



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
09.06.2004 Bulletin 2004/24

(51) Int Cl.7: **C23F 13/04, F24D 19/00**

(21) Application number: **03025225.8**

(22) Date of filing: **05.11.2003**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PT RO SE SI SK TR**
Designated Extension States:
AL LT LV MK

(72) Inventors:
• **Marchetti, Ruggero**
60044 Fabriano (AN) (IT)
• **Latini, Lucio**
60044 Fabriano (AN) (IT)

(30) Priority: **27.11.2002 IT an20020057**

(74) Representative: **Gentili, Enrico**
c/o MAR.BRE S.R.L.,
1,Viale A. Merloni
60044 Fabriano (AN) (IT)

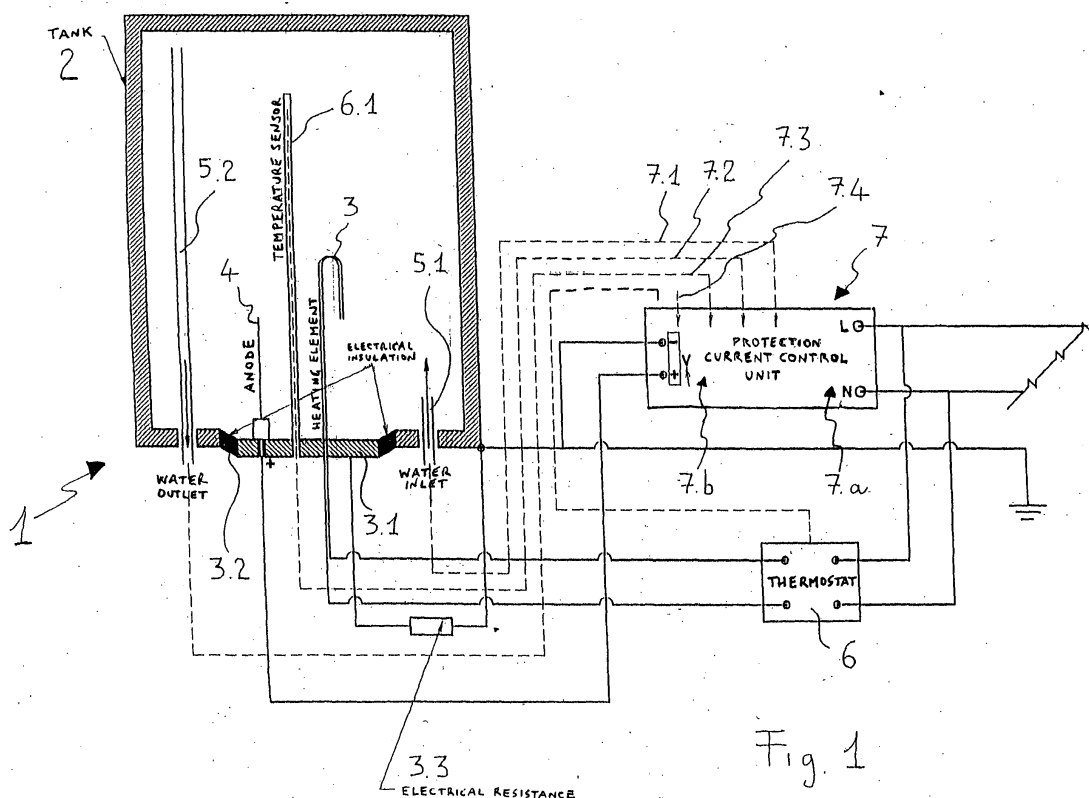
(71) Applicant: **MERLONI TERMOSANITARI S.p.A.**
60044 Fabriano (Ancona) (IT)

(54) **Impressed current device responsive to the operative parameters of the structure to be protected**

(57) It is described a method for impressed current cathodic protection against corrosion of water heater tanks (1), in particular accumulator tanks. According to this invention said impressed current is regulated according to one or more operative parameters variable in time, at least one of said operative parameters being

identified directly during the function of said water heater (1) or derived indirectly from one or more further operative parameters, in turn at least one of said further operative parameters being identified directly during the function of said water heater.

The means adapted to permit the application of said method are also described herein.



Description

[0001] The aim of the present invention is to provide methods and means to determine the optimal value of the protective current, using a device for impressed current cathodic protection against corrosion, for particularly advantageous use in protecting metal water heater tanks, in particular accumulator tanks, and even more in particular electrically heated tanks.

[0002] The cathodic protection method is well known for eliminating, or at least considerably limiting the phenomenon of corrosion in metal tanks containing electrically conductive liquids, and water in particular.

[0003] Cathodic protection is formed by lowering the potential of the metal structure of water heaters to levels where corrosion processes are arrested. This type of protection provides for the circulation of direct current, through the accumulated water, from an anode towards the walls of the water heater tank that acts as a cathode.

[0004] The element that acts as an anode can be composed of a metal or a metal alloy with an electrochemical potential considerably higher than that of the metal structure to be protected; this anode is called sacrificial because it is subject to progressive consumption during water heater use and must be replaced regularly. This is a very simple means of protection, wherein the disadvantage is that, if the anode is not replaced, corrosion begins immediately.

