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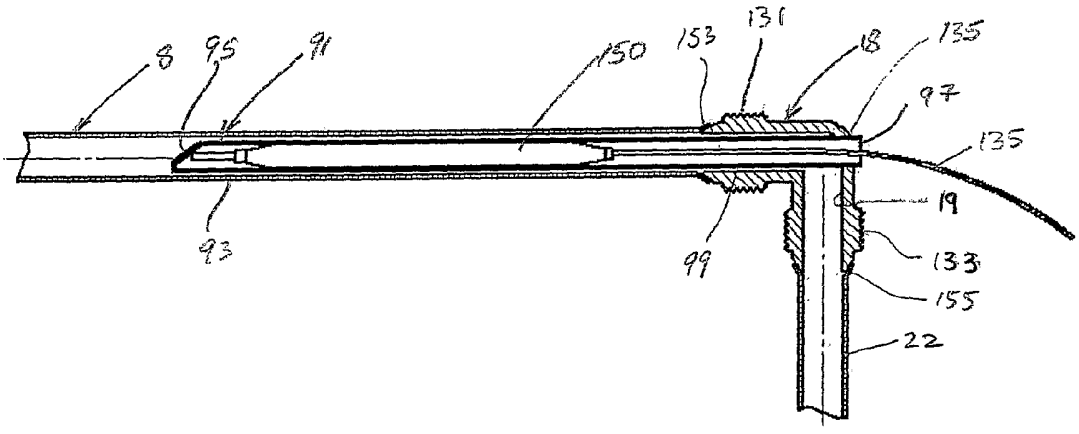
(54) **Title:** TEMPERATURE SENSING PROBE AND WATER HEATING APPARATUS



(57) **Abstract:** A temperature sensing probe (91) for mounting in a tube or pipe (22) through which flows a fluid, the probe including: a body (18) having coupling means (131,133) thereon to enable fluid tight coupling of the tube or pipe (8) to the body (18); a fluid passageway in the body (99) to enable fluid to flow therethrough to or from the tube or pipe (8); a probe tube (93) which is closed at its distal end, the probe tube (93) being connected to the body (18) so the distal end is spaced from the coupling means (131,133) ; and a temperature sensing element (150) mounted in thermal contact within the probe tube (93), the arrangement being such that when the body (18) is, in use, coupled by the coupling means (131,133) to the tube or pipe (8), the distal end of the probe tube (93) is located within the tube or pipe (8).

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TEMPERATURE SENSING PROBE AND WATER HEATING APPARATUS

This invention relates to a temperature sensing probe and water heating apparatus.

The principles of the invention are generally applicable to water heaters of the type disclosed in International Publication No. WO 2004/025188. The content of that specification is incorporated herein by cross-reference. The principles of the invention are also applicable to other types of water heaters.

An object of the invention is to provide a temperature sensing probe which is capable of yielding fast response times.

According to the present invention there is provided a temperature sensing probe for mounting in a tube or pipe through which flows a fluid, the probe including:

a body having coupling means thereon to enable fluid tight coupling of the tube or pipe to the body;

a fluid passageway in the body to enable fluid to flow therethrough to or from the tube or pipe;

a probe tube which is closed at its distal end, the probe tube being connected to the body so that the distal end is spaced from said coupling means; and

a temperature sensing element mounted in thermal contact within said probe tube, the arrangement being such that when the body is, in use, coupled by the coupling means to said tube or pipe, the distal end of said probe tube is located within said tube or pipe.

It will be appreciated that in this arrangement, the probe tube is located directly in the fluid flowing in the tube or pipe and therefore this minimises the thermal flow path between the temperature sensing element and the fluid flowing through the tube or pipe thus enabling rapid response times.

Preferably, the probe tube has an open end opposite to said distal end and wherein the temperature sensing element is coupled to a communicating link which passes through

said open end.

Preferably further, the coupling means is a male or female compression fitting which cooperates, in use, with a complementary fitting for coupling the tube or pipe to the body.

The temperature sensing probe of the invention is advantageously used in conjunction with a heat exchange coil. Accordingly the invention also provides a heat exchanger having:

a heat exchange coil formed from a coil of metallic tube having two ends;

a temperature sensing probe mounted at one of the ends of the tube for sensing the temperature of fluid flowing in the tube,

said probe including:

a body having coupling means thereon to enable fluid tight coupling of said one end of the tube to the body;

a fluid passageway in the body to enable fluid to flow therethrough to or from the tube;

a probe tube which is closed at its distal end, the probe tube being connected to the body so that the distal end is spaced from said coupling means; and

a temperature sensing element mounted in thermal contact within said probe tube, the arrangement being such that the distal end of said probe tube is located within said tube.

The invention also provides a water heating apparatus including:

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil;

a temperature sensing probe mounted in the heat exchange coil, the probe including:

a body having coupling means thereon to enable fluid tight coupling of the body to the heat exchange coil;

a fluid passageway in the body to enable fluid to flow therethrough to or from the heat exchange coil;

a probe tube which is closed at its distal end, the probe tube being connected to the body so that the distal end is spaced from said coupling means; and

a temperature sensing element mounted in thermal contact within said probe tube, the arrangement being such that the distal end of said probe tube is located within the heat exchange coil.

Another aspect of the invention is concerned with improving the response time of the water heating apparatus. It has been found that the location of the temperature sensor which controls the water heating means can greatly influence the speed of response of the water heater.

According to this aspect of the present invention there is provided a water heating apparatus including:

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil; and

a temperature sensor for controlling said water heating means characterised in that the temperature sensor is located so as to sense water in the coil at or near said outlet end of the heat exchange coil.

