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(54) ELECTRIC WATER HEATING ELEMENT

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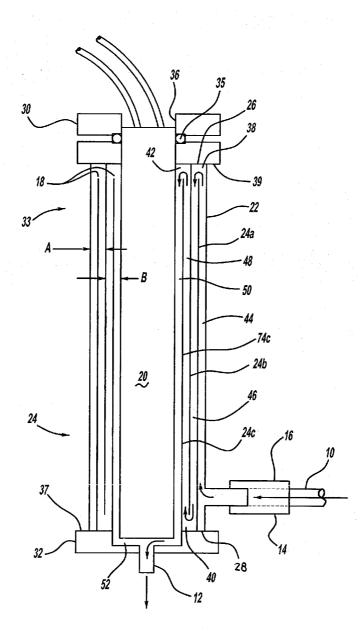
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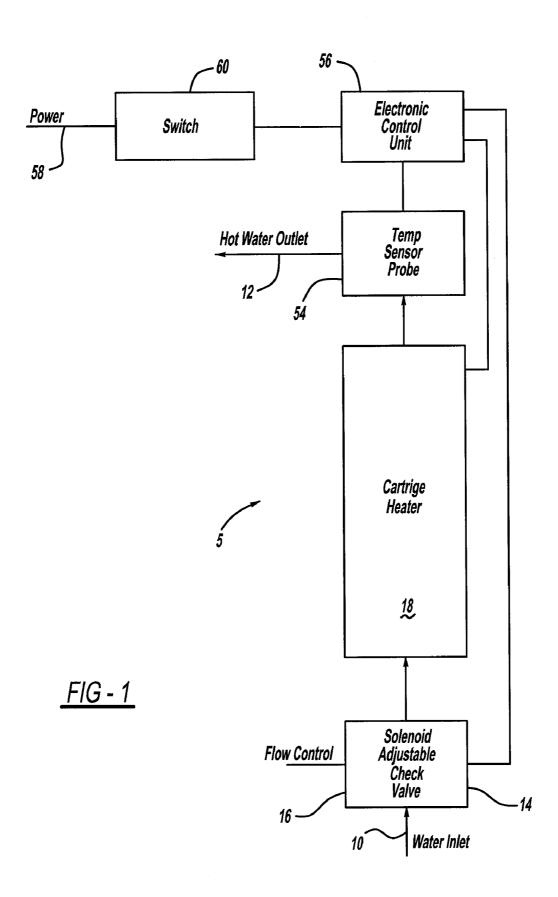
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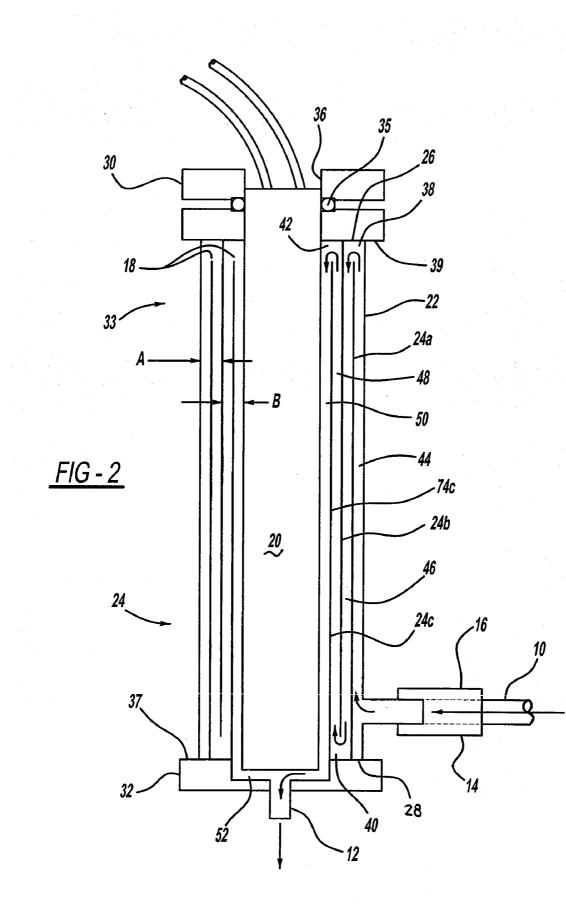
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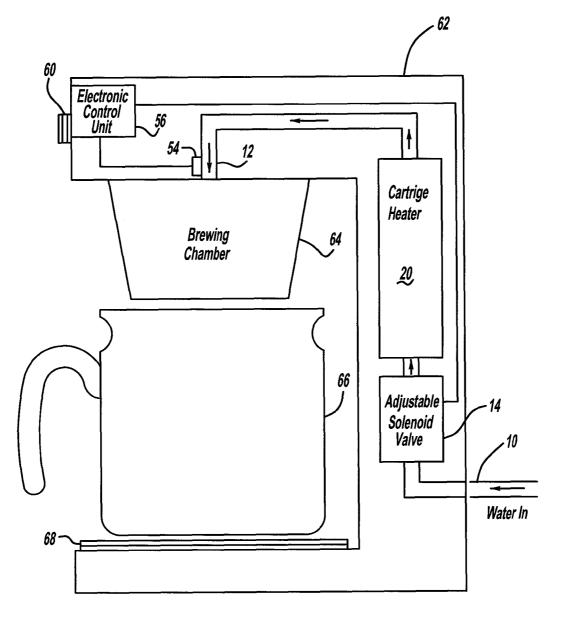
(57) **ABSTRACT**