[0005] More advantageously, the current can be sent into circulation by an external generator, and in this case the protection system is provided by impressed current. The generator is equipped with a terminal (the negative pole) electrically connected to the metallic mass to be protected, while the other (the positive pole) is connected to the electrode that acts as an anode, which is also electrically insulated from the metallic mass.

[0006] This type of very efficient protection is becoming far more widespread, also for the protection of mass-produced water heater tanks, to the detriment of sacrificial anodes, but known technology still presents problems, including the difficulty in maintaining the electrical potential between an electrode and the structure to be protected at optimal value to eliminate or limit electrochemical corrosion as far as possible.

[0007] This value is obtained by applying voltage between the electrode and the structure to be protected that counters the electrochemical potential of the structure bringing it to a more suitable value, or in other words, impressing the correct value to the direct electrical current between the electrode and the structure to be protected. This current, commonly called "impressed current", will be hereafter also referred to as "protection current".

[0008] The aforesaid difficulty results from the fact that the optimal value of the protection current does not only depend on the constructive characteristics of the water heater such as:

- dimensions and form of the structure;
- nature of the protective layer generally present;
- presence or not of one or more immersed heating elements;
- position and dimensions of the anode;
- thermal power of the heating elements;
- material with which the heating elements and their coatings are built;
- extent of the heating elements and their coating.

[0009] If this were the fact, it would be simple to regulate the generator once and for all during the construction stage, so that it would produce exactly the correct protection current necessary. In reality however, the optimal value of the protection current also depends strongly on the operative conditions: characteristics such as the electrical conductivity of the water from the aqueduct at the inlet, the temperature of the water in the tank, the amount of lime deposited on the metal surfaces to be protected, the temperature of the metal surfaces to be protected, in particular the surface temperature of the heating elements, that vary with the weather and the working conditions, thus modifying the system electrochemical potential to a great extent.

[0010] The simpler protection devices using impressed current ignore the effect of the working conditions and supply a constant impressed current for all types of water heater. It is well known however that these currents also cause slight water hydrolysis with harmful production of oxygen and hydrogen. Therefore, the value of the impressed current should be the minimum necessary to inhibit corrosion; higher values produce gases for no use, while lower values do not guarantee completely efficient protection.

[0011] So, devices have been proposed that measure the electrochemical potential with sufficient regularity in order to adjust the protection current value basically instant by instant. However, these devices require an additional electrode for measuring the electrochemical potential, as well as a sufficiently accurate measuring instrument for said potential.

[0012] Document EP 0 285 747 indicates how to use the electrode that acts as an anode, periodically and for very short moments, also as the electrode of the potential measuring instrument, an instrument that cannot be eliminated.

[0013] The main aim of the present invention for water heaters, and in particular accumulator water heaters, is to indicate methods and means to evaluate, in an indirect and basically continuous mode, the electrochemical potential of the structure to be protected through the identification of the water heater function and without the need for regular direct potential measuring operations.

[0014] A further aim of the present invention for the aforesaid water heaters, is to protect the corrodible structure by supplying the anode with the quantity of current considered optimal by an impressed current ca-

thodic protection device to counter the corrosive effect of the evaluated electrochemical potential.

[0015] A further aim of certain variants of the present invention, for the aforesaid water heaters, is to be able to vary the ratio between the amounts of protection current applied to the surface of the heating elements and the quantity applied to the surface of the rest of the structure to be protected.

[0016] It must be stated that, since the value of the protection current is immediately deductible from the value of the electrochemical potential, the indirect evaluation of the latter is basically equivalent to the calculation of said protection current.

[0017] These and other aims are attained according to the invention through the use of a method and the corresponding means, that provide for data acquisition concerning the water heater working status and the supply of impressed current in the amounts considered optimal for the current working status of the type of water heater in question.

[0018] In fact, it can be noted that if the aforesaid constructive characteristics of the water heater and certain working conditions are known, the electrochemical potential of the structure is basically calculated with sufficient precision, and therefore also known is the amount of impressed current to be applied to counter said potential and the consequential corrosion. Said method and means result as obvious from the present description, that describe certain preferred embodiments, together with the appended illustration, and the appended claims that form an integral part of the same description.

[0019] Figure 1, the only illustration included, shows a schematic view of a water heater 1 equipped with a cathode protection device according to the present invention.

[0020] With the water heater 1, also shown are the tank 2 and a heater 3, in this case, an electric heater, both liable to corrosion since both are manufactured in metal. It is also demonstrated that electrode 4 acts as the anode on the cathodic protection device, electrically insulated from the metal structure to be protected 2 and 3, that act as a cathode, the inlet pipe 5.1. for the aqueduct water and the outlet 5.2 for the heated water. The numeral 6 indicates the monitoring thermostat on the heater 3, able to receive signals concerning the water temperature value from a temperature sensor immersed in the sheath 6.1. Associated with the water heater is the protection current control unit 7 that includes at least one signal processing device 7.a adapted to process the protection current value in dependency of the value of specific input data from 7.1 to 7.4 and to transmit the signal to a generator 7.b of the same protection current adapted to modulate the intensity on signals supplied by said signal processing device 7.a.