By positioning the probe at or near the end of the heat exchange coil can significantly shorten the response time for activation of the water heating means. This is because when mains water flows through the coil, corresponding to when a hot tap is turned on, the outgoing water causes an almost immediate decrease in the temperature sensor. When, however, the tap is turned off and flow of water in the coil ceases, the dead water in the storage tank quickly heats the mains water in the coil, and thus the temperature of mains water in the coil and the dead water stored in the storage tank, are substantially the same. This gives a quick response and permits quick shut-off of the water heating means, thereby preventing overheating.

The quick response of the thermostat enables the water heating apparatus to turn on the water heating means more quickly and so provide hot water at high flow rates.

It will be appreciated that by locating the temperature sensor in, at or near the outlet of the coil, it has a dual function in that it effectively monitors the tank temperature when water is not flowing through the coil but it effectively monitors the temperature flowing within the coil when water is flowing in the coil.

Advantageously, in this aspect of the invention, the temperature sensor can include the temperature sensing probe defined above.

A further aspect of the invention is concerned with improving the overall thermal efficiency of the heating apparatus. In accordance with the invention this can be done by coupling a further heat exchanger to extract heat from the flue gases from the gas burner.

In accordance with this aspect of the invention there is provided water heating apparatus including:

a storage tank for storing heated water;

a gas burner for heating water in the storage tank;

a flue for passage of flue products from the gas burner;

a first heat exchanger located within the storage tank;

first coupling means for coupling a mains water supply to the first heat exchanger coil so that water from the mains supply, in use, passes through the first heat exchanger and is heated by extraction of heat from the water in the storage tank; and

second coupling means for coupling a second heat exchanger to said storage tank so that water therefrom can, in use, circulate through the second heat exchanger, the second heat exchanger including a flue gas flow passage to which said flue can be connected whereby heat from the flue gases heats the water circulating in said second heat exchanger.

Water heaters of the type disclosed in the aforementioned International publication can be used for supplying water to a domestic hot water service as well as to supply heated water for circulating in a heating system. If excessive demand is placed on the water heater, usually consumers wish to maintain the temperature of the domestic water supply reasonably hot. In accordance with this aspect of the invention, a priority sensor is provided so as to selectively cut off the supply of heated water to the heating system when the temperature of the domestic hot water or the water stored in the tank falls below a predetermined level. This can therefore maintain the domestic hot water temperature at an acceptable level and supply of heated water to the heating system is temporarily suspended.

In accordance with a second aspect of the invention there is provided water heating apparatus including:

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

first coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil; and

a first temperature sensor for controlling said water heating means;

second coupling means to enable connection to a heating system which includes water circulating means for circulating the heated water from the storage tank therethrough; and

a second temperature sensor for shutting off said circulating means when the second temperature sensor senses a temperature in the heated mains water in the heat exchange coil below a predetermined temperature whereby priority is given to supply of heated water from said mains supply.

Water heaters of the type disclosed in the aforementioned International publication can be constructed so as to have flue assemblies connected at the side thereof. In some installations, it would be desirable or even necessary that the flue assembly should be located on a particular side of the heater having regard to spatial considerations and/or ventilation or the like. In accordance with a further aspect of the invention, a water heater is provided which can have a flue assembly connected at either side thereof, thereby enabling the installer to selectively choose the side to which the flue assembly is connected.

In accordance with this aspect of the invention there is provided water heating apparatus including:

a housing;

a storage tank within the housing for storing heated water;

a gas burner for heating water in the storage tank;

a flue pipe for passage of flue products from the gas burner;

a flue manifold coupled to the flue pipe to receive flue products therefrom, the flue manifold having first and second outlets located on generally opposite sides of the housing respectively whereby a flue assembly can be selectively connected to either the first outlet or the second outlet.

Water heating apparatus of the type disclosed in the aforementioned International publication can be coupled to a secondary heat exchanger, as described above, and/or to a heating system. The secondary heat exchanger have the heated water from the storage tank

circulated therethrough. Normally, the couplings for connecting the secondary heat exchanger and/or heating system are located on one side of the apparatus. This can cause problems during installation and in accordance with this aspect of the invention provision is made for selectively coupling the secondary heat exchanger and/or heating system at opposite sides of the heating apparatus.

According to this aspect of the invention there is provided water heating apparatus including:

a housing;

a storage tank for storing heated water;

a gas burner for heating water in the storage tank;

a flue for passage of flue products from the gas burner;

a first heat exchanger located within the storage tank;

first coupling means for coupling a mains water supply to the first heat exchanger coil so that water from the mains supply, in use, passes through the first heat exchanger and is heated by extraction of heat from the water in the storage tank; and

second and third coupling means for coupling a second heat exchanger or heating system to said storage tank so that water therefrom can, in use, circulate through the second heat exchanger, or heating system, and wherein the second and third coupling means are located on generally opposite sides of the housing respectively whereby the second heat exchanger and/or heating can be selectively coupled to opposite sides of the housing.

A further aspect of the invention is concerned with ensuring that the gas burner does not cause localised overheating. In the aforementioned International publication, the water heater includes a gas burner located within a gas burner assembly which is submerged in the water within the storage tank. Owing to spatial constraints, the gas burner is located close to the gas burner housing. In accordance with the invention, the gas burner is shielded from the adjacent parts of the housing so as to minimise heating of those adjacent parts. Alternatively, the burner does not include burner ports adjacent to said parts.

The invention also provides a water heating apparatus including:

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil; and

wherein the water heating means includes a gas burner assembly having a flue characterised in that the flue is coupled to a muffler for absorbing sound from the burner assembly.

The invention also provides a water heating apparatus including:

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil;

wherein the water heating means includes a gas burner assembly having a flue; and

a flue terminal coupled to the flue, the flue terminal including upper and lower portions, the lower portion having an opening which is coupled to receive flue products from the flue, a downwardly inclined surface and an upstanding outer flange and the upper portion is dished downwardly so as to overlie said opening and part of said inclined surface so as to define flue product flow path which is generally radial relative to the flue and the upstanding flange then deflects, in use, the flue products upwardly.

