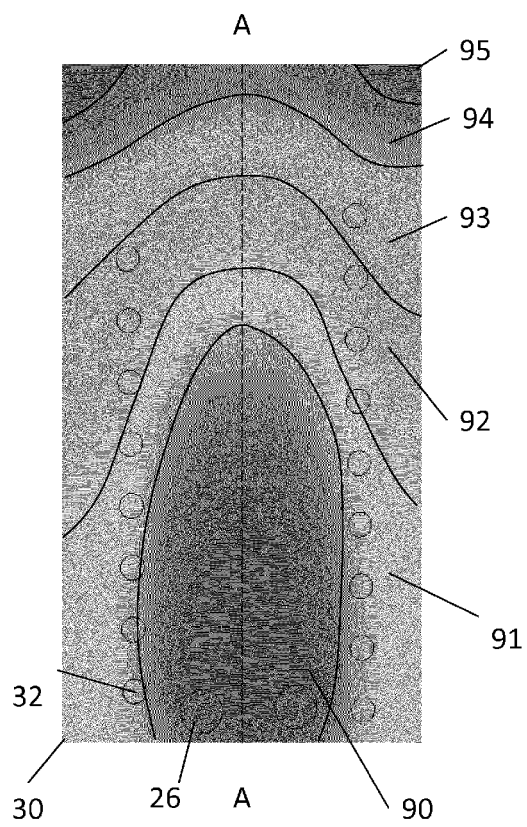


Figure 7

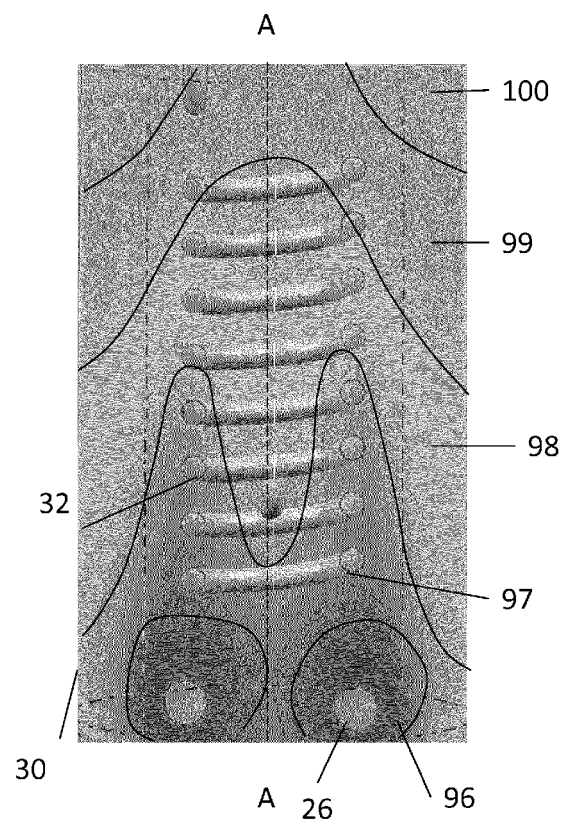


Figure 8



EUROPEAN SEARCH REPORT

Application Number
EP 14 19 4041

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2008/141952 A1 (HAAN GYUNG-HEE [KR]) 19 June 2008 (2008-06-19)	1-5,11, 13,15	INV. A47L13/22 F22B1/28
Y	* paragraph [0004] *	10-12	
A	* paragraphs [0026] - [0033] * * paragraphs [0036] - [0038] *	6-9,14	
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