[0021] The heater 3 can be supported by a metal structure 3.1 attached to the tank 2 by electrically insulated fixing means 3.2 and connected to earthing by a resistive connection 3.3; this device, as is known in at

least patent US 4.975.560, can be used to prevent the electrode 4, generally very close to heater 3, from discharging the greater part of the supplied protection current and thus not providing sufficient protection for the remaining metal structures.

[0022] Therefore, as a basic concept, the method according to this invention consists in first evaluating the value of the current electrochemical potential, subtractable from the working status, after identification of the type of water heater, and afterwards, the value of the impressed current from the electrochemical potential. However since an unequivocal relationship exists between the working status and the electrochemical potential for each type of water heater, and in turn between the electrochemical potential and the optimal impressed current in reality, the identification of the current working status of the water heater permits immediate calculation of the corresponding optimal value of the impressed current without actually having to calculate the electrochemical potential, unless this data is useful for other purposes.

[0023] Therefore, according to this invention, once the signal processing device 7.a has received the input data considered representative of the working status, it transmits in output the optimal value of the protection current calculated according to a specific mathematical relation for each type of water heater. The input data representative of the working status is symbolised in figure 1 by the dotted lines between 7.1 and 7.4 that do not necessarily indicate the actual physical connections, but only the conceptual dependences established by the mathematical relations. To attain the aim of the invention, the operative parameters that must be calculated more or less accurately according to necessity to identify the electrochemical potential of the structure with varying degrees of precision, and as a result, the optimal protection current, are at least one or more of the following:

- water temperature in the water heater,
- amount of lime deposit on the metal surfaces to be protected,
- ON or OFF status of the heating elements,
- electrical conductivity of the inlet water.

[0024] Various alternative methods are available for identifying one or more aspects with varying degrees of precision: either through initial planning during the production or installation stage, or through continuous readings, or finally, through evaluation of other operational parameters more easily identified.

Water temperature in the water heater

[0025] The higher the temperature of the water in the water heater 1, the stronger the electrochemical corrosive action, and the thicker the lime deposit. To identify the temperature, the thermostat 6 simply needs to be

the electronic type; then its sensor can transmit the signal to the signal processing device 7.a directly or through the thermostat 6 itself; the temperature signal is shown in the drawing by the dotted line 7.2. Naturally a temperature sensor destined exclusively for the signal processing device 7.a can be foreseen, in particular if the thermostat 6 is the electro-mechanical type.

Amount of lime deposit on the metal surfaces to be protected

[0026] The lime deposit on the metal surfaces to be protected already acts as a protection, and in any case, the presence of the lime modifies the electrochemical potential. The amount of the lime deposit increases progressively in time according to:

- the hardness of the inlet water,
- the quantity of water progressively treated,
- the temperature to which the water is heated.

[0027] The hardness of the inlet water in the water heater, like its electrical conductivity, parameters that are shown by the dotted line 7.1, are generally relatively constant in time for all localities, and therefore measurable and programmable in the signal processing device 7.a once and for all during installation operations or in the manufacturing plant; however, nothing prevents the application of continuous means for measuring hardness and/or aqueduct water conductivity, mounted on the water heater, and preferably housed by the inlet pipe 5.1, especially considering that current technology has already made devices available with a cost level and accuracy appropriate for this purpose; another manner for identifying this data is to receive it from another device equipped for measuring, such as a dishwasher or a washing machine, according to well known techniques previously illustrated in other patents such as at least EP 0 582 239 and PCT/IB00/00095 aimed at resolving problems of domotics.

[0028] As described above, having identified the hardness of the inlet water into the water heater, the thickness of the lime layer can be calculated immediately, through mathematical relations to be developed experimentally, from the identification of the amount of water treated up till this point, and perhaps also through the temperature up to which the water has been heated; in fact, if the water is maintained at very low temperatures, for example, 40 -50°C, the lime deposit is very low.

[0029] In turn the amount of water treated can be calculated from the duration of the ON/OFF status sequences of thermostat 6 and/or possibly also once again the temperature of the water in the water heater tank. In fact in an accumulator type water heater, where water is not drawn off, the thermostat 6 is activated regularly at certain intervals and for basically identifiable duration, to restore the thermal energy lost through dispersion;

the periods of ON status of the thermostat 6 that are more frequent and longer than those necessary for simple replacement of dispersed energy are basically proportional to the quantity of cold water introduced to be heated, and therefore they are directly related to the lime deposits, if the water hardness and thermal power of the heater 3 are known.

[0030] Similarly, lowering of temperature that is quicker than that due to natural water-cooling indicate the amount of cold water introduced with sufficient precision. The signal indicating the amount of water drawn off is shown in figure 1 by the dotted line 7.3; in fact this can consist of an ON/OFF status signal of thermostat 6 or water temperature; in the first case this coincides with signal 7.4, and in the second with signal 7.2.