Preferably, the downwardly inclined surface is frustoconical and including an inner cylindrical flange the interior of which constitutes said opening.

Preferably the downwardly inclined surface includes drainage holes adjacent to the outer flange.

Preferably the upper portion includes supporting legs which are connected to the downwardly inclined surface.

Preferably further the outer flange is provided with drainage openings which are radially aligned with the supporting legs whereby the legs prevent flue products flowing radially through the drainage openings in the outer flange.

The invention also provides a water heating apparatus including:

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil;

wherein the water heating means includes a gas burner assembly which is supplied, in use, with a gas-air mixture via a supply duct characterised in that a flow restricting device can be selectively inserted in said supply duct in order to selectively control the rate of flow of gas-air mixture through the supply duct.

The invention also provides a water heating apparatus including:

a housing;

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is

heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil;

a flue pipe which, during storage or transport terminates at or near said housing;

a flue terminal assembly; and

mounting means for coupling the flue terminal assembly to said flue pipe, the flue terminal assembly being mounted in an operative position on the exterior of the housing.

Preferably the housing has a removable top and the arrangement is such that the flue terminal assembly can be stored within the housing and above said storage tank, during storage or transport.

The invention also provides a water heating apparatus including:

a housing;

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil; and

an expansion tank coupled to said storage tank to permit expansion and contraction of said heated water and wherein the expansion tank is located above said storage tank and within said housing.

The invention will now be further described with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of water heating apparatus of the invention;

Figure 2 is a side view of a thermostat probe of the invention;

Figure 3 is a plan view of the thermostat probe;

Figure 4 is a cross-sectional view along the line 4-4; and

Figure 5 is a cross-sectional view showing the temperature sensor mounted in the

probe;

Figure 1 is a schematic view of a water heating apparatus 2 constructed in accordance with the invention. As mentioned above, the water heating apparatus can be of the type disclosed in International Publication No. WO 2004/025188 although the principles of the invention are applicable to other types of water heater. The water heating apparatus includes a main tank 4 located within a sheet metal housing 6. Located within the main tank 4 is a gas burner assembly 100 which is supplied with a combustible mixture of gas and air. Located within the main tank 4 is a coil assembly 8 which in the preferred form of the invention is in the form of two helical coils of copper tubing which are connected in parallel so as to reduce resistance to water flow therethrough. The coil assembly 8 includes inlet and outlet couplings (not shown) which are connected to a cold water inlet line 14. The inlet line 14 is connected to a cold water inlet coupling which is accessible from the exterior of the housing 6. The coil assembly 8 includes outlet couplings 18 which are connected to a high temperature outlet line 22. The outlet line 22 includes a T-coupling 24 which is connected to a high temperature outlet line 26 which is provided so as to utilise high temperature water which might be required in some circumstances such as supply to a kitchen or laundry. As will be described in more detail below, the water within the main tank 4 is under pressure and can be heated to above 100°C, typically the operating temperature being in the range 80°C to 90°C but temperatures of 110°C could be selected in some circumstances. High temperature water at about this temperature is thus available from the coil in the high temperature outlet line 26, assuming that water flowing in the coil assembly has sufficient time to reach or substantially reach the same temperature as the water within the main tank 4. The water in the main tank 4 does not boil because it is under pressure, say 15 psi to 50 psi (above atmospheric pressure), and therefore 110°C is well below the boiling point for water at this pressure.

The apparatus includes a mixing valve 34 which receives high temperature water on the outlet line 22. It also receives cold water via inlet line 14. The mixing valve includes an outlet line 40 which extends to the housing 6 and terminates in a hot water

outlet coupling (not shown). The mixing valve 34 is arranged to mix cold water from the mains supply with the high temperature water from the coil assembly 8 so as to produce water at a temperature which is suitable for use in bathrooms. Typically this water is in the range 40°C to 60°C and preferably 45°C.

As the main tank 4 is normally operated at above atmospheric pressure, say at 50 psi, it needs to be of relatively robust construction. The main tank 4 can be of welded steel construction and having a cylindrical sidewall 46, an inclined top wall 48 and a bottom wall 50. Because the main tank 4 is made of steel, it would be susceptible of rusting or corrosion if significant amounts of oxygen or air were dissolved in the water within the main tank or otherwise admitted to the main tank. Normally, however, the water within the main tank 4 is a fixed volume of water and any oxygen therein would cause very limited corrosion before it were exhausted. This applies even where the water within the main tank 4 is circulated in an hydronic heating system because essentially the same volume of water is maintained in the system. Nevertheless, fresh water may be occasionally introduced into the main tank 4 to compensate for any water which may be lost due to leakage or the like. The top wall 48 of the main tank 4 includes an air bleed valve 53 located near the highest point of the top wall 48 so that any gas bubbles in the main tank 4 will migrate towards the valve 53 and be vented.

The main tank 4 includes a temperature pressure relief valve 66 which has an outlet external to the housing 6. The valve 66 is set to open when either the temperature exceeds say 90°C or the pressure exceeds 50 psi.

As mentioned above, the water within the main tank 4 can be used for supplying hot water to an hydronic heating system 61. Accordingly, the main tank 4 includes a heating water outlet line 70 connected to a coupling accessible from the exterior of the housing 6. The apparatus also includes a heating water return line 74 connected to a coupling which is also accessible from the exterior of the housing 6. The heating system 61 may include radiating panels 63 and/or fan coil units for extracting heat from the water within the main tank 4. In hydronic heating systems the water which is circulated is

essentially a fixed volume of water and therefore corrosion of the main tank 4 and the hydronic heating elements is not normally a significant problem.

