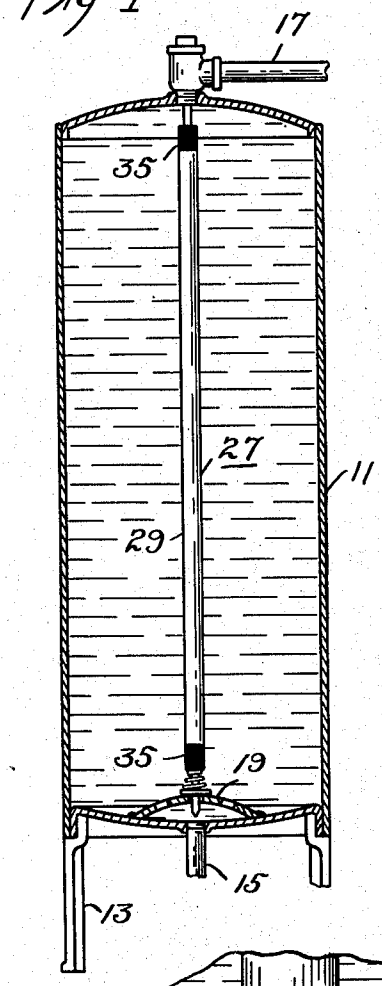
Oct. 20, 1953 C. M. OSTERHELD 2,656,314

CORROSION PREVENTING MEANS

Filed May 28, 1947 2 Sheets-Sheet 1

Fig-1



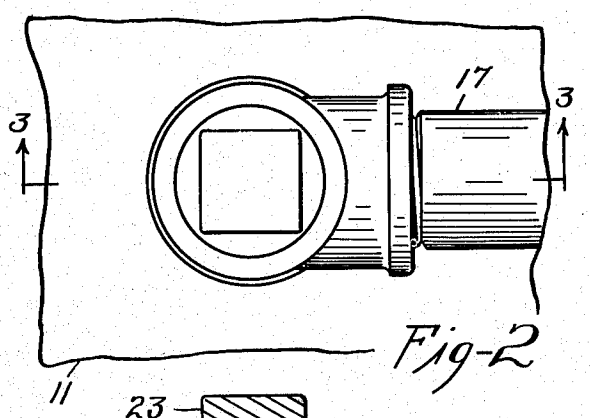


Fig-2

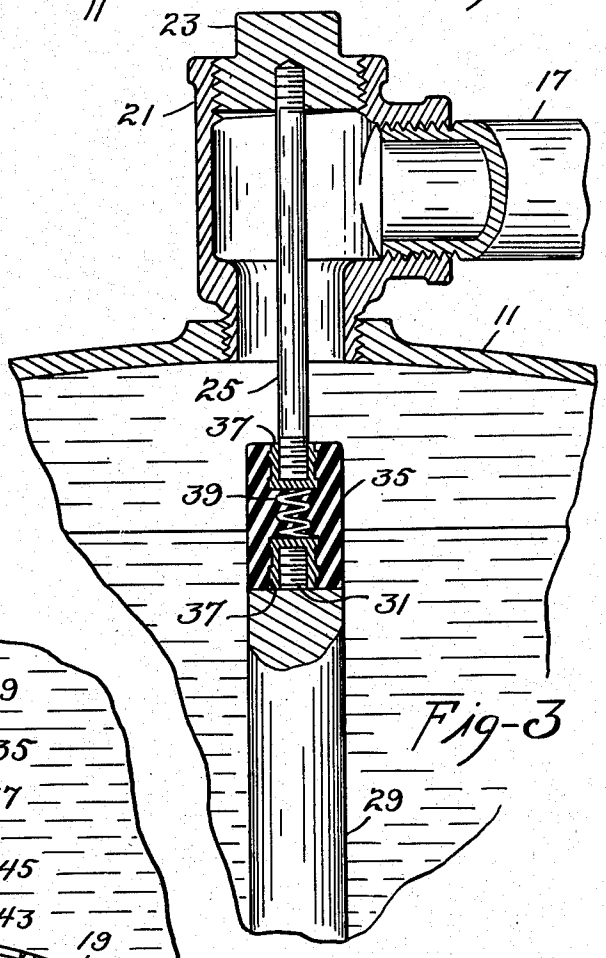


Fig-3

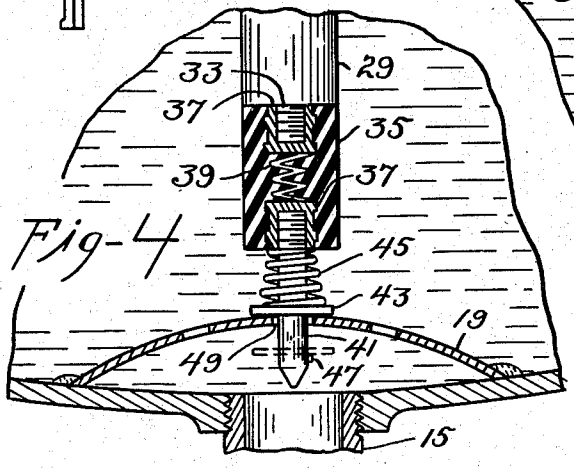


Fig-4

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CORROSION PREVENTING MEANS

Filed May 28, 1947 2 Sheets-Sheet 2

Fig-5

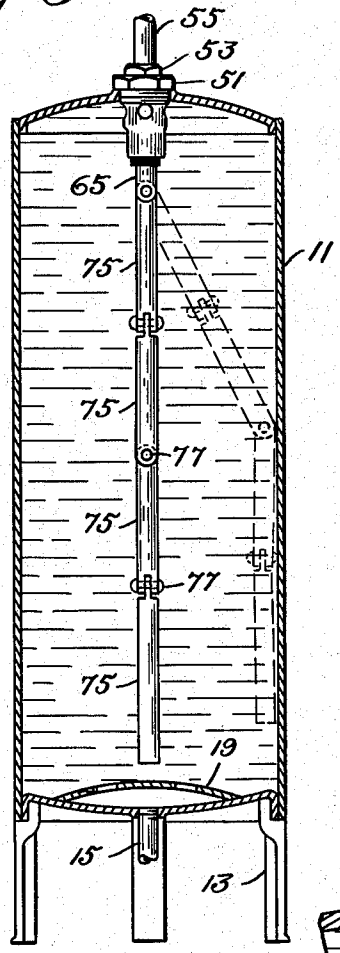
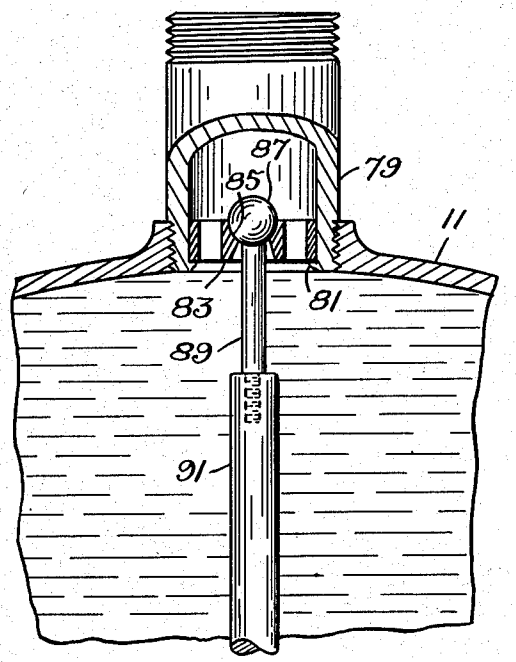


Fig-6



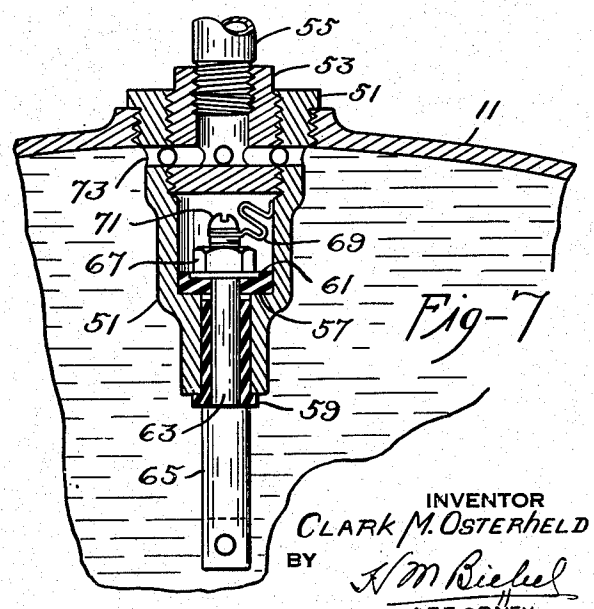


Fig-7

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Patented Oct. 20, 1953 2,656,314

UNITED STATES PATENT OFFICE

2,656,314

CORROSION PREVENTING MEANS

Clark M. Osterheld, Stoughton, Wis., assignor to McGraw Electric Company, Elgin, Ill., a corporation of Delaware

Application May 28, 1947, Serial No. 750,900

14 Claims. (Cl. 204—197)

1

My invention relates to ferrous metal storage tanks, and more particularly to hot water storage tanks such as used for domestic purposes. As is well known, hot water is frequently withdrawn from such tanks and replaced by incoming cold water.

One of the objects of my invention is to provide a relatively simple but highly efficient means for preventing corrosion of the inside surface of a hot water tank when the same is filled over extended periods with water.

Another object of my invention is to provide a corrosion-preventing means and method that shall be simple and easy to install, that shall continue in operating condition over extended periods of time and use of which shall result in reducing the initial cost of the tank itself.

Another object of the invention is to provide as means in a metallic hot water tank a sacrificial anode from which, without the necessity of an externally supplied voltage, a protective current will flow through the water itself to all areas of the tank, the anode sacrificing itself to corrosion and preventing corrosion of the tank. Further, it is proposed to provide a protective anode of a material which is practically useful with respect to operating efficiency, operating life, and cost of initial installation and replacement.

Another object of my invention is to provide relatively simple means for preventing corrosion of the inside surface of a ferrous metal hot water tank that shall embody means to control the rate of dissociation of the corrosion-preventing member. More particularly, it is proposed to provide control means that, while prolonging the operative life of the corrosion-preventing member, will ensure full protection of the tank. In conjunction with a protective sacrificial anode, in the electrical connection between the anode and the tank, it is proposed to incorporate an electrical resistance element of suitable ohmage to prolong the life of the anode but not so large as to reduce the protective current flow to the tank below the minimum required to ensure complete tank protection.

A further object of my invention is to provide uniformity of protection against corrosion throughout the entire surface area of the tank.

