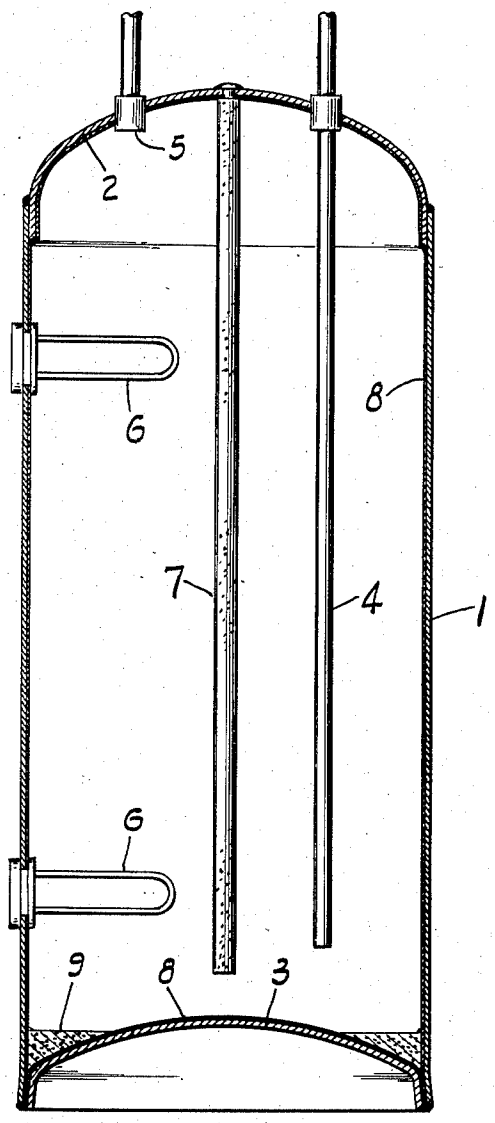
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HOT WATER TANK AND METHOD OF INCREASING THE EFFECTIVENESS OF CATHODIC PROTECTION OF THE SAME

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HOT WATER TANK AND METHOD OF INCREASING THE EFFECTIVENESS OF CATHODIC PROTECTION OF THE SAME

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This invention relates to a method of increasing the effectiveness of the cathodic protection of a metal water storage structure and particularly has reference to a hot water storage tank which is provided with a corrosion-resistant lining of glass or the like.

To protect a steel water heater tank from corrosion, cathodic protection is frequently applied to the tank. To decrease the cathodic area of the protective circuit and thereby decrease the total current required to protect the tank, the inside metal surfaces of the tank are coated with a vitreous enamel, glass or plastic composition. The operation of the cathodic circuit depends on the ability of the water contained within the tank to conduct an electric current.

In some localities, such as the New England area of the United States, the municipal water supplies are of such a nature that the water is naturally soft, that is, has a very low proportion of dissolved solids, and therefore has a high resistivity. This condition is not favorable to cathodic protection since the water offers a high resistance to current flow between the anode and any exposed metal tank surfaces. Due to this resistance to current flow, complete protection of the exposed areas of the metal tank is difficult to achieve, particularly where there are a considerable number of exposed tank areas or where the exposed areas are a substantial distance from the anode.

This invention is based on the concept that, if a high current can be made to initially pass through the soft, high resistivity water from the fixed potential anode to the cathode (any metal in the tank exposed through the coating through imperfections or defects or which has not been coated, such as spud connections and the like) a polarized condition will be built up on the exposed areas and complete protection of these areas can be subsequently maintained with a steady current of lower density than the initial current.

According to the present invention an electrolyte is introduced into the naturally soft water in the tank at a rate sufficient to increase the dissolved solids content of the water to a value of about 150 to 400 p. p. m., thereby correspondingly increasing the conductivity of the water to a range of about 250 micromhos to 650 micromhos. With the conductivity of the water then at a higher standard, the metal tank areas exposed through imperfections in the glass coating or uncoated metal areas will be adequately protected regardless of their size or position with respect to the anode.