The hydronic heating system 61 may include various components located within an insulating housing 141. The radiating panels 63 receive hot water from the main tank 4 via line 134 which is connected to the water outlet line 70 (or 71). After circulation through the radiating panels 63 or the like, the water is pumped via pump 136 to a return line 135 to the water return line 74 (or 73) of the heating apparatus 2. Located within the housing 141 is a make up valve and gauge unit 137 which can be used for topping up water to the heating system (and main tank 4) from a cold water line 139 which is connected to the cold water inlet line 14, as shown. The line 139 may include a pressure relief valve 60 which opens when the pressure within the hydronic system exceeds a predetermined level, say 250 psi. Also located within the housing 141 is an expansion tank 143 which allows for expansion of the water which is circulated through the heating system 1 and the water within the main tank 4.

The heating components within the housing 141 could be incorporated in the sheet metal housing 6 of the heating apparatus 2. This would be particularly suitable in the case where the apparatus 2 was not to be used for hydronic heating. In that case, however, it would still be desirable to include the pressure relief valve 60, make up valve and gauge unit 137 and expansion tank 143.

In the preferred form of heater of the invention, the outlet line 70 and return line 74 are effectively duplicated on the other side of the unit. Accordingly, the main tank 4 includes a second hot water outlet line 71 and return line 73. This enables the heating system 61 to be connected to the water heater 2 at the opposite side which may be desirable in some circumstances having regard to spatial constraints and ventilation or the like. Alternatively, a secondary heat exchange unit 75 can be coupled to the heating apparatus 2 in order to extract heat from the flue gases from the burner assembly 100, as will be described in more detail below. It will be appreciated that the duplication of the outlet lines 70 and 71 and return lines 74 and 73 provide substantial flexibility when the

equipment is installed because the heating system 61 and/or secondary heat exchange unit can be connected at either side of the heater. When the secondary heat exchange unit 75 is not utilised, a flue terminal can be connected to the flue outlet line, in the usual way.

The apparatus 2 includes a gas inlet coupling 78 which, in use, is connected to a gas supply line 80. The gas supply line 80 supplies gas for the burner assembly, as will be described in more detail below. Air for combustion is admitted to the housing 6 through vents 82.

A layer of insulation 90 is located between the outer surface of the main tank 4 and the housing 6 so as to avoid heat losses from the main tank. Located within the housing and above the main tank 4 is a fan 92. The fan 92 draws air and gas into its input and its outlet is connected to a gas air supply duct 94. Admission of gas to the fan 92 is controlled by a gas control valve 96 which receives gas from the gas supply line 80.

The burner assembly 100 is located in the lower part of the main tank 4 and in use is completely immersed in the water within the main tank. The burner assembly 100 includes a plurality of water connection passages 152 therethrough. Located within the burner assembly 100 is a gas burner 102 which is coupled to the duct 94. A flue pipe 104 extends from the burner assembly through the interior of the main tank 4 and extends through the top wall 48 to the flue manifold 84. The flue manifold 84 extends transversely across the top of the main tank 4 and provides a flue outlet selectively at either side of the housing 6 of the water heater. This again provides flexibility for installation. In the illustrated arrangement the manifold 84 is held in place by a treaded tie rod 85 and nut 87, the lower end of the rod 85 being welded to the flue pipe 104.

As the interior of the main tank 4 is subject to above atmospheric pressures, it is desirable that the top and bottom walls 48 and 50 be reinforced so as to prevent buckling thereof under the internal pressure. The tank may include reinforcing rods (not shown), the ends of which are welded to the top and bottom walls 48 and 50 so as to restrain outward deformation of these walls. Alternatively, a single larger diameter rod could be

used.

The heating water outlet line 70 or 71 may include a valve or tap (not shown). When the main tank 4 is being initially filled, a mains supply can be connected to the valve or tap in order to fill the main tank 4 from a mains supply. After initial filling, the valve or tap can then be closed. If, however, hydronic heating is to be utilised the valve or tap can be opened after connection to the hydronic heating components. In the illustrated arrangement, the line 134 indicates a supply line to the hydronic components and a circulating pump 136 may be provided in this line.

The apparatus may also include an electric heating element 140 located within a tube which extends laterally into the main tank 4 a short distance above the bottom wall 50. The purpose of the electric element 140 is to enable heating of the water within the main tank 4 in emergency circumstances in the event that the gas supply becomes interrupted. Typically the heating capacity of the element 140 is 2.4kw.

The apparatus includes a temperature sensing element 150 which is arranged to provide input signals to the gas control valve 96 which controls operation of the fan 92 which, in turn, controls flow of gas to the fan 92. Basically, when the temperature sensing element 150 senses a temperature below its set operating temperature, say 80° to 90°C, it has contacts which close and this causes the gas control valve to operate the fan 92 and to supply gas thereto. This causes flow of a combustible gas air mixture through the duct 94 to the burner 102. The control valve 96 also causes ignition of the mixture so that heating will occur.

The gas burner assembly 100 includes a plurality of water passages 152 therethrough. When heating occurs within the burner assembly 100, convection currents will be established causing rising heated convection currents to flow upwardly through the coil assembly 8 where heat transfer will take place to the water within the coil assembly 8. This causes consequential cooling of the water within the main tank 4, thereby causing cooler, downwardly flowing convection currents to occur near the sidewalls of the main

tank 4. This cooler water will then be drawn into the lower ends of the passages 152 through the burner assembly 100 and reheated. These convection flow paths within the water in the main tank 4 provide for good heat transfer. Some heat transfer also takes place from flue gases flowing in the flue pipe 104.