A further object of the invention is to provide corrosion protection for a metallic hot water tank with a sacrificial anode which will operate satisfactorily under varying conditions which affect the amount of the protective current flow between the anode and the tank, and to provide means for minimizing the effect of such conditions. In particular, it is proposed to minimize variations in protective current flow on the changes in the resistance or conductivity of the water with changes in temperature, which may

2

be considerable in hot water tanks, by providing a resistance element having an ohmage which is constant, or substantially so, under temperature changes, and which resistance element will materially lessen fluctuations in the protective current with changes in the water resistance.

Other objects of my invention will either be apparent from a description of several forms of devices embodying my invention or will be pointed out in the course of such description and particularly in the appended claims.

It has long been known that water used for ordinary heating purposes or for domestic or other similar uses contains different substances and that it may either be slightly acid (trace of hydrochloric acid), alkali-containing (such as sodium hydroxide) or saline (such as magnesium chloride). When such water is contained in a tank it will, of course, under certain conditions, constitute an electrolyte and may have a deleterious action and effect upon the inside surface of the tank, particularly so if the tank consists of a ferrous metal, which in itself may contain impurities of the kind usually found in iron. Various methods of protection against such action have been proposed.

The most common prior method of protecting ferrous metal water tanks against deterioration due to water conditions has been to coat the inside surface of the tank with zinc. However, such method is far from reliable for reasons hereafter pointed out, and is expensive as well.

I have found that by the use of my invention, it is unnecessary to provide a zinc coating on the inside surface of a tank adapted to contain domestic water, that is, to be filled over extended periods of time, the water itself, of course being changed as withdrawals from the tank occur in ordinary use. In such case the tank should be made of relatively pure iron, now available on the market. However, the invention is operative in a zinc lined tank, and with advantages over the use of either such protective coating or the invention alone as hereafter explained.

In practicing my invention I provide, irrespective of whether the inside surface of the tank is zinc coated or not, a corrosion-preventing member comprising a rod or other block of a material anodic relative to the ferrous metal of the tank, this anodic member having, preferably, but not necessarily, a shape or outline symmetrical to that of the tank itself, the anodic member being supported in the tank in a predetermined position relatively to the inside walls thereof by suspending or supporting means or both. An electrical connection is established between the anodic member and the tank, preferably at one or both ends, through an interposed current-reducing ohmic resistance member or members

suitably encased in a waterproof housing for protection against water in the tank. Conveniently, such a member may be housed in the supporting means by which the anodic member is secured to the tank. I use the term "anodic" to indicate that the material thereof, either a metal or alloy, will be that pole or terminal from which an electric current flows through the water electrolyte to the other pole or terminal of the circuit, which other pole or terminal is the cathode and in this case is the tank itself. In other words, the anodic member is the one which is dissolved or attacked by the electric current caused by the electrolyte engaging two dissimilar electric conducting materials.

The sacrificial anodic member comprises magnesium. There are numerous materials in the electromotive series which are anodic to iron. However, some of such materials are too active in water and would be consumed so rapidly as to be impractical for present purposes. Other such materials, including zinc, have a low operating efficiency and the protective current flow which they are capable of producing under many conditions would be below the minimum to insure complete protection against corrosion, and this would be particularly true where an external resistance is to be employed in the circuit between the sacrificial anode and the cathodic metal surface to be protected. Such operating inefficiency in part results from a low potential difference between such metals and iron but also results from the tendency of the metals to polarize in an electrolyte solution. Such polarization materially reduces the effective protective current. Zinc is considered unsatisfactory for this reason. Again, various metals, particularly when containing impurities, are subject to local battery action, one type of polarization, between different surface areas thereof in an electrolyte solution which causes them to be consumed too rapidly to make them useful for a sacrificial anode and the local current flow serves no useful function in the protection of the tank. While magnesium is subject to a certain amount of local battery action which hastens its corrosion and useful life, it undergoes very little polarization of other types and is well adapted to ensure adequate current flow to protect the tank when employed with as well as without a substantial resistance in conjunction therewith.

In the drawings:

Figure 1 is a view in vertical section through a domestic hot water tank of cylindrical shape having mounted therein a device embodying my invention;

Figure 2 is a fragmentary top plan view thereof showing certain parts only;

Figure 3 is a fragmentary view taken on the line 3—3 of Fig. 2;

Figure 4 is a fragmentary view of the bottom portion of an element embodying my invention;

Figure 5 is a view in vertical section taken through a domestic hot water tank and including in modified form an anodic element embodying my invention;

Figure 6 is a fragmentary view showing only the top end of a tank end of a still further modification of anodic invention; and

Figure 7 is a fragmentary view showing the upper part of the tank and of the support for the anodic elements shown in Figure 5 of the drawings.

I have illustrated a domestic hot water tank 11 as of elongated shape and of cylindrical transverse section and provided with supporting means 13 and a cold water inlet 15 at the bottom of the tank, as well as a hot water outlet pipe 17, the latter being connected to the tank at the upper end thereof. The inner end of cold water inlet pipe 15 is covered by a perforate baffle member 19 of metal which I have shown, for purposes of illustration, as being of circular shape and of arcuate section.

The hot water outlet pipe 17 may be threaded into a fitting 21 of T-shape, one end of which is screwed into an opening in the top of the tank while the upper end thereof is closed by a plug 23, which plug is adapted to receive a metallic suspending rod 25 and the anodic element 27 now to be described.