[0031] For most of the practical applications of this invention, an estimation of the lime deposit such as that described above can be considered sufficient; however for other applications, this could be considered as being:

- either not sufficiently precise, although it does represent a considerable progress compared to known methods that do not consider the lime deposit increase in time at all,
- and/or too complex to be calculated.

[0032] In fact, even admitting that the aforesaid operative parameters (inlet water hardness, amount of water treated progressively, temperature to which the water is heated) are identified with sufficient precision during their time duration, the entity of the lime deposit on metal surfaces can be different, and therefore also the protection it provides, even with the same level of deposit. In fact, the lime does not always adhere to the surfaces, but sometimes deposits partially or completely on the bottom of the tank 2.

[0033] However, the method used to calculate lime deposit according to the present invention can be perfected and/or simplified even further using as a further or alternative operative parameter the value of the electrical potential difference that the impressed current generator 7.b applies between the electrode 4 and the metal structures to be protected 2 and 3.

[0034] Said generator 7.b, as described, adjusts the potential difference in order to supply the required impressed current. Since for each type of water heater, using the same amount of impressed current, the electrical potential necessary to generate it depends exclusively on the electric resistance in the path between the electrode 4 and the metal structures to be protected 2 and 3, said potential results as an indication of the lime deposit on the metal structures to be protected. Consequently, since the mathematical model calculates the lime deposit that has formed, it can also be used to calculate the electric resistance in the path between the electrodes 4 on one hand and 2 and 3, on the other, assigning the appropriate value to the electrical conductivity in the water in tank 2.

[0035] The identification of the electrical potential applied by generator 7.b. can therefore result as useful to correct at appropriately regular intervals, the calculation of the amount of lime deposit on the metal structures to be protected, calculations performed using the methods described above. In fact, if the applied electrical potential results as lower than that calculated for the applied impressed current at that point, this means that the electrical resistance in the path between electrodes 4, 2 and 3 is lower than the level foreseen, and therefore the amount of the lime deposit on the metal structures is also lower than the level foreseen; consequently, the impressed current value must be increased compared to the value established up to this point by the selected mathematical model. This can be obtained by modifying the appropriate parameters used as a basis for the mathematic model itself because of the difference between the foreseen electrical potential, and the potential actually obtained. On the contrary, if the electrical potential results as higher than the expected level, the amount of lime deposit is larger than expected, and according to the same criteria, the value of the impressed current must be reduced. This method presupposes the capacity to evaluate the quantity of lime deposit, but is aimed at correcting the mathematical model to take into consideration the mode and amount of lime deposit that are different from those expected.

[0036] However, it is obvious at this point that the electrical potential applied by the generator can also be used to calculate a direct estimate of the lime deposited progressively, leaving to one side the operative parameters such as inlet water hardness, amount of water progressively treated, temperature to which the water is heated. In this case, naturally the calculated estimate is improved by the identification of the electrical conductivity of the inlet water; in fact if the type of water heater and the electrical conductivity of the water are identified, differences between the electrical resistance values in the path between electrode 4 and the metal structures 2 and 3, and the expected value for the metal structures 2 and 3 without lime deposit, identified through experiments, cannot be attributed to other factors than the formation of lime deposit.

ON/OFF status of heating elements 3

[0037] As far as the ON/OFF status of the heating elements 3 are concerned, this is an important aspect since when they are heated said elements are even more subject to corrosion, and need greater protection with impressed current. Obviously the ON/OFF status of the heating elements 3 coincides with the ON/OFF status of the thermostat 6 and the corresponding signal is shown in figure 1 by the dotted line 7.4. With particular reference to the protection of the heating elements 3, the mathematical model that calculates the optimal impressed current could increase the value when said heating elements 3 are in ON status, resulting in an in-

crease in the current supply to all the structures to be protected; alternatively or in combination, according to a variant in this invention, the resistance value of the resistive connection 3.3 could be reduced in continuous mode or in small quantities, therefore increasing the impressed current fraction on the total, that would be directed towards said heating elements 3.

Electrical conductivity of inlet water

[0038] Obviously the value of the electrical conductivity of the water has an effect on the corrosion process, and therefore on the value of the protection current to be generated. As mentioned previously, the conductivity measuring methods can be identical to those used for measuring hardness levels.

[0039] As has been explained above, certain operative parameters important for corrosion effects have both direct and indirect effects on the corrosion process, modifying other parameters that, in turn, have a direct effect; for example, as the temperature increases, there is an increase in the corrosion process, but also in the lime deposit, which on the contrary, limits the corrosion process. This does not signify that continuous temperature monitoring is essential: if for example the thermostat 6 is of the type that cannot be adjusted by the user, temperature progress during heating operations can be considered as identified since the beginning.