The invention is an on-demand electric water heater which includes one heater housing having an electric cartridge heating element surrounded by at least one water heating chamber containing a partition member mounted on the top cover or base cover of the heater housing to define opposing flow passages along the longitudinal direction of the electric cartridge heating element such that as cold water enters the housing and proceeds along the opposing flow passages, heat generated by the electric cartridge heating element is absorbed by the incoming cold water flowing along the opposing flow passages to minimize heat losses from the on-demand electrical water heater.









<u>FIG - 3</u>

ELECTRIC WATER HEATING ELEMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

[0002] Not applicable.

REFERENCE TO SEQUENCE LISTING

[0003] Not applicable.

BACKGROUND OF THE INVENTION

[0004] 1. Field of the Invention

[0005] The present invention is directed to providing hot water through the use of a tankless water heater unit which is specifically adapted to heat water on a continuous on-demand basis as the water passes from a conventional water source along a path of water flow through the unit and along an outlet path for commercial or residential use.

[0006] 2. Description of the Related Art

[0007] The most common approach today to obtaining heated water in both domestic and commercial settings involves the utilization of large storage tanks for the storage of hot water. Although such heated storage tank systems can provide hot water at a relatively good flow rate, inefficiency is prevalent in such types of water heater assemblies due to the fact that the water maintained within such storage tanks is effectively reheated continuously even when the storage tank is not being utilized on a regular or continuous basis.

[0008] Another approach to providing hot water involves the use of continuous flow or "tankless" water heaters wherein the water is almost instantaneously heated as it passes along a continuous flow system. Such continuous flow or tankless water heating systems are far more efficient from the standpoint of expending energy for the purpose of heating water which is currently being used. However, one serious common drawback of traditional tankless continuous water heating systems is their inability to provide hot water at high flow rates. Typically, traditionally tankless water heater systems have difficulty providing domestic hot water (e.g., for shower water with a temperature of approximately 90°-100° F. (32°-38° C.)) at flow rates greater than approximately six gallons per minute (22.7 liters per minute). Such existing factors in the currently available continuous flow water heaters result in restricting usage to limited domestic applications and no usage in commercial applications wherein industrial applications processed hot water is typically water with a temperature of at least 140° F. (60° C.) or higher.

[0009] Other than limited flow rates, there are additional drawbacks which have been defined in the use of continuous flow "tankless" water heaters. It is difficult to regulate the output temperature as flow rates fluctuate without the use of expensive and complex controls. Another existing and known problem with instantaneous water heaters is the lack of reliability with frequent breakdowns, therefore, requiring the need for frequent maintenance and repair.

[0010] The prior art has proposed some continuous flow water heaters of the type referred herein. The patent to Insley, U.S. Pat. No. 4,762,980, discloses an apparatus for electrically heating water utilizing at least two electrically powered heating resistance elements disposed sequentially along a

path of flow but wherein separate chambers in which the separate heating elements are arranged are connected by a single common port or opening located at a common end of both the chambers and heating elements. Insley discloses his heating elements as a continuous electric resistance heating coil extending successfully through separate interior channels rather than two totally segregated elements. The heating coils controlled by temperature controller means having a temperature sensor to reduce or eliminate the effects of radiant energy generated by the heating coil on the temperature sensor.