It has been found that the location of the temperature sensing element 150 significantly affects the performance of the water heater. Generally speaking, a quick response time is required to quickly activate the burner assembly 100 when substantial flow rates of cold water pass through the coil assembly 8. This ensures that the hot water delivered by the heater does not significantly fall or fall to unacceptable levels. Also, once hot water ceases to be drawn from the unit, the burner assembly 100 needs to be shut down so as to avoid overheating and/or waste of energy. It has been found that exceptionally good results can be obtained if the temperature sensing element 150 is located so as to sense the temperature of the water in the coil assembly 8 at or near the outlet coupling 18 (or one of them in the case where two coils are connected in parallel).

In the illustrated arrangement, the temperature sensing element 150 is located within a probe assembly 91 constructed in accordance with the invention. Figures 2 to 5 illustrate in more detail the temperature sensing probe assembly 91. The assembly includes the coupling 18 which is in this instance, in the form of a compression elbow having threads 131 and 133 which in use cooperate with compression nuts (not shown) for connecting ends of the coil assembly 8 and high temperature outlet line 22 thereto, as diagrammatically showing in Figure 5. The end of the copper tube forming the coil assembly 8 is formed with a flare 153. Simultaneously a flare 155 is formed on the end of the outlet line 22. In this way the flares 153 and 155 can cooperate with compression nuts to form water tight connections in the usual way. The probe assembly 91 includes a probe tube 93 which passes through a bore 135 formed in the body of the elbow 18. The inner end 95 of the probe tube 93 is closed but the outer end 97 is open. The probe tube 93 is soldered or braised to the body of the coupling 18 adjacent to the end 97 so as to form a water tight joint therewith. The temperature sensing element 150 is located within the interior of the tube 93, preferably near its inner end 95. The element 150 may be in the

form of a temperature sensitive bulb or thermistor. In either case, the element 150 is connected to a line 135 which passes from the open outer end 97 of the tube to enable the element 150 to be appropriately coupled to control circuitry. During fabrication of the probe assembly 91, after mounting of the probe tube 93 in the coupling 18, the interior of the probe tube 93 is filled with a thermally conductive paste. This may be in the form of a silicon based heat composition such as UNICK. The element 150 is then inserted into the paste so that it is located as close as practicable to the inner end 95 of the tube 93. An annular gap 99 is maintained between the probe tube 93 and the internal bore 19 of the coupling 18 so as to permit flow of heated water therethrough. In this arrangement, the element 150 directly senses the temperature of the water flowing at the outlet of the coil assembly 8. If the temperature drops below a predetermined level, say 80°C to 90°C, the gas control valve 96 causes operation of the fan 92 so that the combustible mixture is supplied to the burner assembly 100. It has been found that the response time can be as low as say 15 seconds from the time of drawing hot water from the coil assembly 8. When, however, flow of hot water from the coil assembly 8 ceases, the temperature of the water within the coil assembly 8 and hence the temperature sensed by the element 150 will quickly equalise with the temperature of the water within the main tank 4. If this is above operating temperature then the element 150 will cause the burner assembly 100 to cease operating. Alternatively, if the temperature is below operating temperature, operation of the burner assembly 100 will continue until the correct operating temperature is maintained. It will be appreciated that this particular location of the element 150 produces exceptional results because when hot water is being drawn from the unit, it essentially senses the temperature thereof. When, however, temperature ceases, it effectively senses the temperature of the dead water within the main tank 4 because under static conditions the temperature within the coil assembly 8 will be essentially the same as the temperature of the dead water within the upper part of the tank 4.

The secondary heat exchanger 75 includes a cylindrical stainless steel tank 213 which is surrounded by a layer 215 of insulating material within a housing 218. The heat exchanger 75 includes a centrally located flue gas duct 217, the upper end of which is connected to a connecting duct 219 which receives flue gas from the flue manifold 84. In

this arrangement, the free end of the connecting duct 219 simply fits into the open end of the exhaust manifold 84 so as to form a snug connection therewith. The other end of the manifold 84 can be closed by means of a cap or plug (not shown).

The lower end of the flue gas duct 217 opens into an annular flue gas jacket 221 which permit the flue gases to flow upwardly to a flue outlet 223 fitted with a flue terminal housing 225. The tank 213 includes an inlet line 227 located near its bottom which can be connected in use to the water outlet heating line 71 (or 70). Similarly, the top of the tank is provided with a return line 229 which can be connected to the heating water return line 73 (or 74). In use, the water within the main tank 4 can circulate within the tank 213 in the spaces between the flue gas duct 217 and the flue gas jacket 221. Relatively cool water from the bottom of the main tank 4 can flow by convection to the bottom of the tank 213 where it will come into contact with the hot surfaces of the duct 217 and jacket 221. This will cause heating of the water which will tend to rise by convection and return to the main tank 4 via the return line 229. The jacket 221 may include a baffle or baffles 231 to induce turbulent flow of the flue gases so as to increase heat transfer. The lower end of the tank 213 includes a condensate outlet 233 which is provided with a water trap 235. The condensate outlet 233 enables removal of any liquid condensate from the flue gases. Typically, the flue gases in the flue manifold 84 are at about 250°C and a substantial amount of the energy in the flue gases can be utilised by the secondary heat exchanger 75. It is envisaged that the provision of the secondary heat exchanger 75 results in an overall efficiency increase of about 7% to 10%. It is desirable not to operate the heater (excluding the secondary heat exchanger 75) such that the efficiency is above 80% because this could cause undesirable condensation within the burner housing 170 and/or flue pipe 104 and or manifold 86.

It has also been found that the provision of the secondary heat exchanger 75, in the form shown, acts as a sound attenuator or muffler so as to make the heating apparatus much quieter in operation.