[0040] In short, using known mathematical techniques, it is possible to construct specific mathematical models for every type of water heater, with the insertion of coefficients to be determined through experiment, to establish a dependence relation of the protection current for application by one or more operative parameters such as, herein provided as an example, but being by no means all-inclusive, those listed above and therefore: hardness and/or electrical conductivity of the inlet water and/or the temperature of the water in the water heater and/or the ON/OFF status of thermostat 6; these parameters are indicative, and precision increases according to the number of parameters included plus the accuracy of their calculation, the electrochemical potential generated by the system and therefore, the protection current to be generated. Naturally, since the phenomenon is of the same nature for all or many types of water heater, once the operative inlet parameters have been selected, it is possible to construct a single general mathematical model that includes the parameters to which specific values are assigned to define the model for more than one type of water heater. Said mathematical model can be made more or less complex and accurate, according to the operative parameters chosen for monitoring and to the quantity of experimental data collected for the adjustment setting.

[0041] It can be seen that according to the theory that water heaters equipped with an electronic thermostat 6 and where the electrochemical characteristics of aqueous water initially measured and stored using known

means in the signal processor 7.a are considered constant, the protection current control unit 7 is able to maintain the current constantly at optimal level by simply processing the signals transmitted by the thermostat 6 (water temperature and ON/OFF status of thermostat 6), and perhaps also possibly by generator 7.b. (applied electrical potential) without the need for any additional sensors.

[0042] Lastly, according to a variant of the invention, it can be seen that it is possible to modulate the protection current received from the heating elements 3 without basically modifying the protection current received from the other corrodible elements, due to the possibility of creating a mathematical model that foresees this possibility according to the ON/OFF status of said heating elements. In relation to this aspect, a simple variant of the invention can therefore consist in a method and corresponding means, already familiar, that provide for reducing or respectively, increasing the value of the resistance of the resistive connection 3.3 even by a small amount according to whether the thermostat 6 is in the ON status or respectively, in the OFF status. For example, this can be easily obtained with electronic components, arranging in parallel mode, or respectively, in sequence, two resistors along the resistive connection 3.3, or by by-passing at least one of the two resistors arranged in sequence. In fact, according to a very simple variant of this invention, operations can be limited exclusively to varying the resistance value of the resistive 3.3 by a small amount using electromechanical means (sequence/parallel switch-over of the two resistors, or by pass of one of the two) according to the variation of the ON/OFF status of a thermostat; for efficient use, this thermostat could be electromechanical to activate said circuit modifications directly using known methods.

[0043] In this case the signal processing device 7.a would not be necessary since the mathematical model is reduced to a simple rule: ON status (respectively OFF) = resistors in parallel mode (respectively in sequence); otherwise: ON status (respectively OFF) = a by-passed resistor (respectively not by-passed) or, better still, it is the thermostat 6 itself that assumes the role of the said signal processing device 7.a.

[0044] However, in most cases when the current to be generated depends more or less on the value of the input data between 7.1 and 7.4, said signal processing device 7.a will include at least one microprocessor that could be equipped with not only a calculating unit, but storage memory as well according to the situation in question.

[0045] In general therefore, the present invention explains that

- as well as depending on other constructive characteristics, optimal protection current, for each water heater model also depends on one or more operative parameters to a greater or lesser degree;
- it is possible to obtain the said operative parameters

easily, whether directly or indirectly;

- therefore it is possible to construct more or less complex and accurate mathematical models experimentally that provide as a result the value of the optimal protection current for each distinct working status identified by the values of the group for operative parameters taken into consideration.
- This description has illustrated several of the preferred embodiments of the present invention; naturally many other variants are possible for those skilled in the art, without however, exceeding the established limits of this invention.

15 Claims

1. Method for impressed current cathodic protection against corrosion in water heater tanks (1), in particular accumulator tanks, where the impressed current is able to take into consideration certain constructive parameters remaining constant in time, **characterised by** the fact that said impressed current is further regulated according to one or more operative parameters variable in time, and at least one of said operative parameters being
 - either directly identified during the same water heater (1) operations
 - or derived indirectly from one or more further operative parameters, at least one of these further operative parameters being in turn directly identified during the water heater (1) operation.
2. Method for cathodic protection according to the previous claim **characterised by** the fact that one of said operative parameters may be the temperature of the water in the water heater (1).
3. Method for cathodic protection according to claims 1 or 2 **characterised by** the fact that one of said operative parameters can be the amount of lime deposited on the metal surfaces to be protected (2, 3).
4. Method for cathodic protection according to claims 1 or 2 or 3 **characterised by** the fact that one of said operative parameters can be the ON/OFF status of the heating elements (3).
5. Method for cathodic protection according to claims 1 or 2 or 3 or 4 **characterised by** the fact that one of said operative parameters can be the electrical conductivity of the inlet water.