[0011] Todd, U.S. Pat. No. 4,567,350, discloses an instantaneous electric water heater for both household and commercial use including a plurality of sequentially arranged individual heating chambers connected in series flow relationship between a cold water inlet and a hot water outlet wherein heating elements are energized by a flow switch at the time the hot water is demanded and are controlled by an adjustable thermostat which sets the outlet hot water temperature. An adjustable regulator is provided to assure that the water flow rate will not exceed the capacity of the heater to heat the water to a minimal acceptable level.

[0012] U.S. Pat. No. 4,604,515 issued to Davidson and U.S. Pat. No. 4,638,147 issued to Dytch et al. includes a solid state switch to control electrical current to the heating elements. Dytch mounts the solid state switch on a wall of the heating chamber, thereby cooling the switch while recovering generated heat. Dytch also teaches locating a temperature sensor at the outlet of the heater.

[0013] Hurko, U.S. Pat. No. 4,808,793 discloses a tankless electric water heater having an instantaneous hot water output which includes an open ended folded tubular conduit having a separate metal sheath emerging heating element inserted into each end of the conduit. This patent also discloses the use of a self regulating (PTC) heating cable either disposed in or wrapped around the tubular conduits which is continuously energized independently of the metal sheathed heating elements so as to maintain the water in the tubular conduits at a constant predetermined temperature.

[0014] U.S. Pat. No. 5,479,558 to White, Jr. et al. describes a flow-through tankless water heater with a flow switch. The flow switch has an arm and a ball joint, but requires significant water flow to energize the flow switch.

[0015] U.S. Pat. No. 6,552,283 to Cabrera describes a flow switch. The flow switch has a floating magnetic set of balls that have a specific gravity higher than water yet will float upwardly in a pipe when water flows, thereby coming into proximity with a magnetic switch and energizing the heating elements. The floating set of magnetic balls must be retained within the pipe to prevent them from flowing out of the water heater. This requires screens within the flow of water which, in many circumstances, corrode or clog during use.

[0016] A need therefore continues to exist for hot water delivery systems that can provide hot water in a more energy efficient manner than storage tanks systems yet still deliver hot water at the higher flow rate associated with storage tank systems.

BRIEF SUMMARY OF THE INVENTION

[0017] The present invention relates to an instantaneous on-demand hot water system which passes the incoming water through at least one surrounding continuous flow cham-

ber. Each chamber includes an electric heating element which is activated as the continuous flow of water enters the chamber.

[0018] In accordance with the present invention, the instantaneous on-demand water heater provides hot water at a high flow rate and even temperature by passing the water to be heated through a tortuous labyrinth path in a chamber enclosure surrounding the electrical heating element providing the source of heat. In order to insure that the instantaneous ondemand hot water system consumes power only when the user demands hot water, the instantaneous water heater has a flow control responsive to the flow of water to turn on the electric heating element. Further, the electric heating element, as a safety device, is also controlled by a high temperature sensing switch which will shut off the electrical heating element upon sensing that the high temperature limit has been exceeded. Also, an adjustable thermostat is used to set the final temperature of the hot water output of the heating device. [0019] The on-demand heating system in accordance with the present invention utilizes a vertically oriented enclosure containing an inner upright baffle which directs the flow of the incoming water from its water inlet located at the lowest point of the enclosure, upwards along the length of the vertically oriented enclosure to the top of the enclosure where the incoming water is made to overflow the baffle and reverse its flow from upward to downwards into direct contact with the outer wall of the internal electric heating element such that heat carried outwards from the electric heating element is absorbed by the flowing water as it flows along the path within the surrounding chamber.

[0020] Accordingly, it is a principal object of the present invention to provide an improved on-demand instantaneous electric hot water system.

[0021] It is another object of the present invention to provide an improved energy efficient electrical hot water system. **[0022]** It is yet another object of the present invention to provide an on-demand hot water system which has precise temperature regulation to insure that the water is delivered at an even temperature.