This element 27 includes more particularly a block, preferably in the form of a magnesium rod 29. Both ends of this rod, which is shown as somewhat shorter than the axial or longitudinal dimension of the tank itself, is made of reduced size and screw threaded, as shown at 31 and 33 in Figs. 3 and 4 of the drawings. I do not desire to be limited to a rod form of block, but I have obtained very good results in the use of such kind of members in domestic hot water tanks made of ferrous metal.

I provide members 35 of electric-insulating material, which may consist of a molded composition which will withstand the acid, alkaline or saline waters to which they may be subjected when in use in a tank, or they may be made of ceramic or vitreous material. Each member is provided with a tubular insert or thimble 37 which is provided with internal screw threads and which are electrically connected to the respective ends of a sealed-in resistor member 39, which may be made of Nichrome or any other suitable material adapted for the purpose and which has a predetermined ohmic resistance as hereafter more fully explained.

The suspending rod 25, as was hereinbefore noted, has screw threaded engagement at its upper end (in a vertically-extending hot water tank) with the plug 23, while its lower end fits into and has screw threaded engagement with one of the thimbles 37, while the lower thimble 37 in the upper member 35 is engaged by the reduced end portion 31 of the rod 29.

I provide a similar member 35 at the lower end of the rod, one thimble or tubular insert 37 of which has screw threaded engagement with reduced end portion 33 of rod 29, while the lower thimble 37 is engaged by the upper end of a short pin 41 which has mounted thereon a washer 43 and a coil spring 45 extending between the tubular insert 37 and the lower end of the member 35 and the washer 43, the washer being normally biased along the pin or rod 41 into engagement with a stop pin 47 fixed near the lower end of rod 41. When the anodic element structure 27 is in its normal operative position in a hot water tank of the kind shown in Fig. 1, the rod 41 extends through an opening 49 in baffle 19, this opening 49 being in substantial alignment with the cold water inlet pipe 15. It will be noted that the anti-corrosion element 27 will therefore be substantially coaxial with the cylindrical tank 11 for a purpose to be hereinafter referred to. While I have shown a single corrosion-preventing element only, I do not desire to be limited thereto and may use a plurality of such elements peripherally spaced from each other and on a circle of predetermined but relatively small diameter.

In case the tank is filled with water which, due

to the presence therein of minerals and other matter, is not pure but is either acid, alkali or saline, an electrolytic action will occur between the magnesium of the rod or rods within the tank and the inside surface of the ferrous metal tank, the amount of such electrolytic action being, of course, dependent upon the degree of acidity or alkalinity or salinity of the water and, to some extent, also dependent upon the exposed surface area engaged by the water.

It will be understood that since the rod element **29** is electro-positive with respect to the iron of the tank, galvanic current will flow through the water electrolyte from the rod to the tank and thence from the tank back to rod **29** through the interposed resistor elements **39**. The rod will gradually be consumed as positive metallic ions thereof go into solution while a relatively large galvanic pressure is established which prevents the flow of ions from the inner surfaces of the negative iron of the tank into solution. Thus the tank is effectively protected from corrosion as long as the galvanic circuit is maintained until the rod is consumed.

The current flow as here controlled is relatively small, preferably of the order of 5 to 10 milliamperes, so that corrosion of the magnesium rod is not rapid. The flow of current and the rate of dissociation and life of the rod will depend, although not entirely, upon value of the resistor elements, and will vary with the character of the water and the internal resistance of the water between the rod and the tank wall. In localities where the water has a high mineral content, the internal resistance will be lower, and the current flow and rate of dissociation of the rod higher, than in localities where the water has a relatively low mineral content. Nevertheless, it has been found in practice that the rod would require replacement in many instances within a year or so unless conservation methods as here proposed are taken to control the current flow. Thus, if a direct connection is made between the anode rod **29** and the tank, instead of making the connection through the interposed electrical resistor **39**, the flow of current would vary only with the internal resistance of the water solution. It should be kept in mind, of course, that the internal resistance of the water is the total resistance of the water path between the anode and the tank. Since it is practically impossible to so arrange the anode, at least when in the form of a rod, so that it will be uniformly spaced from all side and end surfaces of the tank, even though arranged in axial position in a cylindrical tank as in Fig. 1, the internal resistance, and consequently the amount of the protective current flow, will vary between the anode and the different areas of the tank surface. Since it is important that at least the minimum current necessary for protection should flow to all surface areas of the tank, the internal resistance of the water is considered to be the maximum internal resistance of the longest water path between the anode and the tank.

It has been found that an extremely small galvanic current flow in the circuit, plus a relatively high potential difference between the anodic rod and the tank, provide the best conditions for uniform protection of all areas of the tank and prolong the useful life of the anodic rod. The resistor elements **39** serve to obtain these conditions by providing an appreciable resistance in the external portion of the galvanic circuit in addition to the internal resistance of the water electrolyte. The value of the resistor

should be 5 ohms, or better, 10 ohms, as a practical minimum, and normally will be considerably higher as hereafter explained.

The reason that the present protective means is more effective and reliable than a zinc coating on the interior tank wall can be readily understood. Extended tests on my part have shown that this zinc may contain small quantities of impurities such as tin, copper, aluminum, carbon or sulphur, either any one of these impurities or a plurality of such impurities. These minute particles of impurities may be found in the zinc coating at separated spots. In case the zinc coating contains any one or all of the above mentioned impurities and if these are located at or near the perforations in the zinc coating, the iron may be attacked because of electrolytic action between the impurities and the iron will be corroded or dissociated, and the same comment may be made as to similar conditions of dissociation of the iron occurring in case the iron itself contains impurities usually found mixed therewith.