A prototype of the water heating apparatus has been constructed and has proven to

be very efficient. The prototype had the following nominal dimensions:

height of main tank 4	914mm
diameter of main tank 4	560mm
approximate volume of main tank 4	130 litres
number of water convection passages 152	20
volume of expansion tank 143	12.5 litres
diameter of flue pipe 104	76.2mm
number of coils in the coil assembly 8	2
number of convolutions of each coil	9
length of each coil	12.19m
external diameter of each coil	12.7mm
gas input	200 MJ/hour
normal water temperature at outlet of coil assembly 8	80-90°C
normal water temperature at outlet line 40	45°C
normal water temperature at outlet lines 70 or 71	80-90°C
approximate time to heat water within the main tank to operating temperature	10 mins
setting of temperature sensing element 150	80°-90°C
setting of temperature sensing element 211	50°C
setting of temperature sensing element 230	112°C
diameter of probe tube 93	8mm
length of probe tube 93	300mm
wall thickness of probe tube 93	0.8mm
gap 99 about	9mm

Many modifications will be apparent to those skilled in the art without departing from the spirit and scope of the invention.

CLAIMS:

1. A temperature sensing probe for mounting in a tube or pipe through which flows a fluid, the probe including:

a body having coupling means thereon to enable fluid tight coupling of the tube or pipe to the body;

a fluid passageway in the body to enable fluid to flow therethrough to or from the tube or pipe;

a probe tube which is closed at its distal end, the probe tube being connected to the body so that the distal end is spaced from said coupling means; and

a temperature sensing element mounted in thermal contact within said probe tube, the arrangement being such that when the body is, in use, coupled by the coupling means to said tube or pipe, the distal end of said probe tube is located within said tube or pipe.

2. A probe as claimed in claim 1 wherein the probe tube has an open end opposite to said distal end and wherein the temperature sensing element is coupled to a communicating link which passes through said open end.

3. A probe as claimed in claim 2 wherein the coupling means is a male or female compression fitting which cooperates, in use, with a complementary fitting for coupling the tube or pipe to the body.

4. A probe as claimed in claim 3 wherein the compression fitting includes threads and a tapered surface on the body and wherein the passageway terminates at a port adjacent to said tapered surface.

5. A probe as claimed in claim 4 wherein part of the probe tube extends through the passageway and passes through said port, there being a gap between the probe tube and the passageway and port so that the fluid, in use, flows in said gap.

6. A probe as claimed in any one of claims 3, 4 or 5 wherein the compression fitting is

a male compression fitting and part of the passageway is defined by a cylindrical bore located inwardly of said male compression fitting.

7. A probe as claimed in claim 6 wherein the probe tube is cylindrical and is concentrically mounted in said cylindrical bore.

8. A probe as claimed in claim 7 wherein the body is in the form of an elbow and wherein an opening is formed in the body through which said probe tube passes, the probe tube being coupled to the body at said opening in a fluid tight manner.

9. A probe as claimed in claim 7 wherein said open end of the probe tube is located adjacent to said body.

10. A probe as claimed in any one of claims 1 to 9 wherein heat conductive packing material is located between the temperature sensitive element and the interior of the probe tube.

11. A heat exchanger having:

a heat exchange coil formed from a coil of metallic tube having two ends;

a temperature sensing probe mounted at one of the ends of the tube for sensing the temperature of fluid flowing in the tube,

said probe including:

a body having coupling means thereon to enable fluid tight coupling of said one end of the tube to the body;

a fluid passageway in the body to enable fluid to flow therethrough to or from the tube;

a probe tube which is closed at its distal end, the probe tube being connected to the body so that the distal end is spaced from said coupling means; and

a temperature sensing element mounted in thermal contact within said probe tube, the arrangement being such that the distal end of said probe tube is located within said tube.

12. A water heating apparatus including:

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil;.

a temperature sensing probe mounted in the heat exchange coil, the probe including:

a body having coupling means thereon to enable fluid tight coupling of the body to the heat exchange coil;

a fluid passageway in the body to enable fluid to flow therethrough to or from the heat exchange coil;

a probe tube which is closed at its distal end, the probe tube being connected to the body so that the distal end is spaced from said coupling means; and

a temperature sensing element mounted in thermal contact within said probe tube, the arrangement being such that the distal end of said probe tube is located within the heat exchange coil.

13. A water heating apparatus including:

a storage tank for storing heated water;

water heating means for heating water in the storage tank;

a heat exchange coil located within the storage tank;

coupling means for coupling a mains water supply to an inlet end of the heat exchange coil so that water from the mains supply, in use, passes through the coil and is heated by extraction of heat from the water in the storage tank so that heated water is available at an outlet end of the heat exchange coil; and

a temperature sensor for controlling said water heating means characterised in that the temperature sensor is located so as to sense water in the coil at or near said outlet end

of the heat exchange coil.

14. Water heating apparatus including:

a storage tank for storing heated water;

a gas burner for heating water in the storage tank;

a flue for passage of flue products from the gas burner;

a first heat exchanger located within the storage tank;

first coupling means for coupling a mains water supply to the first heat exchanger coil so that water from the mains supply, in use, passes through the first heat exchanger and is heated by extraction of heat from the water in the storage tank; and

second coupling means for coupling a second heat exchanger to said storage tank so that water therefrom can, in use, circulate through the second heat exchanger, the second heat exchanger including a flue gas flow passage to which said flue can be connected whereby heat from the flue gases heats the water circulating in said second heat exchanger.