[0023] Yet a further object of the invention is to provide an on-demand water heater having means for regulating against excessive hot water demand, means for limiting the water temperatures in the event of thermostat malfunctions, and means for activating the water heater only when hot water is desired by the user.

[0024] Other objects and advantages of the invention will become apparent from the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIG. **1** is a schematic diagram of the on-demand electric hot water heater system;

[0026] FIG. **2** is a cross-sectional view of the cartridge heater element of the present invention; and

[0027] FIG. **3** illustrates the use of the present invention in the making of a cup of coffee.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] With reference to the figures, an on-demand instantaneous hot water heating system **5** having a cold water inlet **10** and hot water outlet **12** is shown. The improved water heater will provide instant hot water to a location or locations

where hot water is to be delivered. Such locations may include a bathroom or kitchen sink, a shower stall, a washer in the laundry room and/or a bathing facility, including any one of many industrial or commercial applications.

[0029] As the cold water enters, it passes through a flow control valve 14 in communication with the cold water inlet 10 and a control unit 56 which helps maintain a constant flow rate for the incoming water. A one-way check valve 16 also communicates with the cold water inlet 10 to prevent backflow from the on-demand instantaneous hot water heating system 5.

[0030] In the illustrated embodiment, the cold water enters the first of a series of tubular heating chambers 18 surrounding a cartridge heating element or heating source 20. The radially outermost heating chamber consists of an outermost tube 22 of copper or stainless steel tubing surrounding one or more inner tubes or partitions 24a of copper or stainless steel tubing. Both inner and outermost tubes 24a, 22 have a first end 26 and second end 28. The outermost tube 22 is permanently interconnected at the first end 26 to a top cover 30 and to a base cover 32 at the second end 28 to create a sealed tubular housing 33 that is completely sealed with the exception of a cold water inlet 10 in the outermost tube 22 and a hot water outlet 12 in the base cover 32. The electrical cartridge heating element 20 is approximately centrally mounted within a passage 36 in the top cover 30 and sealed in the top cover 30 by a elastomeric seal 35 mounted within the passage 36. The electrical cartridge heating element 20 is suspended within the sealed tubular housing 33 and has a stainless steel outer surface. The electrical cartridge heating element 20 is an off-the-shelf item and is readily available in a variety of output capacity sizes from a variety of heater control suppliers.

[0031] The one or more inner tubes 24 have only one of their first or second ends 26, 28 fixed or interconnected with either the top cover 30 or the base cover 32. In the preferred embodiment shown, the second end 28 of the first inner tube 24a is permanently fixed to the base cover 32 while the first end 26 extends to within approximately one-half $(\frac{1}{2})$ inch of the top cover 30 to leave an opening 38 between the first end 26 and the bottom 39 of the top cover 30. A second inner tube 24b is mounted radially inwards of the first inner tube 24a. This second inner tube 24b has its first end 26 permanently fixed to the top cover 30 while its second end 28 is suspended downwards to within approximately one-half (1/2) inch of the top 37 of the base cover 32 to leave an opening 40 between the second end 28 of the second inner tube 24b and the base cover **32**. A third inner tube 24c is radially inward of the second inner tube 24b and like the first inner tube 24a, its second end 28 is fixed to the base cover 32 while its first end 26 extends toward the top cover 30 but terminates approximately onehalf $(\frac{1}{2})$ inch away from the bottom surface 39 of the top cover 30 to define an opening 42 between the first end 26 of the third inner tube 24c and the top cover 30. This arrangement defines two chambers A, B, each chamber having an inner tube acting like a baffle or partition to define longitudinal passages, one being an inlet passage and the other a return passage through which the water flows that surrounds the cartridge heating element 20.