There is always the further danger in a coated tank that the protective zinc coating is not perfect and contains perforations in the form of minute openings as the result of any one or several operating difficulties and conditions experienced in the zinc coating of the inside of a closed ferrous metal water tank. Where the coating is defective the zinc surrounding the perforation will go into solution, since it is anodic to iron, that is, zinc ions will pass into solution and flow to the exposed iron, thereby preventing the iron ions from going into solution. This causes dissociation of the zinc with attendant increase in the size of the opening in the zinc. As long as the distance from the iron to the edge of the protecting zinc is small, the zinc will protect the iron uncovered by the perforation and no corrosion of the iron will occur, but when the zinc has been eaten back a little further, the current flow is from the zinc to the nearby area of the iron, and the more distant uncovered areas of the iron are no longer protected and corrosion begins at the unprotected part. The galvanic couple comprising the zinc and the iron being so connected cannot set up an appreciable electromotive force, so that the iron is protected only closely adjacent to the edge of the zinc coating.

The use of a zinc lining on the tank as the sole corrosion preventing means for the ferrous tank metal is subject to the objections previously mentioned. When employed in conjunction with the magnesium sacrificial anode not only does the zinc coating not adversely affect the tank protectioning function of the anode and function itself for the same purpose but the coating and anode each improve the functioning of the other. Magnesium is anodic to zinc as well as to iron so that the current flow from the anode protects the zinc lining against corrosion, in the absence of which the tank metal will be preserved against contact with the water in the tank. Further, the presence of the zinc coating will prolong the life expectancy of the anode since the potential difference between magnesium and zinc is less than between magnesium and iron so that the protective current flow will be somewhat less and the anode will be consumed more slowly.

It is desirable that hot water tanks should have many years of useful life without corrosion. It is similarly desirable that the anodic protective rod here employed to prevent corrosion should itself have as long and useful life as possible and not

require replacement in six months or a year or two. The operating life of the anode protection of the tank can be prolonged through the addition of one or more resistor elements as previously explained. Furthermore, the anode life and resistor value are interrelated and vary directly with one another. The resistor value required to provide a selected minimum life for a particular anode can, at least approximately, be readily predetermined, and conversely, it can be determined what the minimum life of anode will be when using a resistor of a particularly selected value.

The life of the anode and the value of the external resistance depend on a number of factors. The higher the total current flow from the anode, both protective current flow to the tank and the local flow under battery action between different areas of the anode, the more rapidly will the anode go into solution and the shorter its life. Hence, it is desirable to use as high a value external resistor as practical to ensure not less than the minimum protective current flow to the tank necessary for complete protection against corrosion. The effect of battery action is quite appreciable and causes the anode to be consumed in less than half the life expectancy of the anode if determined theoretically only on the basis of the current flow to the tank. While the shortening of the life of the anode by battery action is not definitely known, it is here assumed, to be on the safe side, that battery action reduces the life of the anode by 65% or, to state the matter conversely, that the anode will be consumed in 35% of its theoretical life expectancy.

The protective current is determined by five factors. One is the potential difference between the anode and iron and for magnesium this is taken as 1.43 volts. Another factor is the specific conductance of the water which will vary considerably with waters of different hardness and softness. The protective current will further be determined by the internal resistance of the water path between the anode and the surface of the tank, and this in turn depends upon the specific conductance of the water and the difference in dimensions of the tank and the anode and upon the temperature. The resistance of solutions of electrolytes declines at about the rate of 1% for 1° F increase in temperature. The other factor is the value of the external resistor which is in series with the internal resistance of the tank, and the sum of which is the total resistance. The adverse effect of polarization of the magnesium anode is ignored because it would be substantially negligible as long as the pH is below 12.5, which would be true for any known domestic water supply.

The unit consumption rate of the anode metal in grams per ampere hour being expressable both in terms of weight and time

$$\frac{W}{T}$$

and in terms of current and anode metal electrochemical equivalent

$$\frac{E}{R}\cdot Eq.$$

the formula derived from the resulting equation for approximately determining resistance and time, one from the other, is as follows:

$$(R_1R_2)=\frac{E\cdot Eq}{W}\cdot T \text{ or } T=\frac{W}{E\cdot Eq}\cdot(R_1R_2)$$

where:

R_1=value of the internal water resistance

R_2=value of resistance in ohms of the resistor

E=the potential difference in volts between the anodic metal and tank metal (1.43)

Eq=electrochemical equivalent of magnesium in grams per ampere hour (.447)

T=years of anode life, expressed in hours (8760 hours per year)

W=weight of anode in grams, or in pounds times 453.59.

The value of the internal resistance R_1 for any given operating temperature can be determined approximately for any given water from the tank and anode dimensions and the specific conductance of the water for average tank. Assuming a tank 39'' long and 15.75 inside diameter and a co-axial magnesium anodic rod 1.575'' in diameter, the internal resistance of the tank will run roughly from 112 ohms to 2 ohms at 65° F. for waters varying in hardness from 20 p. p. m. to 1000 p. p. m. and varying in specific conductance between 0.33×10^{-4} to 16.5×10^{-4}. If the temperature is 167° F. the internal resistance will be 37% of its value at 65° F.