6. Method for cathodic protection according to claim 3 **characterised by** the fact that the amount of lime deposited on the metal surfaces to be protected (2, 3) can be calculated through an experimental mathematical experiment, 5
- from the hardness of the inlet water,
 - and from the amount of water progressively treated. 10
7. Method for cathodic protection according to the previous claim **characterised by** the fact that said experimental mathematical relation used to calculate the amount of lime deposited on the metal surfaces to be protected (2, 3) also takes into consideration the temperature of the water in the water heater. 15
8. Method for cathodic protection according to claim 5 **characterised by** the fact that the electrical conductivity of the inlet water is identified and stored in the control unit (7) of the protection current before the initial function of the water heater (1). 20 25
9. Method for cathodic protection according to claim 5 **characterised by** the fact that the electrical conductivity of the inlet water is identified during the water heating (1) operating function. 30
10. Method for cathodic protection according to claim 6 **characterised by** the fact that the hardness of the inlet water is identified and stored in the protection current control unit (7) before the initial function of the water heater (1). 35
11. Method for cathodic protection according to claim 6 **characterised by** the fact that the hardness of the inlet water is identified during the water heating (1) operating function. 40
12. Method for cathodic protection according to claim 6 **characterised by** the fact that the amount of water progressively treated is evaluated using the mathematical relation from the difference between the actual duration of the ON/OFF status sequence of the thermostat (6) and the expected duration of the same sequences in the case of failure to draw in hot water. 45 50
13. Method for cathodic protection according to claim 6 **characterised by** the fact that the amount of water progressively treated and evaluated using the mathematical relation from the difference between the actual lowering or water temperature in the water heater (1) and the expected 55
- lowering of the same water in the case of failure to draw in hot water.
14. Method for cathodic protection according to one or more claims from 6 to 13 **characterised by** the fact that said experimental mathematical relation is corrected at appropriate intervals to compare the electrical potential value actually applied by the generator 7.b with that foreseen by the mathematical model, 5
- there being a difference between the two values demonstrating the difference between the actual lime deposited on the metal surfaces to be protected (2, 3) and that foreseen by the mathematical model,
 - and there being the correction applied to modify the value of the impressed current to be supplied according to the operative parameters employed to evaluate said amount of deposited lime.
15. Method for cathodic protection according to claim 3 **characterised by** the fact that the amount of lime deposited on the metal surfaces to be protected (2, 3) is directly evaluated through the experimental mathematical relation according to the difference between the value of the electric resistance in the path between electrode (4) and the metal structures to be protected (2, 3) and the value, identified experimentally, of the same metal structures (2, 3) free of lime deposit. 20
16. Method for cathodic protection according to previous claims 15 and 5 **characterised by** the fact that the calculated estimate of the amount of lime is made more accurate because of the identified electrical conductivity of the inlet water. 35
17. Method for cathodic protection according to at least claim 4 **characterised by** the fact that during the ON status of the heating elements (3) the ratio between the protection current supplied to the heating elements (3) themselves and the remaining structures (2) subject to corrosion is increased. 40
18. Method for cathodic protection according to claim 17 **characterised by** the fact that said ratio between the protection current supplied to the same heating elements (3) and the remaining structures (2) subject to corrosion is varied to small degrees. 50
19. Method for cathodic protection according to claim 17 55

characterised by the fact that said ratio between the protection current supplied to the same heating elements (3) and the remaining structures (2) subject to corrosion is varied in continuous quantities.

20. Method for cathodic protection according to one or more of the previous claims

characterised by the fact that the impressed current to be distributed towards the structures to be protected (2, 3) is calculated from a specific mathematical model for each type of water heater (1) and contains coefficients to be determined experimentally to establish a relation of dependence between the protection current to be applied and operative parameters taken into consideration.

21. Method for cathodic protection according to the previous claim

characterised by the fact that said mathematical model can be considered formally valid and identical for more than one type of water heater (1) and characterised for each of said same water heaters through the assignment of specific values to appropriate parameters.

22. Protection current control unit (7) against corrosion of structures (2, 3) of water heaters (1) being adapted to implement the method of cathodic protection according to claim 1

characterised by the fact that it includes at least:

- one signal processing device (7.a)
 - being adapted to process the value of the protection current from specific input data (7.1, 7.2, 7.3, 7.4),
 - and to transmit said signal to a generator (7.b) of the same protection current,
- said generator (7.b), being adapted to modulate the intensity of said current according to the signals transmitted by said signal processing device (7.a),
- means adapted to receive from outside said protection current control unit (7) the values of the operative parameters taken into consideration.

23. Protection current control unit (7) according to claim 22 being adapted to implement the method of cathodic protection according to at least claim 2

characterised by the fact that the water temperature in the water heater is identified by the temperature sensor of the heater (3) monitoring thermostat (6), said thermostat being

electronic.

24. Protection current control unit (7) according to claim 22 being adapted to implement the method of cathodic protection according to at least claim 2

characterised by the fact that the water temperature in the water heater is identified by a specific temperature sensor.

25. Protection current control unit (7) according to any of the claims from 22 to 24 being adapted to implement the method of cathodic protection according to at least claim 4

characterised by the fact that the ON/OFF status of the heating elements (3) is identified by the ON/OFF status of the thermostat (6).