[0032] The cold water, after flowing through the one-way check valve 16 and flow control valve 14 enters the first chamber A via a three-quarter inch to one inch cold water inlet connection 10 near the second end 28 of the outermost tube 22 and enters into the inlet passage 44 between the outermost

tube 22 and the first inner tube 24a after passing through the adjustable flow control valve 14 and begins to rise in the inlet passage 44 towards the top cover 30. When the water level reaches the top of the first inner tube 24a where the opening 38 exists, the water will spill over the first inner tube 24a and by way of an opening 38, the water will begin to flow downwards along the return passage 46 between the first inner tube 24a and the second inner tube 24b within the first chamber A. A great deal of turbulence is created in the flow of the water by the fact that the water is forced to completely change direction as it flows through the opening 38 and downwards along the return passage 46 between the first and second inner tubes 24a, 24b. Because of this turbulence, the water flow becomes a good heat absorber of any heat that radially dissipates from the cartridge heating element 20. As the water continues to flow downwards in the return passage 46 between the first and second inner tubes 24a, 24b, it will be diverted by the base cover 32 and be forced through the opening 40 to change directions and begin to flow upwards in the incoming passage 48 of the second chamber B between the second inner tube 24b and the third inner tube 24c. Again, the flow will be very turbulent because of the reversal of directions from the return passage 46 in the first chamber A to the incoming passage 48 of the second chamber B. Any heat that is radially dissipated from the cartridge heating element 20 will be absorbed by the turbulent water flow in the various passages surrounding the cartridge heating element 20 which results in preheating of the incoming cold water and significantly reduces heat losses from the cartridge.

[0033] The flow pattern of the first chamber A now repeats itself. That is, the water will rise in the incoming passage 48 between the second inner tube 24b and the third inner tube 24c until it reaches the opening 42 near the top cover 30 and spill over into the second chamber's return passage 50 between the outer surface of the cartridge heating element 20 and the third inner tube 24c where it will absorb the majority of the heat output of the cartridge heating element 20 as it travels downward towards the hot water outlet 12 in the base cover 32. An outlet passage 52 is created in the base cover 32 so that the heated water can flow out of the sealed tubular housing 33 and into a three-quarter inch to one inch outlet connection where a hot water temperature probe 54 monitors the temperature of the heated water. This hot water is then delivered to its final use destination.

[0034] In the preferred embodiment, the radial distance between the cartridge heating element 20 and the third inner tube 24c, as well as the radial distance between the third 24cand second inner tube 24b, second 24b and first 24a inner tubes and first 24a inner tube and the outermost tube 22, was selected to be approximately 20 to 30 thousands of an inch (0.020-0.030) in order to obtain an output flow of approximately 18 ounces per minute for a 140° F. rise in water temperature using a 3000 watt, 3/4 inch diameter cartridge heating element 20. The cold water incoming temperature was measured to be between 55° F. and 60° F. With this arrangement, a 3/4 inch diameter 4000 w cartridge heating element 20 produced a hot water flow rate of approximately 24 ounces per minute, again, with 140° F. rise in water temperature. From these results, it appears that the preferred embodiment produces an approximate flow of six ounces of hot water per minute with a 1000 watt cartridge and 140° F. temperature rise and the flow increases in direct relationship to the wattage of the cartridge heating element 20 used. That is, a 2000 watt cartridge will produce 12 ounces per minute at hundred and 140° F. rise in temperature while a 3000 watt heating cartridge will produce hot water flow of 18 ounces per minute 140° F. rise in water temperature. As the radial distance between incoming passages and return passages within each chamber increases, in an attempt to attain higher capacity heaters, the wattage output of the cartridge heating element 20 will need to be calculated in order to obtain a predetermined temperature rise in the hot water as it passes through the tubular housing. Because of its design and the passages of water surrounding the cartridge heating element 20, the ondemand cartridge heater is very efficient since any heat loss radially is absorbed by the water in the surrounding passages and this captured heat will preheat the incoming cold water, thereby, significantly increasing the efficiency of the cartridge heater housing. A person skilled in the art will quickly recognize that the number of chambers used to surround the hot water cartridge may vary as a function of the application. For example, a larger cartridge heater, i.e. 12,000-15,000 watt having higher heat losses may benefit from four chambers surrounding the heater cartridge to capture heat loss and to use such heat loss to preheat the colder incoming water.

[0035] At the hot water outlet **12** is located a hot water temperature probe **54**, which may incorporate a high temperature cut-off switch for added safety protection. Such safety item is generally required by local building codes.