In the formula above, T represents the theoretical life expectancy of the magnesium anode in the absence of battery action. Since over 50% of the consumption of the anode is due to local battery action the value found for T must be reduced by at least that amount. To ensure against over-calculation, it is best to assume that the actual life expectancy of the anode is about 35% of T.

The value of the external resistance R_2 may be as low as 5 ohms, or preferably 10 ohms as a practical minimum, but unless the water resistance R_1 is relatively high, the rate of consumption at such value would be far greater than necessary to ensure minimum protective current. I normally prefer to employ a resistor having a value ranging from 100 to 200 ohms, say one of 150 ohms, for general usage as this range is sufficient to ensure adequate potential difference and relatively long tank protection without replacement of the anode, and at the same time provides a substantial margin of safety to ensure an adequate current flow for complete tank protection, under widely different conditions of water resistance and taking into account the average temperature of the water over a yearly period. While the effective water resistance increases with tank size, because of greater distance between the anode and tank wall, as well as with the purity of the water so that a given anode employed with a resistor of predetermined value will have a longer life the larger the tank, the difference in diameter of the more commonly used sizes of tanks for domestic water, at least those used in the household, is not sufficiently great to materially change the water resistance. Thus it is possible to employ a standardized resistor in the range above noted for the usual domestic hot water tank of 50 gallons and larger tanks up to a capacity of at least 150 gallons or 200 gallons. In the case of extremely small tanks it would be desirable to increase the resistance value, and in the case of abnormally large tanks to use a lower resistance value in order to obtain a similar predetermined operating life for the anode. In hot water tanks under average conditions a magnesium anode of two pounds, or thereabouts, will have an actual life expectancy as high as 15 years or more. Even where such

an anode is used in the absence of an external resistor it may have a useful life of several years or more under favorable water conditions.

Where the tank is provided with a protective zinc lining such lining is cathodic relative to the magnesium anode while being anodic relative to the ferrous tank metal and in the absence of perforations in the lining the flow of current between the anode and coating will be somewhat less, with a Mg-Zn potential difference of 1.11, than between the anode and an uncoated ferrous tank wall with a Mg-Fe potential difference of 1.43. Accordingly, in the preceding formula E may be taken as the potential difference, 1.11, between the anode and zinc coating instead of between the anode and iron wall for a zinc lined tank.

For reasons of initial and replacement cost it is undesirable to employ protective anodes of substantial diameter, although the thicker the anode the greater the amount of material available therein for consumption, and the longer its useful life. I ordinarily employ an anode of between one-half inch and two inches in diameter, most commonly one of three-quarters of an inch. To insure full protection of the bottom of the tank the length of the anode should be such that the distance between the lower end of the anode and tank bottom is no greater than the radial distance between the anode and the tank. The length will be determined by the length of the tank. It will be apparent for reasons already explained that by using a current reducing resistor in conjunction with the anode a small size anode will have an operating life as long, or even longer, than an anode of greater size connected to the tank in the absence of a resistor under equivalent conditions. In other words, the resistor controls both the size and life of the anode.

Referring now to Figs. 5 and 7 of the drawings, I have there illustrated a modification embodying my invention which includes a somewhat different form of anodic element suspended in a cylindrical tank at its top end only.

The cover of the tank 11 is provided with a tubular bushing 51, the upper end of which is adapted to have screw threaded engagement in an opening in the cover of the tank 11 and which upper end is adapted to receive a nut 53 having an opening into which a hot water outlet pipe 55 may be screwed. The lower end portion of bushing 51 is provided with a flat internal shoulder 57, and the lower end of the bushing may receive a tubular spacer 59 of electric-insulating material. A flat washer 61, of electric-insulating material, is adapted to rest upon the shoulder 57 and the upper end 63 of a short anodic rod 65 of magnesium is adapted to fit in the elongated washer or bushing 59 in a fluid-tight manner and to be held therein by a nut 67, in the manner shown more particularly in Fig. 7 of the drawings.

I provide a resistor member 69 of any desired type, such as a small wire of suitable resistor material, one end of which may be held by a short machine screw 71 against the upper end of portion 63, while the other end of the resistor may be electrically connected with the bushing 51 by any suitable means such as soldering or brazing. The bushing 51 is provided with a plurality of laterally-extending openings 73 therein to permit of the outflow of hot water into and through outlet pipe 55.

I may use in connection with the upper end member 65, a plurality of pivotally connected portions 75 in the shape of magnesium rods having tongue and slot connections with each other through a pin 77. As shown in the broken lines in Fig. 5 of the drawings, in case the tank is laid on its side during shipment or at any other time, the pivotally connected sections 75 will not be subjected to an undue strain caused by the unsupported end thereof, since at least some of these sections may rest upon the tank wall itself when the tank is in a horizontal position.

Referring now to Fig. 6 of the drawings, I have there illustrated a still further modification of a corrosion-preventing element in which a short pipe section 79 may be screwed into the cover of tank 19, the upper end of section 79 being screw threaded to receive a pipe fitting, while the lower end thereof may have an inner shoulder member 81 upon which a perforated metal bushing 83 is adapted to rest. The bushing 83 is provided with a central spherical seat 85 on which the upper enlarged spherical end 87 of a suspending and supporting rod 89 is adapted to rest. The lower end of rod 89 has screw threaded engagement with the upper end of an anodic rod 91 of magnesium.