26. Protection current control unit (7) according to any of the claims from 22 to 25 being adapted to implement the method of cathodic protection according to at least claim 9

characterised by the fact that the electrical conductivity of the inlet water is identified by measuring means in continuous mode, preferably housed near the inlet pipe (5.1).

27. Protection current control unit (7) according to any of the claims from 22 to 25 being adapted to implement the method of cathodic protection according to at least claim 9

characterised by the fact that the electrical conductivity of the inlet water is identified in continuous mode by the measuring means in combination with a device external to the water heater (1) and is signalled to the control unit (7) by means known in domotics.

28. Protection current control unit (7) according to any of the claims from 22 to 27 being adapted to implement the method of cathodic protection according to at least claim 11

characterised by the fact that the hardness of the inlet water is identified by measuring means in continuous mode, preferably housed near the inlet pipe (5.1).

29. Protection current control unit (7) according to any of the claims from 22 to 28 being adapted to implement the method of cathodic protection according to at least claim 11

characterised by the fact that the hardness of the inlet water is identified in continuous mode by the measuring means in combination with a device external to the water heater (1) and is signalled to the control unit (7) by means known in domotics.

30. Protection current control unit (7) according to any of the claims from 22 to 28 being adapted to implement the method of cathodic protection according to at least claim 14 or 15

characterised by the fact that

- the protection current generator (7.b) is adapted to transmit to the signal processing device (7.a) the electrical potential value applied from said generator (7.b),
- while said signal processing device (7.a) is adapted to receive and use the said signal.

31. Protection current control unit (7) according to any of the claims from 22 to 29 being adapted to implement the method of cathodic protection according to at least claim 18

characterised by the fact that

the resistive connection (3.3) between the heating elements (3) and the protection current control (7) is composed of two resistors that can be connected in parallel mode or in sequence, and according to which respectively, the ratio between the protection current supplied to the said heating elements (3) and the remaining structures (2) subject to corrosion must be increased or reduced.

32. Protection current control unit (7) according to any of the claims from 22 to 29 being adapted to implement the method of cathodic protection according to at least claim 18

characterised by the fact that

the resistive connection (3.3) between the heating elements (3) and the protection current control (7) is composed of two resistors that can be connected in parallel, one of which can be by-passed when the ratio between the protection current supplied to the heating elements (3) and the remaining structures (2) subject to corrosion must be increased.

33. Protection current control unit (7) according to any of the claims from 22 to 29

characterised by the fact that

said signal processing device (7.a) is composed of at least one microprocessor including a calculating unit.

34. Protection current control unit (7) according to the previous claim

characterised by the fact that

said microprocessor also includes a memory unit.

35. Protection current control unit (7) being adapted to implement the method of cathodic protection according to at least claim 18

characterised by the fact that

- the resistive connection (3.3) between the heat-

ing elements (3) and the protection current generator (7.b) is composed of two resistors connected in parallel mode when the thermostat (6) is in ON status, and in sequence mode when the thermostat (6) is in OFF status,

- the thermostat (6) can be the electronic type,
- the switch-over on the connection between the two resistors is obtained using known electro-mechanical means.

36. Protection current control unit (7) being adapted to implement the method of cathodic protection according to at least claim 18

characterised by the fact that

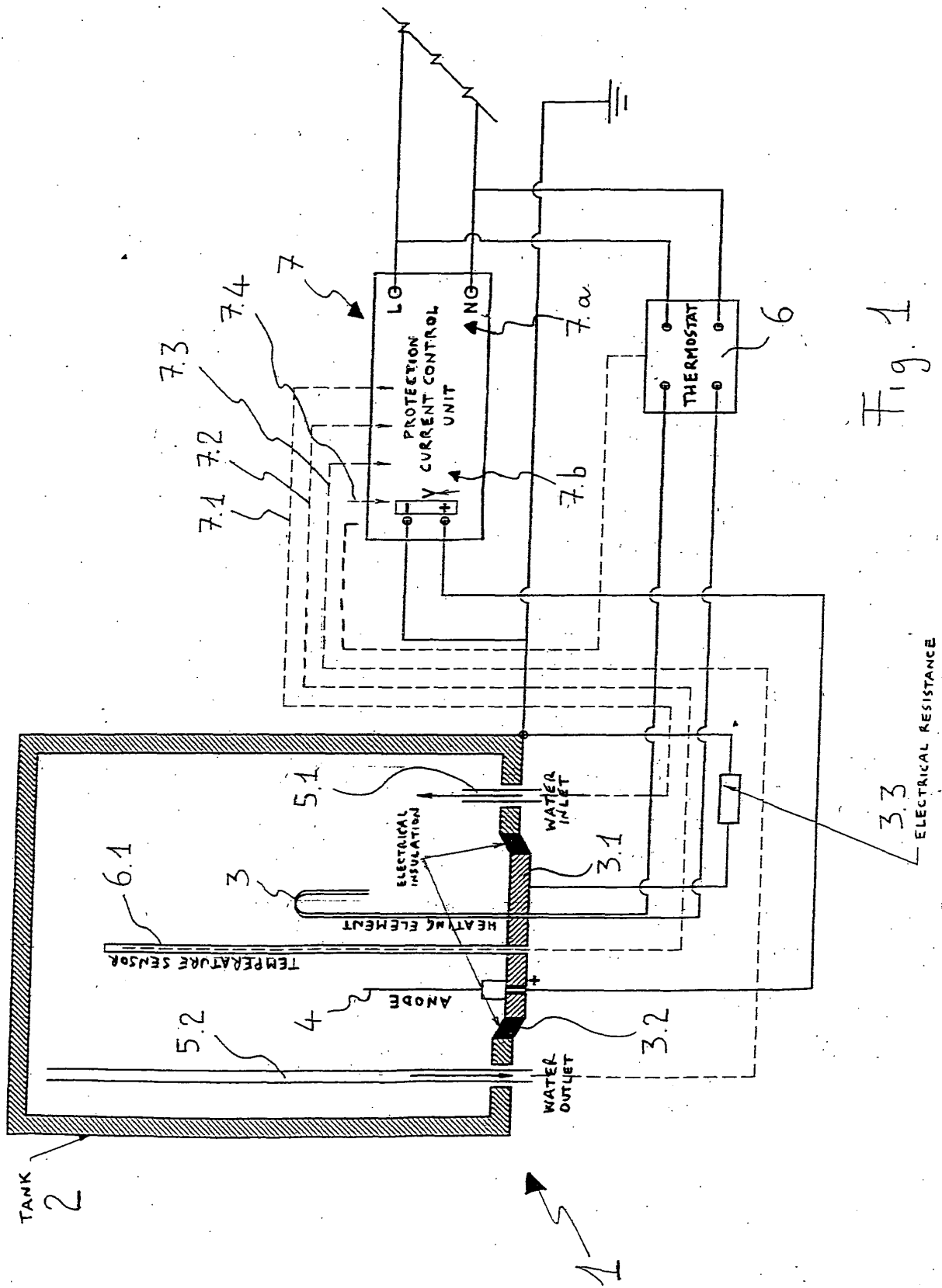
- the resistive connection (3.3) between the heating elements (3) and the protection current generator (7.b) is composed of two resistors of which one is by-passed when the thermostat (6) is in ON status, and connected in sequence mode when the thermostat (6) is in OFF status,
- the thermostat (6) can be the electronic type,
- the switch-over on the connection between the two resistors is obtained using known electro-mechanical means.

37. Method for impressed current cathodic protection against corrosion in water heater tanks (1), in particular accumulator tanks, where the impressed current can be regulated according to certain constructive parameters being constant in time according to one or more of the claims from 1 to 21.

38. Method for impressed current cathodic protection against corrosion in water heater tanks (1), in particular accumulator tanks, where the impressed current can be regulated according to certain constructive parameters being constant in time according to the descriptions and illustrations provided for the specific aims and purposes.

39. Protection current control unit (7) according to any of the claims from 22 to 32 being adapted to implement the method of cathodic protection according to one or more claims from 1 to 21.

40. Protection current control unit (7) against the corrosion of the structures (2, 3) of water heaters (1) according to the aforesaid descriptions and illustrations for the specified aims and purposes.





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 02 5225

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	FR 1 473 570 A (BUDERUS EISENWERK) 17 March 1967 (1967-03-17) * the whole document *	1,2,22, 24,37-40	C23F13/04 F24D19/00
X	WO 00/70124 A (PULLIAINEN MARTTI ; SAVCOR PROCESS OY (FI); LAURILA TIMO (FI); PAUNONE) 23 November 2000 (2000-11-23) * the whole document *	1,2,22, 24,37-40	
X	US 4 407 711 A (BABOIAN ROBERT ET AL) 4 October 1983 (1983-10-04) * column 4, lines 27-68; claim 1 *	1,5,26, 27,37-40	
A	US 3 373 100 A (HAYDN RUBELMANN) 12 March 1968 (1968-03-12)		
A	US 4 975 560 A (WARDY DAHER T ET AL) 4 December 1990 (1990-12-04)		
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			C23F F24D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 8 April 2004	Examiner Van Leeuwen, R
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04001)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 02 5225

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

08-04-2004

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
FR 1473570	A	17-03-1967	BE 678749 A	01-09-1966
			CH 466669 A	15-12-1968
			DE 1521688 A1	25-09-1969
			NL 6604550 A	07-10-1966
WO 0070124	A	23-11-2000	FI 991116 A	18-11-2000
			AU 760526 B2	15-05-2003
			AU 4571900 A	05-12-2000
			BR 0010644 A	19-02-2002
			CA 2372920 A1	23-11-2000
			EP 1190113 A1	27-03-2002
			WO 0070124 A1	23-11-2000
			JP 2000328273 A	28-11-2000
			NO 20015430 A	06-11-2001
US 4407711	A	04-10-1983	NONE	
US 3373100	A	12-03-1968	NONE	
US 4975560	A	04-12-1990	NONE	