[0036] As shown in FIG. 1, an electronic control unit 56 is mounted between an electrical power source 58 and the cartridge heating element 20. The electronic control unit 56 supplies power to the heating element 20. The electronic control unit 56 also communicates with the flow control valve 14 and hot water temperature probe 54 so as to enable programming of the flow of water through the cartridge heating element 20 as well as to probe the hot water temperature outlet of the cartridge heating element 20 to enable continuous operation within the prescribed parameters of the ondemand instantaneous hot water heating system 5. The electronic control unit 56 is powered through a switch 60 which may be conveniently placed depending upon the application. [0037] As set forth above, larger capacity cartridge heaters will result in the ability to significantly increase larger hot water delivery rates. It is also within the knowledge of a person skilled in the art, that if greater flow rates are needed a plurality of cartridge heaters with a known capacity may be used in conjunction with a set-up using a manifold to collect the output of the plurality of cartridge heaters to provide a large supply of on-demand instant hot water.

[0038] FIG. **3** illustrates an application of the current invention. The on-demand instantaneous hot water system illustrated in FIG. **1** is mounted with a housing **62** of a modern coffee maker, having a brewing chamber **64** overhanging a coffee pot **66** sitting on an electric warming device **68**. When a pot of coffee is desired, the appropriate measure of coffee grounds is placed within a filter (not shown) in the brewing chamber **64** and the switch is activated. Hot water is instantaneously delivered to the brewing chamber **64** by the cartridge heater system for the desired number of cups selected by the user.

[0039] From the foregoing, it will be seen that the invention is one well adapted to obtain all of the objects herein set forth, together with other advantages which are obvious and which are inherent to the structure.

[0040] It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and well within the scope of the claims. Although one embodiment has been shown in the drawings, many other embodiments may be made of the invention without departing from the scope thereof. It is to be understood that all matter herein set forth shown in the accompanying drawings is to be interpreted as illustrated and not in a limiting sense.

What is claimed is:

1. An on-demand electrical hot water heater comprising:

- at least one water heating chamber having an inlet passage and an outlet passage, said at least one water heating chamber having one end and an opposite end;
- a top cover member mounted to said one end of said at least one water heating chamber, said top cover member having a passage therethrough;
- an electrical heating element sealingly mounted in said passage of said top cover member, said electrical heating element further suspended in said at least one water heating chamber and having a peripheral surface;
- means for connecting said electrical heating element to a source of electric power;
- said at least one water heating chamber surrounding said electrical heating element to define a sealed heater housing having said inlet and said outlet;
- a base cover mounted to said opposite end of said at least one water heating chamber, said base cover having an opening therethrough, said opening defining said outlet passage;
- said at least one water heating chamber further having: an outer wall;
 - an inner wall defined by said peripheral surface of said electrical heating element; and
 - a partition member mounted to one of said top cover or base cover, to define opposing flow passages along the longitudinal direction of said electrical heating element;
 - whereby as cold water enters said inlet and proceeds along said opposing flow passages, heat generated by said electrical heating element is absorbed by said incoming cold water flowing along said opposing flow passages such as to minimize heat losses from said on-demand electrical water heater; and
- means for connecting said electrical heating element to a source of electrical power.

2. The on-demand electrical hot water heater as claimed in claim 1 further comprising means responsive to the flow of water through said at least one water heating chamber for activating a flow sensor in response to the flow of water exceeding a predetermined threshold.

3. The on-demand electrical hot water heater as claimed in claim 1 further comprising means responsive to the temperature of the water flowing out of the hot water outlet for activating a temperature sensor in response to the temperature of the water at said hot water outlet exceeding a predetermined adjustable threshold temperature.

4. The on-demand electrical hot water heater as claimed in claim 1 wherein said power connecting means further comprises:

- means responsive to the flow of water through said at least one water heating chamber for activating a flow sensor in response to the flow of water exceeding a predetermined threshold;
- means responsive to the temperature of the water flowing out of the hot water outlet for activating a temperature

sensor in response to the temperature of the water at said hot water outlet exceeding a predetermined adjustable threshold temperature; and

an electronic control unit for connecting said electrical heating element to a source of electrical power in response to said means responsive to the flow of said water and means responsive to the temperature of said water being simultaneously in an activated state.

5. The on-demand electrical hot water heater as claimed in claim 1 further comprising a one-way flow valve mounted to an incoming cold water line to prevent backflow of said incoming cold water.