It is evident that the rod 91 will swing on its spherical seat and thereby reduce the stress on the rod in case the tank is tilted from its normal vertical position during assembly, shipment or installation.

The device embodying my invention thus provides relatively simple, inexpensive, easily installed and highly effective means for its intended purpose to not only reduce but substantially entirely prevent dissociation and corrosion of the inner surface of a ferrous metal tank, irrespective of whether the inner surface of the tank is coated with zinc or not. It further provides an anodic rod which can be, but preferably is not connected directly to the tank, but through a resistor, which is electrically insulated from the changing water in the tank. The ohmic resistance of the resistor is relatively high, so that I obtain protection by metering the current flow. A resistor which has too high an ohmic resistant reduces the current flow to a value which will not fully protect the tank because too few anodic ions are flowing to prevent the iron ions from flowing.

The anodic rod or member may be secured by a mounting to the side wall of the tank, and may extend crosswise instead of lengthwise, if desired.

I wish to point out that while I have illustrated and described a particular form of hot water tank, which is most frequently used in domestic hot water installations, my invention is not limited thereto in its broader aspects. Should the shape of the tank, and particularly of its interior surface, be quite different from that shown in the drawings, my invention preferably, but not necessarily, contemplates the use of a corrosion-preventing anodic member of a shape symmetrical to that of the inside surface of the tank but of much smaller outer surface area.

While I have illustrated and described specific embodiments of my invention, I do not desire to be limited thereto, since all modifications coming clearly within the scope of the appended claims are to be considered as being covered thereby.

This application is a continuation of my copending application, Serial No. 568,360, filed December 15, 1944, (now abandoned), which in turn

is a continuation-in-part of my copending application, Serial No. 356,622, filed September 13, 1940 (now abandoned).

I claim as my invention:

1. The combination with a ferrous metal domestic hot water tank in which cold water supplied from any of the conventionally available water sources is recurrently input and heated, and from which hot water is withdrawn at recurrent times and in varying amount according to demand, of anti-corrosion means for protecting the tank interior against corrosion comprising an elongated sacrificial magnesium metal anode of substantially smaller cross-section than the tank located within the tank to be surrounded by the tank water and relatively distant from areas of the tank to be protected, and electrically conductive means connecting the anode to the tank and adapting the anode to supply a galvanic current flow to areas of the tank metal when exposed to contact with the tank water.

2. The combination with a ferrous metal domestic hot water tank in which cold water supplied from any of the conventionally available water sources is recurrently input and heated, and from which hot water is withdrawn at recurrent times and in varying amount according to demand, of anti-corrosion means for protecting the tank interior against corrosion comprising a zinc lining on the interior of the tank, an elongated sacrificial magnesium metal anode of substantially smaller cross-section than the tank located in the tank to be surrounded by the tank water and relatively distant from the tank interior, and electrically conductive means connecting the anode to the tank and adapting the anode to supply galvanic current flow to the zinc lining and to any areas of the tank metal exposed to contact with the tank water.

3. The combination with a ferrous metal domestic hot water tank in which cold water supplied from any of the conventionally available water sources is recurrently input and heated, and from which hot water is withdrawn at recurrent times and in varying amount according to demand, of anti-corrosion means for protecting the tank interior against corrosion comprising an elongated sacrificial magnesium metal anode of substantially smaller cross-section than the tank located within the tank to be surrounded by the tank water and relatively distant from areas of the tank to be protected, and electrically conductive means including an electrical resistor element connecting the anode to the tank and adapting the anode to supply a galvanic current flow to areas of the tank metal when exposed to contact with the tank water.

4. The combination of claim 3 wherein the electrical resistor element has a value within the range of 5 ohms to 200 ohms.

5. The combination of claim 3 wherein the electrical resistor element is located in the tank and further including a water impervious housing encasing and protecting said electrical resistor element against contact by tank water.

6. The combination with a ferrous metal domestic hot water tank in which cold water supplied from any of the conventionally available water sources is recurrently input and heated, and from which hot water is withdrawn at recurrent times and in varying amount according to demand, of anti-corrosion means for protecting the tank interior against corrosion comprising a zinc lining on the interior of the tank, an elongated sacrificial magnesium metal anode of substantially smaller cross-section than the tank located in the tank to be surrounded by the tank water and relatively distant from the tank interior, and electrically conductive means including an electrical resistor connecting the anode to the tank and adapting the anode to supply galvanic current flow to the zinc lining and to any areas of the tank metal exposed to contact with the tank water.

7. The combination of claim 6 wherein the electrical resistor element has a value within the range of 5 ohms to 200 ohms.

8. The combination with a ferrous metal domestic hot water tank in which cold water supplied from any of the conventionally available water sources of ranging composition as to corrosion action is recurrently input and heated, and from which hot water is withdrawn at recurrent times and in varying amount according to demand, said tank having a wall opening, of anti-corrosion means for protecting the tank interior against corrosion comprising a metal plug constituting a removable closure for said tank wall opening and having electrically conductive connection with the tank, an elongated sacrificial magnesium metal anode of substantially smaller cross-section than the tank and adapted to pass through said tank wall opening, said anode being insulated from the plug by an electrical insulator and supported by the plug within the tank to be surrounded by the tank water and relatively distant from areas of the tank to be protected, and an electrical resistor element supported by the plug and electrically interconnecting the anode and the plug and adapting the anode to supply a galvanic current flow to areas of the tank metal when exposed to contact with the tank water.