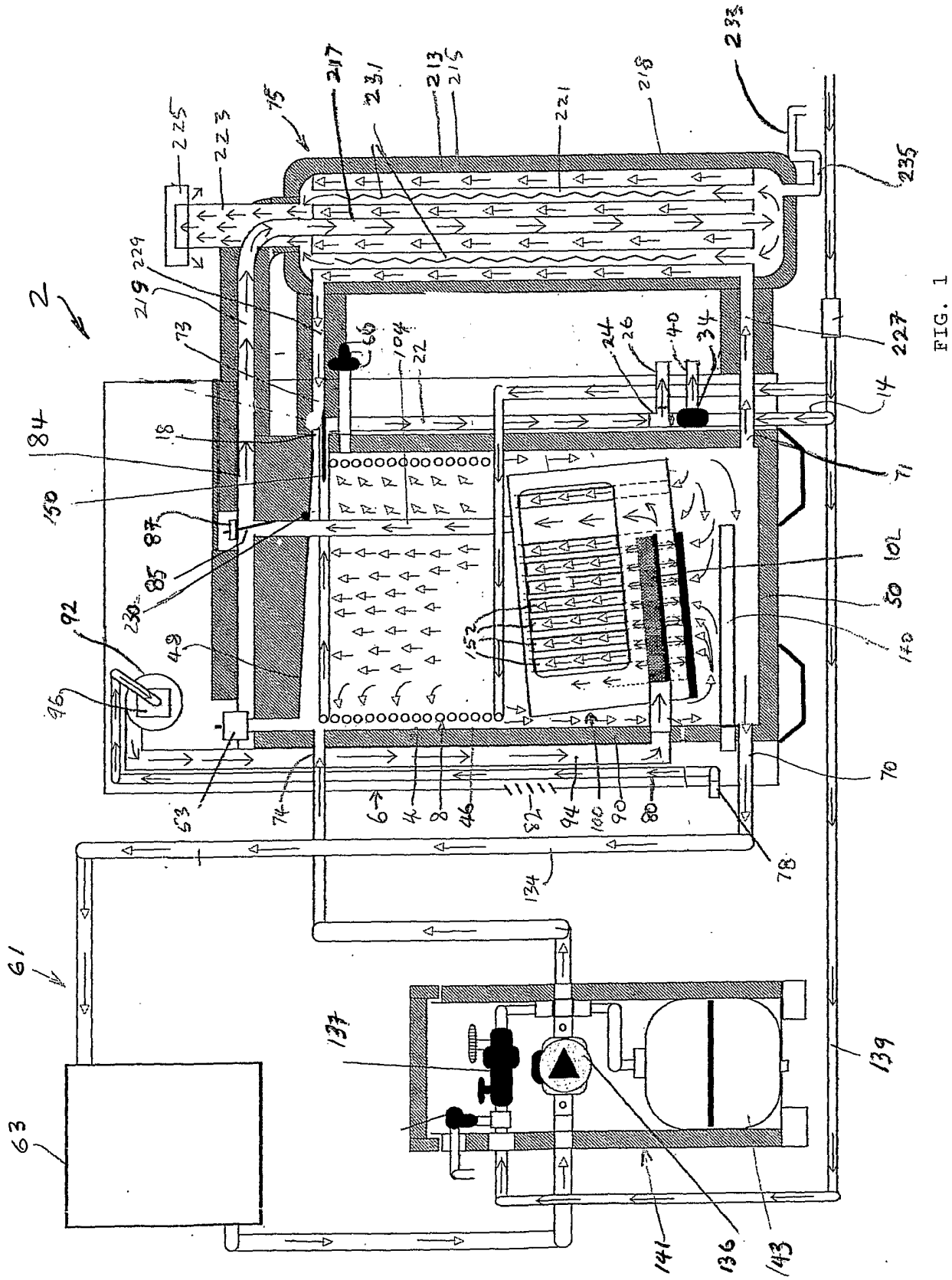
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FIG. 1