6. An on-demand electrical hot water heater comprising:

- at least one water heating chamber having an inlet and an outlet;
- an electrical heating element disposed in said at least one water heating chamber, said electrical heating element having a peripheral surface;
- means for connecting said electrical heating element to a source of electric power;
- said at least one water heating chamber surrounding said electrical heating element to define a sealed heater housing having said inlet and said outlet, said at least one water heating chamber having a closed end and a partly open end, said electrical heating element mounted in said closed end;
- said at least one water heating chamber further comprising: an outer wall;
 - an inner wall defined by said peripheral surface of said electrical heating element; and
 - a partition member mounted to one of said closed end or partly open end of said at least one water heating chamber to define opposing flow passages along the longitudinal direction of said electrical heating element whereby as cold water enters said inlet and proceeds along said opposing flow passages, heat generated by said electrical heating element is absorbed by said incoming water flowing along said opposing flow passages such as to minimize heat losses from said on-demand electrical hot water heater.

7. The on-demand electrical hot water heater as claimed in claim 6 further comprising means responsive to the flow of water through said at least one water heating chamber for activating a flow sensor in response to the flow of water exceeding a predetermined threshold.

8. The on-demand electrical hot water heater as claimed in claim **6** further comprising means responsive to the temperature of the water flowing out of the hot water outlet for activating a temperature sensor in response to the temperature of the water at said hot water outlet exceeding a predetermined adjustable threshold temperature.

9. The on-demand electrical hot water heater as claimed in claim 6 wherein said power connecting means further comprises:

- means responsive to the flow of water through said at least one water heating chamber for activating a flow sensor in response to the flow of water exceeding a predetermined threshold;
- means responsive to the temperature of the water flowing out of the hot water outlet for activating a temperature sensor in response to the temperature of the water at said hot water outlet exceeding a predetermined adjustable threshold temperature; and

an electronic control unit for connecting said electrical heating element to a source of electrical power in response to said means responsive to the flow of said water and means responsive to the temperature of said water being simultaneously in an activated state.

10. The on-demand electrical hot water heater as claimed in claim 6 further comprising a one-way flow valve mounted to an incoming cold water line to prevent backflow of said incoming cold water.

- **11**. An on-demand electrical hot water heater comprising: a heater housing having:
 - an outer wall having a cold water inlet;
 - a top cover member at one end, said top cover member having a passage therethrough;
 - a base cover member at an opposite end, said base cover member having a passage therethrough, said passage defining an outlet;
 - an electrical heating element sealingly mounted in said passage of said top cover member, said electrical heating element further suspended in said heater housing and having a peripheral surface;
 - means for connecting said electrical heating element to a source of electric power;
 - at least one water heating chamber surrounding said electrical heating element;
 - said at least one chamber defining said outer wall of said heater housing;
 - an inner wall defined by said peripheral surface of said electrical heating element; and
 - at least one partition member mounted to one of said top cover member or base cover member to define opposing flow passages along the longitudinal direction of said electrical heating element, whereby as said cold water enters said cold water inlet and proceeds along said opposing flow passages, heat generated by said electrical heating element is absorbed by said incom-

ing cold water flowing along said opposing flow passages such as to minimize heat losses from said ondemand electrical hot water heater.

12. The on-demand electrical hot water heater as claimed in claim 11 further comprising means responsive to the flow of water through said at least one water heating chamber for activating a flow sensor in response to the flow of water exceeding a predetermined threshold.

13. The on-demand electrical hot water heater as claimed in claim 11 further comprising means responsive to the temperature of the water flowing out of the hot water outlet for activating a temperature sensor in response to the temperature of the water at said hot water outlet exceeding a predetermined adjustable threshold temperature.

14. The on-demand electrical hot water heater as claimed in claim 11 wherein said power connecting means further comprises:

- means responsive to the flow of water through said at least one water heating chamber for activating a flow sensor in response to the flow of water exceeding a predetermined threshold;
- means responsive to the temperature of the water flowing out of the hot water outlet for activating a temperature sensor in response to the temperature of the water at said hot water outlet exceeding a predetermined adjustable threshold temperature; and
- an electronic control unit for connecting said electrical heating element to a source of electrical power in response to said means responsive to the flow of said water and means responsive to the temperature of said water being simultaneously in an activated state.

15. The on-demand electrical hot water heater as claimed in claim 11 further comprising a one-way flow valve mounted to an incoming cold water line to prevent backflow of said incoming cold water.

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