9. The combination with a ferrous metal domestic hot water tank in which cold water supplied from any of the conventionally available water sources is recurrently input and heated, and from which hot water is withdrawn at recurrent times and in varying amount according to demand, said tank having a wall opening, of anti-corrosion means for protecting the tank interior against corrosion comprising a plug constituting a removable closure for said tank wall opening and extending into the tank, an elongated sacrificial magnesium metal anode of substantially smaller cross-section than the tank, and adapted to pass through said tank wall opening, said anode being supported by the plug within the tank to be surrounded by the tank water and relatively distant from areas of the tank to be protected, said plug being formed of water impervious material and with a hollow interior closed to exposure to the tank water, and an electrical resistor element located in the hollow interior of the plug for protection against tank water through which the anode member is electrically connected to the tank and adapting the anode to supply a galvanic current flow to areas of the tank metal when exposed to contact with the tank water.

10. An anti-corrosion unit for protecting the interior of ferrous metal domestic hot water tanks in which cold water is supplied from any conventionally available water source is recurrently input and heated, and from which water is withdrawn at recurrent times and in varying amounts according to demand, said unit being adapted for tank installation as an assembly unit and comprising a closure and supporting plug adapted to be removably mounted in a wall opening of such a tank, an elongated sacrificial magnesium metal

anode of smaller cross-section than the plug supported at one end by the plug and adapted to be located within a tank to be surrounded by the tank water relatively distant from interior areas to be protected, electric insulating means insulating the anode from the plug and an electrical resistor element supported by the plug for electrically interconnecting the anode and a tank, said element having a resistance within a range of 5 ohms to 200 ohms.

11. An anti-corrosion unit for protecting the interior of upstanding cylindrical ferrous metal domestic hot water tanks in which cold water is supplied from any conventionally available water sources is recurrently input and heated, and from which water is withdrawn at recurrent times and in varying amounts according to demand, said unit comprising a metal closure and supporting plug adapted to be removably mounted in a top wall opening of such a tank, an elongated sacrificial magnesium metal anode of smaller cross-section than the plug supported at one end by the plug and adapted, when the plug is mounted in a tank, to be suspended vertically within such tank surrounded by tank water with the anode axis in parallel with the cylindrical tank wall, electric insulating means insulating the anode from the plug and an electrical resistor element supported by the plug electrically interconnecting the anode and the plug, said element having a resistance within the range of 5 ohms to 200 ohms.

12. In an anodically protected hot water heater system of the class wherein a metal hot water tank acts as a cathode and a metal anode is projected into the tank and electrically connected to the tank; the combination with the anode of a metal, water outlet fitting for supporting the anode and electrically connecting it with the tank, the fitting having an axial water passage therethrough, connecting means at the outer end of the fitting for connecting it with piping, external threads around the fitting inwardly of the connecting means, for supporting the fitting on the tank and electrically connecting the fitting and tank, the fitting having a lateral opening inwardly of the external threads, leading from the axial passage through the surface of the fitting, and means mounting the anode on the fitting, said means being below the lateral opening in the fitting and the parts of the assembly inwardly of the external threads on the fitting being no larger in overall diameter than the said threaded portion of the fitting whereby the assembly as a unit may be inserted through an opening in the end of the hot water tank and threadedly attached and electrically connected thereto.

13. An anti-corrosion unit for protecting the interior of ferrous metal domestic hot water tanks comprising a metal outlet pipe fitting and an elongated sacrificial magnesium metal anode electrically connected to and adapted to be supported by the fitting within a hot water tank, the fitting having an axial water passage leading from a first or outer end of the fitting inwardly and having a lateral water delivery opening connecting with the passage and leading through the side surface of the fitting and located inwardly of the outer end of the fitting, connecting means at the outer end of the fitting for connection of the fitting with piping, external threads around the fitting inwardly from said connecting means, for connection of the unit in a threaded wall opening of a hot water tank, attaching means connecting one end of the anode to the fitting, said attaching means being inwardly of the lateral opening in the fitting, means closing the axial passage below the lateral opening in the tubular member, and the parts of the unit inwardly of the external threads on the fitting being no larger in overall diameter than the said threaded portion of the fitting whereby the unit may be inserted through a threaded wall opening of a hot water tank, threadedly attached and electrically connected to the wall.

14. An anti-corrosion unit for protecting the interior of ferrous metal domestic hot water tanks comprising a metal outlet pipe fitting and an elongated sacrificial magnesium metal anode electrically connected to and adapted to be supported by the fitting within a hot water tank, the fitting having an axial water passage leading from a first or outer end of the fitting inwardly and having a lateral water delivery opening connecting with the passage and leading through the side surface of the fitting and located inwardly of the outer end of the fitting, connecting means at the outer end of the fitting for connection of the fitting with piping, external threads around the fitting inwardly from said connecting means, for connection of the unit in a threaded wall opening of a hot water tank, a partition across the fitting inwardly of the lateral opening, the inner end of the fitting having a socket extending thereinto, coaxial with the axial passage, the anode having an upper end located in the socket and means securing the anode tightly and rigidly in the socket, and the parts of the fitting and the anode inwardly of the external threads on the fitting being no larger than the said external threads whereby the said parts may be inserted through a threaded wall opening of a hot water tank, threadedly attached and electrically connected to the wall.

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