During the time that the electrolyte is introduced into the water, the exposed areas of the tank are polarized, and after the electrolyte has been completely dissipated and discharged from the tank by normal withdrawal of water, the current density will decrease due to the lesser conductivity of the incoming soft water. However, the decreased conductivity of the water will then be sufficient to maintain the polarized condition of the exposed metal areas and prevent corrosion of the same.

The drawing furnished herewith illustrates the best

mode of carrying out the invention as presently contemplated and set forth hereinafter.

The single figure of the drawing is a longitudinal section of a domestic water heater tank embodying the present invention.

In the drawing, there is shown a water heater tank comprising a generally cylindrical shell 1 which is enclosed at the top and bottom, respectively, by heads 2 and 3.

Water to be heated is admitted to the tank through an inlet pipe 4, and heated water is withdrawn from the tank through pipe 5. Pipes 4 and 5 are suitably secured within suitable openings in upper head 2.

The water within the tank may be heated by any conventional means. As shown in the drawing, two electrical heating elements 6 are disposed within the upper and lower portions of the tank, respectively, and serve to heat the water therein. Elements 6 are connected to a suitable source of current, not shown. Alternately, the water may be heated by a gas burner disposed beneath the bottom head 3.

To protect the interior tank surfaces from corrosion by the water contained therein, an anode 7 composed of a metal electropositive to steel, such as magnesium, or a generally inert anode having a fixed potential impressed thereon, is suspended from head 2 and extends downwardly within the tank into the electrolyte or water stored therein. As the steel tank is electronegative with respect to anode 7, a galvanic or electrolytic circuit is set up in which the steel tank is the cathode. As electrolytic current flows through the water between the anode and cathode, the anode 8 will corrode preferentially and the steel cathode areas will be protected.

To decrease the amount of cathodic area in the tank and hence minimize the total current necessary to protect the same, the tank is lined with a corrosion-resistant coating 8 of vitreous enamel, glass, plastic or the like.

The coating 8 normally contains a number of small imperfections or defects through which the metal tank surfaces are exposed to the water contained therein, and the current density developed by the cathodic system functions to protect these exposed areas. Also there may be imperfections in the coating where metal areas of the tank or the fittings are not coated in the coating operation.

In many localities the municipal water supplies contain less than 100 p. p. m. of dissolved solids and have an electrical conductivity of less than about 160 micromhos. These waters are generally referred to as naturally soft waters. As the conductivity of water is directly proportional to the concentration of naturally occurring dissolved solids therein, a soft water offers a high resistance to current flow. As a consequence, the small exposed metal areas of a glass-lined tank containing soft water cannot often be adequately protected by the current.

A soft water having a dissolved solids content of less than 50 p. p. m. has an extremely low conductivity, and as a result, only small exposed areas of the tank located near the anode will be protected. If there are a number of exposed areas to be protected, the current flow in a water such as this is not sufficient to adequately protect all of the exposed areas. Similarly, if there are two exposed tank areas, one of which is considerably farther from the anode than the other, a greater portion of the current will flow from the anode to the nearer exposed area while only a small portion of the current will flow to the farther area, with the result that the farther area will not be adequately protected by the current and will corrode.

To more adequately protect all of the tank areas

exposed to the soft water, an electrolyte or a compound capable of dissociating in water is dissolved into the water within the tank at a rate sufficient to increase the dissolved solids content of the water to an amount generally within the range of 150 to 400 p. p. m. As the electrical conductivity of the water is proportional to the dissolved solids content, the conductivity of water will be increased to a value within the range of about 250 to 650 micromhos and thus the flow of current between the anode and the exposed metal areas of the tank is substantially increased so that the current flow to all exposed metal areas is adequate regardless of their proximity to the anode.

As the exposed metal areas of the tank are the cathodic areas in the galvanic circuit the metal is polarized. That is, hydrogen collects on the cathodic areas as a gaseous film and a hydroxide or oxide coating of the metal ions of both the electrolyte and the salts originally in the water is deposited on the cathode.

The electrolyte or dissociable compound may take the form of a non-toxic, metal salt **9** which is slightly soluble in water so that it will dissolve and ionize over a period of time sufficient to permit polarization of the exposed metal areas of the tank.

It is desirable that the salt be only slightly soluble, so that it will require a number of days for the salt to be dissolved and thus the polarized condition on the exposed metal will have an adequate time to develop. If, for example, a very soluble salt were employed, the salt would dissolve rapidly and be dissipated before the required polarized condition was obtained. Thus an excessively large quantity of a soluble salt would be needed in order to maintain an increased solids content in the water for a period of at least three days and generally within the range of three to twenty days which is generally required to effect polarization of the exposed metal areas.

The salt should generally have a solubility such that the total dissolved solids content of the water is increased to a value of about 150 to 400 p. p. m. under normal water withdrawal conditions for the limited period of about three to twenty days. The term "total dissolved solids content" is intended to mean the dissolved solids attributable to both the salt **9** and the original salts in the soft water. While a solids content within this range is desirable, any increase in the dissolved solids content will increase the conductivity of the water and thus aid in protecting the exposed metal areas. A dissolved solids content of over 400 p. p. m., while serving to effectively increase the conductivity, is an uneconomical use of the salt and the temporary high hardness of the water is frequently objectionable.

It has been found that under normal rates of water flow and under the temperature and pressure ranges (about 120° F. to 180° F. and 25 to 80 p. s. i., respectively) normally encountered in a storage tank such as a water heater, a salt having a solubility such that .005 to .05 gram in the physical form employed will dissolve in 100 milliliters of water, will provide, under most conditions, an increase in the dissolved solids content to the desired 150 to 400 p. p. m. range. However, the above solubility range may be varied outside of the limits depending on abnormal variations of the pressure and the temperature of the water within the tank, and the rate of withdrawal of the water.

The salt to be used should be non-toxic in the quantities employed and should not impart color, odor or taste to the water. In addition, the salt should be coarse enough in consistency so that it will not be carried out of the tank by the normal flow of water.

It has been found that alkali metal salts having the aforementioned properties are very satisfactory for use as the salt **9** for they aid in forming the insoluble oxide or hydroxide coating or the cathodic areas to polarize the same.

It has been found that a salt such as gypsum, $CaSO_4$, is particularly suitable for use as the salt **9**, for it is non-toxic, readily available and has a solubility in the aforementioned range to give the required increase in dissolved solids content in the water. Other compounds which can be employed as salt **9** are magnesium carbonate, $MgCO_3.3H_2O$, or calcium hydroxide, $Ca(OH)_2$.

After the salt **9** has completely dissolved, the dissolved solids content of the water within the tank will gradually return to the normally low value due to the withdrawal of water from the tank and the entry of additional soft water. As the dissolved solids content of the water is lowered, the conductivity of the water will be correspondingly decreased. However, because of the polarized condition of the exposed metal areas, a considerably lesser current is then required to maintain protection of the exposed areas. Thus a current of low density which originally would not be sufficient to protect the exposed metal areas acts to protect these exposed areas regardless of their proximity to the anode. It is believed that a lesser current density will protect the exposed areas because the oxide or hydroxide deposit provides a barrier and obstructs the movement of corrosion stimulating constituents to the cathode from the bulk of the water. The polarized condition of the exposed metal areas will be retained indefinitely, and hence the exposed areas will be protected indefinitely, until the galvanic circuit is broken such as by removal of the anode, or draining the water from the tank.

The salt **9**, as shown in the drawing, is in the form of an annular casting disposed on bottom head **3** within the depression between the tank shell **1** and the head. The salt is introduced as a slurry within the completed tank through one of the openings therein and settles within the depression. On hardening of the slurry, the salt remains as an annular casting at the bottom of the tank. The salt may also be placed freely within the tank in the form of lumps or it may be cast as a doughnut around the anode **7** or dip tube **4**, or it may be placed within the tank in any other convenient manner.

A typical illustration of the present invention is as follows: A lump of gypsum, $CaSO_4$, weighing 15 grams was placed within a non-metallic tank containing 5 gallons of water having a conductivity of 50 micromhos. A magnesium anode was employed and a glass-coated steel rod was placed in the tank. Portions of the glass coating were removed to expose the steel rod to the water at three locations, approximately 2, 8 and 8½ inches from the anode.

The gypsum was completely dissolved in seven days and the conductivity of the water during this period averaged approximately 500 micromhos. During this seven day period, a deposit of $Mg(OH)_2$ and $Ca(OH)_2$ was formed on the exposed steel areas. After dissipation of the gypsum, the conductivity slowly decreased to 50 micromhos but the exposed areas showed no signs of corrosion after five months, the time that the experiment has presently operated.

The present invention has also been applied to a 30 gallon, gas-fired, glass-lined water heater which contains a low conductivity water. At the present time, after a period of three weeks, there is no evidence of corrosion on exposed metal samples disposed within the tank.

The present invention provides a simple and inexpensive method of increasing the effectiveness of cathodic protection in naturally soft water. Once the metal areas which have not been coated or which are exposed through imperfections in the lining are polarized by the high current density obtained by the greater conductivity of the water through use of the salt **9**, protection of the exposed areas can be maintained by the substantially lower current density resulting from the decreased conductivity of the water when the salt is completely dissolved.

While the solution of a slightly soluble, non-toxic salt, such as gypsum, is the most economical method of in-

troducing an electrolyte into the naturally soft water, it is contemplated that any other method of introducing a metered amount of an electrolyte into the water in sufficient quantity to effect polarization of the exposed metal areas may also be used, within the scope of the invention.

The invention is directed primarily to a water tank or other water-containing structure which is coated or lined with a non-metallic corrosion-resistant coating, for the low current density of soft waters could not ordinarily maintain the polarized condition of an entire metal tank, if the same were uncoated. However, the low current density of soft water can maintain the polarized condition of small metal areas exposed through defects in a coating and thus adequately protect the same against corrosion.

Various modes of carrying out the invention are contemplated as within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. A method of increasing the cathodic protection of a corrosion-resistant lined water storage vessel connected to a source of naturally soft water and with said water having a concentration of dissolved solids of less than 100 p. p. m. and being capable of conducting a given electric current between an anode disposed within the vessel and any exposed metal areas of the latter but with said given current being incapable of protecting said metal areas from corrosion, comprising, introducing into said vessel a solid electrolyte material selected from the group consisting of calcium sulphate, magnesium carbonate and calcium hydroxide, and with said electrolyte being capable of increasing the dissolved solids content of said water whereby the current density of said water may be increased; flowing water from said source into said vessel and into contact with said material so that the dissolved solids content of the water within the vessel is increased to a range of about 150 to 400 p. p. m. for a period of time sufficient for the increased current to polarize the cathodic metal areas of the vessel exposed to water, and thereafter flowing additional water from said source into and through the vessel with said concentration of dissolved solids and said current density returning to their initial values whereby the polarized condition of the cathodic areas is subsequently maintained by the lesser current to protect the metal areas of the vessel from corrosion.

2. A method of increasing the cathodic protection of a corrosion-resistant lined water storage and heating vessel connected to a source of naturally soft water and with said water having a concentration of dissolved solids of less than 100 p. p. m. and being capable of conducting a given electrolytic current between an anode disposed within the vessel and any exposed metal areas of the vessel wall but with said given current being incapable of protecting said metal areas from corrosion, comprising, introducing into the vessel a predetermined limited quantity of a solid electrolyte material selected from the group consisting of calcium sulphate, magnesium carbonate and calcium hydroxide, and with said electrolyte being capable of increasing the total dissloved solids content of said water whereby the current density of said water may be increased, said material having a solubility in hot water for the physical form employed in the range of about 0.005 to .05 gram per 100 ml. of water, flowing water from said source into said vessel and into contact with said material so that the dissolved solids content of the water within the vessel is increased to a range of about 150 to 400 p. p. m. for a limited period of time sufficient for the increased current to polarize the cathodic metal areas of the vessel exposed to water, and thereafter flowing additional water from said source into and through the vessel whereby said material is finally exhausted therefrom with a corresponding decrease in the dissolved solids content and in the current density of said water to their normal values, the polarized condition of the polarized metal areas being subsequently maintained by the lesser current to protect the same from corrosion.

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