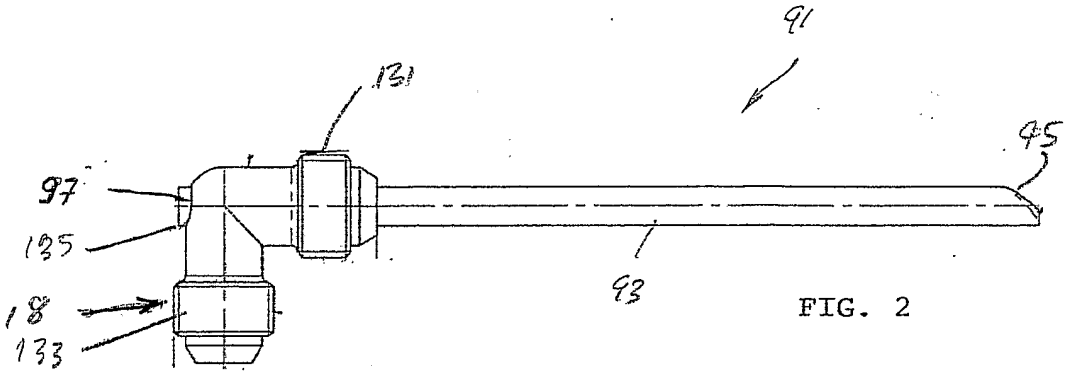

FIG. 2

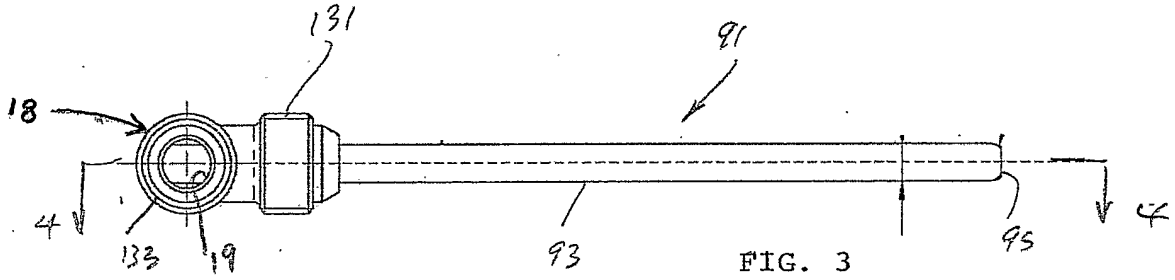

FIG. 3

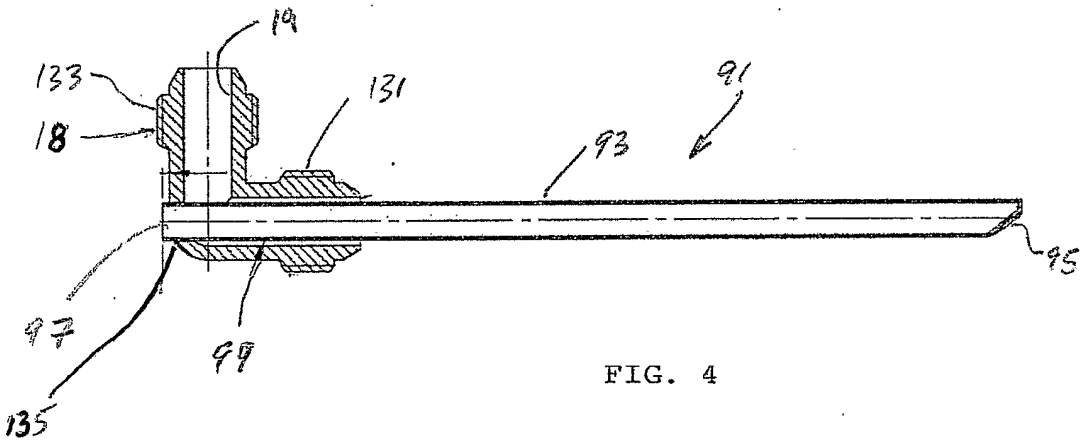

FIG. 4

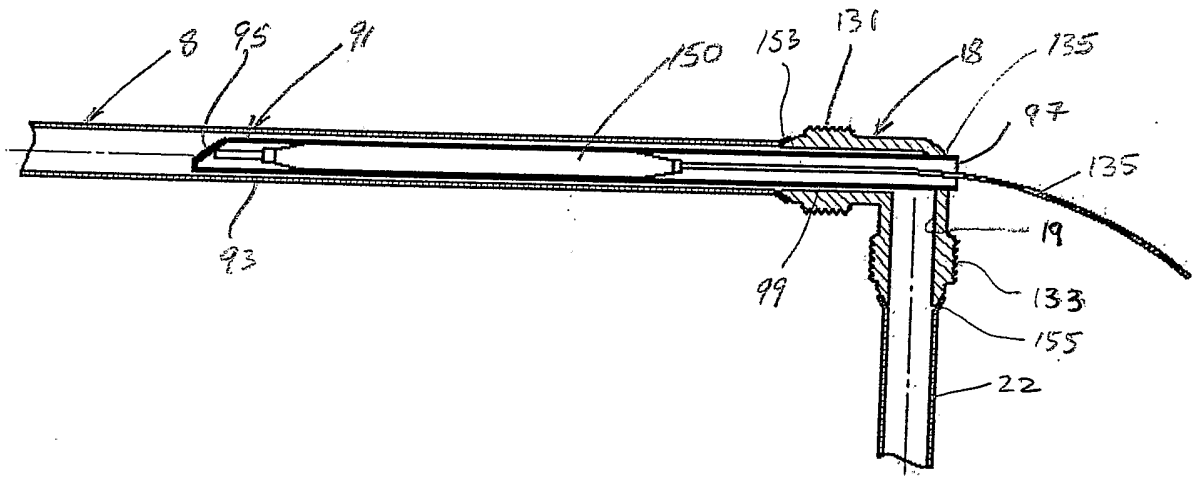

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/001381

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: F24D 19/10; F24H 9/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT; USPTO; ESP@CE: probe, temperature, fluid, water

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,523,427 B1 (FERGUSON) 25 February 2003 Abstract, Fig. 5,9	1-12
X	US 5,386,725 A (YAMAKAWA ET AL) 07 February 1995 Abstract, Fig. 1C, Column 2, line 50 – column 3, line 6	1-12
A	EP 1074825 A1 (PGI INTERNATIONAL LTD) 07 February 2001 Whole document	

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 October 2005	1 NOV 2005
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer V. V. Samuel **SERINEL SAMUEL** Telephone No : (02) 6283 2382

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/001381

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Group I : Claims 1-12
Group II: Claim 13
Group III: Claim 14
(See **Supplemental Box** for details)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-12

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III

The international application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept. In coming to this conclusion the International Searching Authority has found that there are different inventions as follows:

1. Claims 1-12 are directed to a temperature sensing probe including a body having coupling means mounted on a fluid passageway comprising a tube or pipe. It is considered that when the body is, in use, coupled by the coupling means, the arrangement being such that the distal end of the probe is located within the tube comprises a first "special technical feature".

2. Claim 13 is directed to a water heating apparatus with a heat exchange coil located inside the storage tank. It is considered that a temperature sensor which controls the heating is located so as to sense water in the coil at or near outlet end of the heat exchange coil comprises a second "special technical feature".

3. Claim 14 is directed to a water heating apparatus having two heat exchangers coupled to the storage tank. It is considered that the coupling arrangements of both the heat exchangers comprises a third "special technical feature".

Since the abovementioned groups of claims do not share any of the technical features identified, a "technical relationship" between the inventions, as defined in PCT rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept, a priori.

INTERNATIONAL SEARCH REPORT

Information on patent family members

PCT/AU2005/001381

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	6523427						
US	5386725	JP	6074805				
EP	1074825	AU	48699/00	AU	66090/00	CA	2313032
		CA	2357435	GB	2352813	JP	2001324880
		US	6352361	US	6390670	US	6485175
		US	6646040	US	6820738	US	2003119968
		US	2005038172	WO	0111319		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX