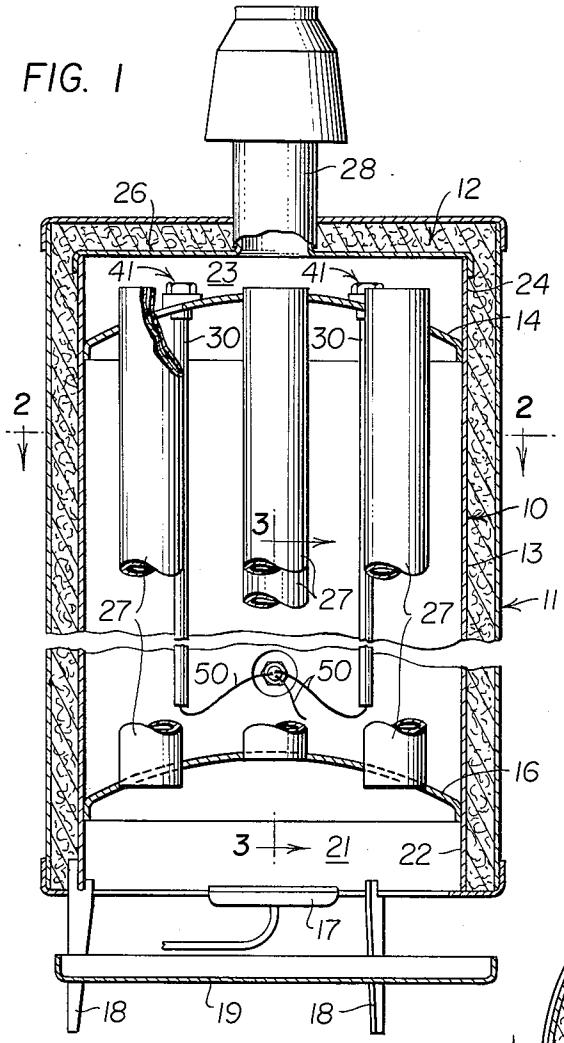
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INDICATOR SYSTEM FOR SACRIFICIAL ANODES

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FIG. 1



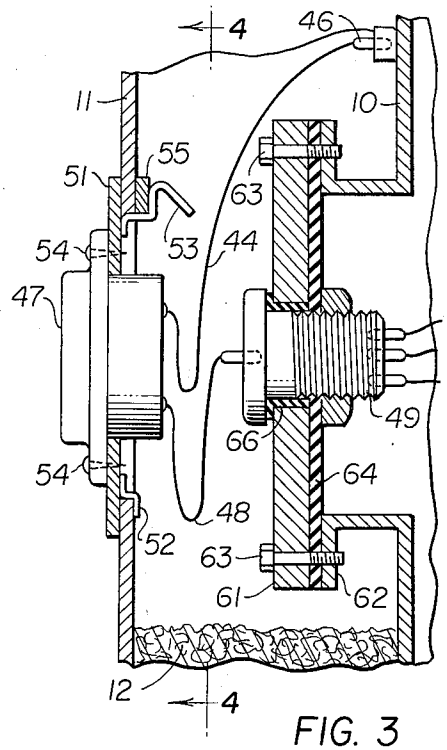


FIG. 3

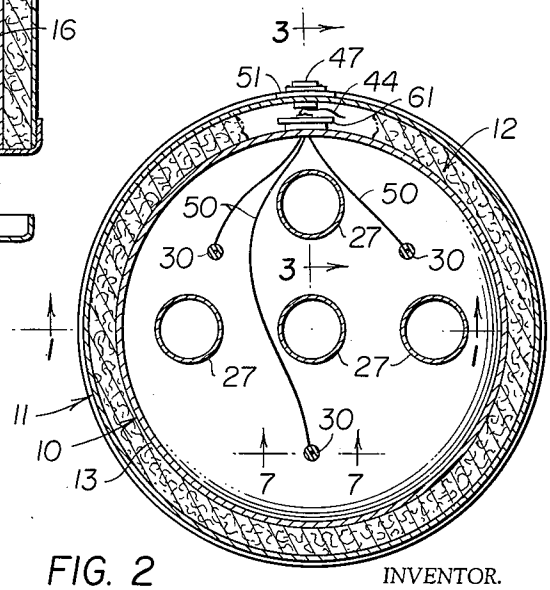


FIG. 2

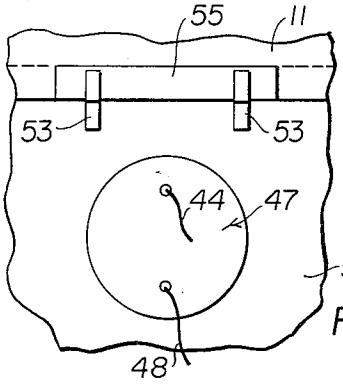


FIG. 4

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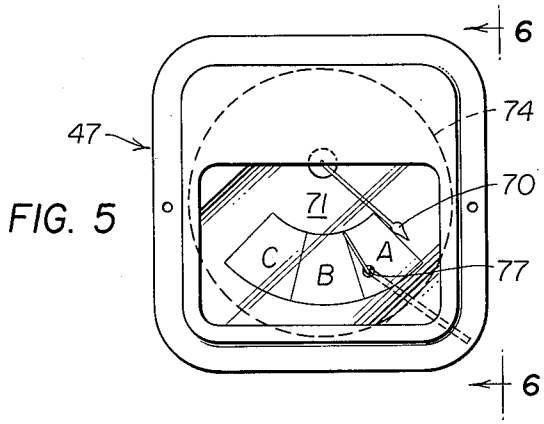


FIG. 5

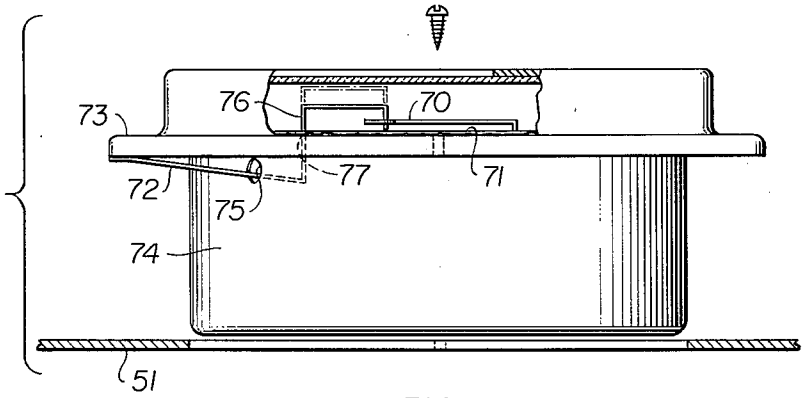


FIG. 6

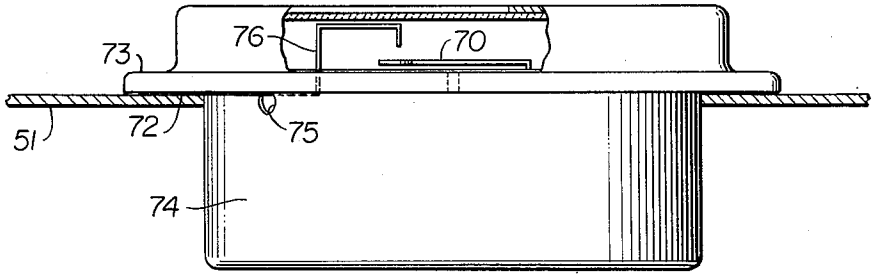


FIG. 7

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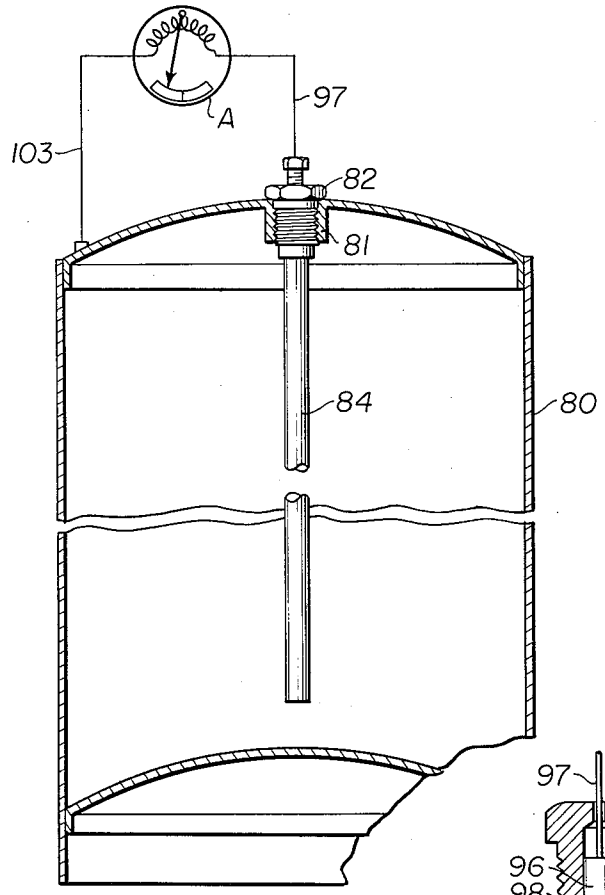


FIG. 9

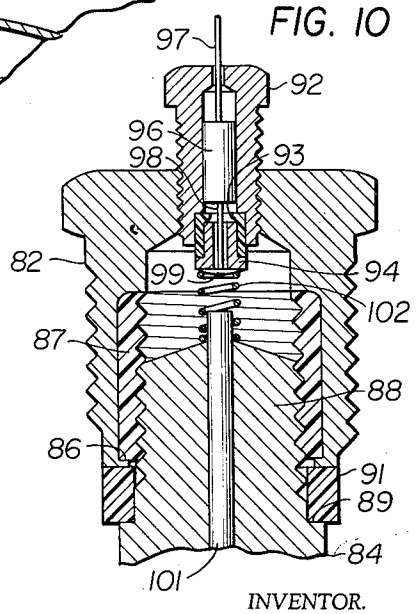


FIG. 10

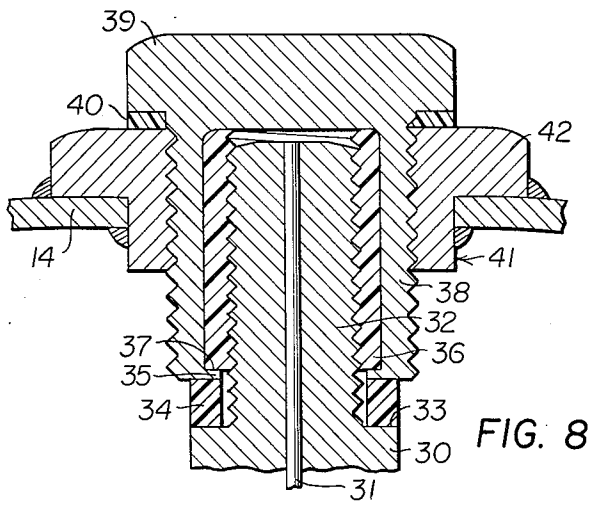


FIG. 8

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3,037,920
INDICATOR SYSTEM FOR SACRIFICIAL ANODES

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Filed May 26, 1958, Ser. No. 737,572
5 Claims. (Cl. 204—148)

This invention relates to hot water heater and storage tanks in which a so-called "sacrificial anode" is employed to protect the interior surfaces of the tank from corrosion by galvanic action between the anode and the tank. The invention is directed to methods and apparatus for controlling the galvanic action and for indicating the condition of the anode during its active life.

More particularly, the invention relates to new tank and anode assemblies including an indicator for visually showing the galvanic activity of an anode in the tank while the assembly is in use and, optionally, also including an additional electrical resistance element in the metallic portion of the electrical circuit for limiting the galvanic current flow, according to the conductivity of the water, to a current value no greater than that required to protect the tank from internal corrosion. The invention also relates to special ammeters and their use in connection with the tank and anode assemblies and to improve anode mounting structures particularly adapted for use where an ammeter is included in the metallic portion of the electrical circuit.

In accordance with common practice, galvanic protection of the interior metal surfaces of hot water heater and storage tanks may be accomplished by mounting inside the tank, a metal element that is anodic, i.e., more electropositive or less noble, relative to the interior metal surface of the tank, and that is termed an "anode" or "sacrificial anode." This anode is electrically connected to the tank by a metallic circuit of relatively low electrical resistance, conventionally by a direct metallic connector by which the anode is suspended in the tank. When the tank is full of water, the anode is also electrically connected to the interior surface of the tank through the water, which connection provides much greater resistance to the flow of electrical current therethrough than does the metallic circuit. Since the anode is electropositive relative to the interior metal surface of the tank, galvanic electrical current is induced which may be considered as flowing around a closed circuit from the anode, through the water to the interior surface of the tank, and through the low resistance metallic connection from the tank back to the anode. The anode is slowly consumed by this galvanic action, whereas the interior metal surface of the tank is protected from corrosion thereby, the consumed metal of the anode forming a reaction product with dissolved material in the water, which reaction product generally is quite insoluble and is largely deposited on the walls of the tank to which the galvanic current flows.

Because the tank is protected at the expense of the anode, the anode is commonly referred to as a "sacrificial anode," as noted above. When the anode is entirely consumed as described, galvanic protection of the tank ceases, and the anode must be replaced before this occurs if continuing protection of the tank is to be maintained. However, the anode is normally not visible, and its condition is normally determinable only by emptying the tank and removing the anode for inspection. This is troublesome and is often reglected, resulting in premature tank failures from internal corrosion.

Depending upon the electrical conductivity of the water in the tank, the galvanic current flowing through the anode-tank circuit may be greater than needed to provide adequate tank protection, or it may be less than needed for this purpose. If the galvanic current is greater than needed, the rate of anode consumption is excessive, and some convenient means for reducing the current induced by a given tank and anode assembly is desirable in order to prolong the life of the anode. If the galvanic current is less than needed, the only remedy is to alter the anode arrangement so as to increase the anode surface area, as by using an anode having a larger surface or by using more than one anode to achieve the same effect.

Since the character of water supplies throughout the country varies over a considerable range, there has long been a need for a convenient way in which to control, at least to a susbtantial degree, the galvanic currents induced by waters of different conductivity. This is required in some instances to maintain a high enough current for adequate tank protection, but is generally desired to prevent excessive current and rate of anode deterioration.

The use of a plurality of anodes has the advantage of enabling the anode surfaces to be better distributed as regards their spacing from welded joints and other critical portions of the tank interior where corrosion tends to be concentrated, since the current flowing to various points on the tank interior varies inversely with the length (resistance) of the water path from those critical points on the tank surface to the nearest anode surface. This consideration makes it desirable in some cases, particularly in large diameter tanks, to employ a plurality of anodes even though the resulting total galvanic current, and consequent rate of anode consumption, becomes much greater than necessary. This accentuates the need for a convenient way in which to control the total galvanic currents induced in a given apparatus by waters of varying conductivity.

Particularly in the case of large and expensive, industrial water tanks designed to last for many years, when suitably protected, the above considerations make it important not only to limit the galvanic current induced so as to secure maximum anode life, but also to facilitate determining when anodes in the tanks have been consumed to the point where they should be replaced. These problems have an important bearing on the ability of water tank manufacturers to guarantee the life of their product, since the life will depend upon the rate of anode deterioration and the diligence of the customer in promptly replacing consumed anodes. Also, the manufacturer normally has no way of knowing how long a customer's tank may have been neglected and retained in use after the anodes have been consumed to the point where protection of the tank is inadequate. Thus, tank life guarantees have generally been limited to a period of time not greatly exceeding the expected effective life of the anode or anodes contained in a tank at the time of its original installation.

The objects of the present invention are to provide improved tank and anode assemblies which either eliminate or, at least, reduce each of the problems discussed above. More specifically, the objects of the invention are: to provide convenient means for limiting the galvanic current so as to permit greater flexibility of tank-anode designs for obtaining maximum tank protection without an excessive rate of anode consumption; to provide simple and reliable means for indicating the condition of an anode or set of anodes in a tank while the tank is in use; and to provide means associated with the electrical circuit of a tank-anode assembly which will enable the tank manufacturer to determine whether or not his customer has permitted the tank to remain in use after the protective galvanic current (due to anode consumption) has dropped below a safe value, whereby the manufacturer may safely offer longer guarantees of tank life conditioned upon proper maintenance of anodes by his customers.

In accomplishing the foregoing objectives, greater tank life at minimum original cost may be assured, accidental neglect causing premature tank failures may be more easily avoided, and neglect as a cause of premature tank failures may be more readily detected.

These objects and advantages of the invention are accomplished in accordance with the invention by providing a resistor element in the galvanic circuit having an electrical resistance selected to maintain the proper galvanic current, the resistor element preferably being interchangeable with similar elements of different resistance values; by providing an ammeter in the galvanic circuit which will continuously indicate the magnitude of the galvanic current and thereby show when replacement of anodes is required; and by providing a special ammeter for the above purpose which, once the galvanic current has dropped below a safe minimum on which a tank life guarantee may be based, will provide the manufacturer with knowledge of this fact and of the fact that the customer's own neglect has voided the guarantee.

The foregoing objects, advantages, and features of the invention and presently preferred embodiments thereof will be more fully understood from the following detailed description of such embodiments of the invention, and from the accompanying drawings in which:

FIGURE 1 is a vertical sectional view of a multiple anode water heater and storage tank assembly embodying the present invention, the section being taken as indicated by the line **1—1** in FIG. 2;

FIG. 2 is a horizontal sectional view of the assembly of FIG. 1, the section being taken as indicated by the line **2—2** in FIG. 1;

FIG. 3 is a fragmentary, vertical sectional view of the assembly of FIG. 1, on an enlarged scale, the section being taken as indicated by the line **3—3** in FIG. 2;

FIG. 4 is a fragmentary elevation on an enlarged scale of the assembly of FIG. 1 taken as indicated by the line **4—4** in FIG. 3.

FIG. 5 is an enlarged, front, elevational view of an ammeter that is mounted in the assembly of FIGS. 1–3.

FIG. 6 is a side view of the ammeter of FIG. 4, taken as indicated by the line **6—6** of FIG. 5 (but rotated 90° for convenience), with a portion of the ammeter case broken away to show certain interior structure, the mounting panel for the ammeter also being shown in section in a position to receive the ammeter and being shown in phantom outline with the ammeter in position to be screwed to the panel, one of a pair of mounting screws for this purpose also being shown.

FIG. 7 is a view similar to FIG. 6, but with the ammeter moved into its mounted position in the aperture of the mounting panel.

FIG. 8 is a fragmentary, vertical sectional view, on an enlarged scale, of the structure for mounting of the upper end of an anode on the top wall of the tank in the assembly of FIGS. 1–3, the plane of the section being taken as indicated by the line **8—8** in FIG. 2;

FIG. 9 is a vertical sectional view of a modified embodiment of the invention in which a single anode is mounted in a water heater tank, the tank jacket and heating mechanism being omitted for simplicity; and

FIG. 10 is an enlarged fragmentary view, in vertical section, of the anode mounting structure of FIG. 9.

Referring to FIGS. 1, 2, and 3, a conventionally shaped water heater storage tank **10** is shown enclosed in an outer shell **11** with a layer of insulation **12**, of rock wool or the like, therebetween around the side wall **13** and the top wall **14** of the tank. Water inlet and outlet connections have been omitted from the drawings for simplicity.

Below a bottom wall **16** of the tank, a gas burner **17** is mounted in any desired manner. The tank **10** may be supported on three legs **18** (only two being shown) between which a drip tray **19** may be mounted. A combustion zone **21** above the burner **17** is surrounded by a lower extension **22** of the tank side wall to which the legs **18** are secured.

A collection zone **23** for combustion products is surrounded by an upper extension **24** of the tank side wall. The top wall **14** of the tank forms the bottom of the collection zone, and an apertured plate **26** forms the top wall of the collection zone. Hot, gaseous, combustion products from the burner **17** pass from the combustion zone **21**, upwardly through four header conduits **27**, and into the collection zone **23**, from where they pass out of the apparatus through a flue pipe **28** communicating with the central aperture of the plate **26**.

Inside the tank **10** are mounted three sacrificial anodes **30** of identical design. Each anode **30** is preferably a rod of magnesium alloy for use in a lined or unlined tank **10** of steel, galvanized steel, aluminum, or other metal or alloy to which the magnesium alloy is anodic. Referring to FIG. 8, as well as to FIG. 1, each magnesium anode **30** is preferably formed around a core wire **31** which extends from top to bottom through the magnesium alloy rod in surface-to-surface electrical contact therewith.

The core wire should be of a metal that is more noble than the metal of the anode. It may suitably be steel or aluminum, for example.

The upper end **32** of each anode is of reduced diameter and is externally threaded, leaving an annular shoulder **33** for engagement by an annular washer **34** of electrically insulating material surrounding the upper end **32** of the anode. The threaded upper end **32** of the anode is screwed into an internally threaded insulating sleeve **36** molded and retained by a flange **37** in the bore of a fitting **38** having an enlarged head **39** shaped to be turned by a wrench. The thickness of the sleeve **36** is sufficient to leave a substantial clearance space **35** between the flange **37** and the anode.

The cap **38** is screwed onto the anode until the flange **36** thereof engages and compresses the washer **34** to provide a watertight seal and thereby support the anode insulated therefrom by the washer **34**, air space **35**, and sleeve **36**. The cap **38**, which may be provided with a sealing washer **40**, if desired, is externally threaded and screwed into an internally threaded ring **41** projecting snugly through an aperture in the top wall **14** of the tank and having an outer flange **42** engaging the top wall of the tank about the aperture therethrough. A watertight joint between the ring **41** and the top wall of the tank is provided by an external and an internal peripheral weld as indicated in FIG. 8.

As will be apparent, the cap **38**, with an anode **30** threaded therein, may be mounted as described and removed for replacement of the anode when needed. Also, the anode may thus be suspended by its upper end from the top wall **14** of the tank while being electrically insulated therefrom. Each anode **30** is mounted as described.

Electrical contact between the anodes **30** and the tank **10**, of course, is maintained by the water in the tank, which constitutes an electrolyte normally having a relatively high resistance. The galvanic current flowing from the anodes to the tank through the water in the tank is carried by a low resistance conductor **44** (FIG. 3) connecting a tank contact **46** to one terminal of an ammeter **47** mounted externally of the tank **10**. The current flowing through the ammeter **47** is then carried by a second low resistance conductor **48** from a second terminal of the ammeter to a low resistance connector plug **49** (suitably made of brass and insulated from the tank **10** as hereinafter described), and thence through the plug **49** to the inside of the tank, at which point the current is divided betwen three parallel, low resistance conductors **50** that respectively connect the plug **49** to the core wire **31** at the lower ends of the three anodes **30**. Thus, a closed metallic circuit is provided for the galvanic current from the anodes **30** through the water in the tank to the tank itself, from the tank through the ammeter **47**,

and back to the anodes through the plug 49. As a result, the ammeter 47 constantly registers the total galvanic current from the three anodes 30 to the tank 10.

The conductor 44 from the tank 10 to the ammeter 47 may be permanently soldered at one end to its ammeter terminal and be soldered at its opposite end to a push-in connector or the like adapted to be removably snapped into a socket in the tank contact. The conductor 48 from the ammeter may be permanently soldered at one end to its ammeter terminal and be soldered at its opposite end to a push-in connector or the like adapted to be removably snapped into the plug 49. The three conductors 50 from the plug 49 to the anodes 30 may be permanently soldered to the lower ends of the three anodes, respectively. The opposite ends of these conductors may have push-in connectors or the like soldered thereto and adapted to be removably snapped into sockets in the inner end of the plug 49.

Access to the interior of the shell 11 and to the interior of the tank 10, for purposes of initial assembly of the electrical circuit and for service incident to the replacement of anodes, may be provided through access openings that are normally closed by a shell closure plate 51 and a tank closure plate 61. The shell closure plate 51 is preferably also used as a mounting panel for the ammeter 47 and may be secured in place by a plurality of rigid hooks and spring clips. The rigid hooks may include two or more S shaped members 52 (only one being shown) distributed along and welded to the inner surface of the closure plate 51 and hooked over the lower edge of the opening in the shell 11. The spring clips preferably include two clips 53 spaced apart a few inches along, and welded to, the inner surface of the closure plate 51, as shown in FIG. 4. The clips 53 may be of a cam actuated type which will be cammed downwardly when pressed inwardly against the upper edge of the opening in the shell 11, and which will then snap back to lock the closure plate firmly in place, as shown in FIG. 3, so as to resist prying this closure plate off from the outside. To remove this closure plate, it will then be necessary first to remove the ammeter 47 by removing its mounting screws 54, the purpose of this being explained hereinafter. Then one may reach through the opening in the closure plate 51 and forcibly pull the clips 53 downwardly against their spring action, while also pulling outwardly on the upper portion of the closure plate 51, to tilt the plate outwardly until the clips 53 are disengaged. Thereupon the closure plate can be lifted upwardly and outwardly to disengage the hooks 52 and free the closure plate for removal. A thickening and stiffening bar 55 may be welded along the upper edge of the access opening in the shell 11 if desired.

The tank closure plate 61 may be removably mounted on a flange 62 about the tank access opening by a suitable number of bolts 63 (two being shown), with an electrically insulating gasket plate 64 disposed between the closure plate and the mounting flange and covering the inner surface of the closure plate.

The plug 49 is mounted in the tank closure plate 61 and is electrically insulated therefrom. As shown in FIG. 3, an opening through this closure plate may be lined with an electrically insulating gasket sleeve 66. If desired, the gaskets 64 and 66 may be integral and be molded onto the closure plate. The plug 49 may be externally threaded and have an outer head adapted to overlie and seal against an outer flange on the gasket sleeve 66, and it may be secured in place by an internal nut overlying and sealing against the gasket plate 64. In this manner water leakage around the plug 49 may be reliably prevented while also electrically insulating the plug 49 from the closure plate 61 and from the tank 10. Also, initial assembly and disassembly for servicing may readily be accomplished in an obvious manner.

In order to limit the galvanic current to a suitable value for adequate tank protection, it may be desirable to increase the resistance of the metallic conductor portion of the closed galvanic current circuit. This may readily be done by using an ammeter having a high enough internal resistance for this purpose. Alternatively, additional resistance may be inserted at any desired point in this part of the circuit in series with the ammeter.

The ammeter 47, for the purposes of the present invention, preferably has a non-linear response to variations in current where a needle type indicator is used. For example, the lower third of the scale (designated A in FIG. 5) may cover the range from 0 to only 20 milliamperes and the upper two-thirds of the scale (divided into parts designated B and C in FIG. 5) may cover the range from 20 to 120 milliamperes. For a tank and anode arrangement of the type illustrated in FIGS. 1–3, having, for example, about 55 square feet of exposed galvanized steel tank surface, the maximum galvanic current may be limited by the resistance of the circuit to about 110 milliamperes (corresponding to about 2.0 milliamperes per square foot of tank surface), and the desirable minimum current may be about 55 milliamperes (corresponding to about 1 ma./sq. ft. of tank surface). This range may be that represented by the segment C of the scale in FIG. 5 and be the desired operating range. The segment B may cover a range down to about 20 milliamperes (corresponding to about 0.4 ma./sq. ft. of tank surface) representing a danger point below which the current must not be permitted to drop. It is contemplated that this may be made a condition in the manufacturer's warranty. The range represented by the segment A of the scale in FIG. 5 will then drop from 20 milliamperes to zero.

Accordingly, an ammeter reading dropping into the range of zone A is an occurrence which the manufacturer will wish to be informed of so that he will know that he has been relieved of responsibility under his warranty by the neglect of the customer. To this end, the ammeter 47 is provided with means for blocking movement of an indicator needle 70 in either direction past the division line between segments A and B of the scale on the ammeter dial or face 71 when the ammeter has been demounted from its mounting panel. This means may comprise an elongated leaf spring 72 having one end welded or otherwise secured against the back side of a mounting flange 73 of the ammeter case, as best shown in FIG. 6. As shown, the spring is normally biased to extend at an angle away from the back side of the flange 73 on which it is mounted, and to extend inwardly into the ammeter case 74 through an aperture 75. The opposite end of the spring 72 may have a small diameter wire 76 soldered thereto and extending transversely therefrom through a small aperture 77 in the ammeter dial or face 71. The wire 76 may project in a straight line through the ammeter dial 71 and beyond the plane in which the needle 70 swings; then be bent approximately through a right angle so as to extend generally parallel to the dial 71 to a point directly opposite the division line on the dial between segments A and B of the ammeter scale; and then be bent again approximately through a right angle to provide a free end portion extending toward the dial and into the path of the needle 70 at the division line between scale segments A and B.

As will be apparent from the foregoing, the free end portion of the wire 76, when the ammeter is demounted, will provide an obstruction to movement of the needle 70 in either direction past the division line between scale segments A and B. However, when the ammeter is mounted on its mounting panel 51, as shown in FIG. 7, the panel engages the leaf spring 72, depresses it against the flange 73 of the ammeter case, and moves the wire 76 to shift its free end portion out of the path of the needle 70. When the ammeter is demounted again, the wire 76 will again move into the path of the needle 70. Thus, the needle obstructing mechanism just described will hold the needle 70 on either the high or low side of the division line between scale segments A and B when

the ammeter is demounted, according to where the needle was at the time of demounting.

The method of utilizing the described needle-blocking mechanism is as follows: The customer using the water heater and storage tank may be instructed that anodes must be replaced when the needle **70** of the ammeter has moved from scale zone C into scale zone B and before it reaches scale zone A on the ammeter dial. The instructions for replacing anodes may specify that the first step in replacing anodes after draining the tank **10** is to demount the ammeter **47** while it is still electrically connected in the anode circuit. This releases the leaf spring **72** and traps the needle on the high or low side of the division line between scale segments A and B. The instructions may specify, as the next steps, that the conductors **44** and **48** be disconnected from the tank and from the plug **49** so as to free the ammeter for return to the manufacturer for inspection, the closure plate **61** be removed, the anode wires **50** be disconnected from the plug **49**, and the anodes **30** be removed from the tank for replacement. The manufacturer's warranty of the tank **10** may be conditioned upon timely replacement of anodes and upon compliance with his service instructions.

By mounting the ammeter **47** on the shell closure plate **51** and locking the shell closure plate onto the shell as shown in the drawing and described above, the prescribed order of steps can be reasonably assured. The ammeter must be removed before the closure plate **51** can be removed or anything done to break the anode circuit, thus trapping the ammeter needle and showing whether or not the galvanic current had first dropped below the critical danger point. By also requiring return of the ammeter as a condition to the purchase of replacement anodes, the manufacturer can be reasonably sure that he receives a correct indication of whether or not the customer broke a condition of the manufacturer's warranty by delaying too long before replacing the old anodes. With this protection, the tank manufacturer may advantageously guarantee a longer life for his tanks and educate his customers to use care in the maintenance of the tanks, with consequent advantages to both.

FIGS. 9 and 10 illustrate a modified embodiment of the invention which is particularly suitable for relatively small tanks in which a single anode provides sufficient tank protection. For simplicity, no outer tank shell or burner, etc., have been shown, and the connection of an ammeter A into the anode circuit has been shown somewhat diagrammatically. It is to be understood, however, that the ammeter should be suitably mounted and connected as a part of the complete assembly, as in FIGS. 1–3, by utilizing any suitable ammeter mounting structure.

Preferably, the ammeter A is provided with a mechanism for holding or blocking the ammeter indicator, such as that illustrated in FIGS. 5–7, for holding the indicator on one side or the other of a scale point separating a safe current range from an unsafe one. The principal purpose of FIGS. 9 and 10 is to illustrate a modified construction for supporting an anode and connecting it electrically to the ammeter without running conductor wires inside the tank.

As shown in FIGS. 9 and 10, a tank **80** may have an inwardly directed flange **81** about an opening through the top wall thereof, and an anode-supporting fitting **82** may be removably threaded into the flange **81** with an anode **84** depending from the fitting. The connection between the anode **84** and fitting **82** is shown in vertical section in FIG. 10.

Referring to FIG. 10, the fitting **82** may have a longitudinal bore of large diameter over its lower portion with an inwardly directed, annular, sleeve-retaining flange **86** about the lower end of this bore. An electrically insulating and sealing sleeve **87** is formed in this bore, as by molding it therein, the sleeve being substantially thicker than the retaining flange **86** and being internally threaded. A reduced diameter upper end portion **88** of the anode **84** is externally threaded and provides a shoulder **89** for seating an electrically insulating and sealing washer **91**. The upper end portion **88** of the anode is screwed into the sleeve **87** so as to be supported thereby in physically spaced relationship with the fitting **82**, while compressing the washer **91** between the shoulder **89** of the anode and the sleeve-retaining flange **86** of the fitting. Thus, the anode is insulated from the fitting **82** and from the tank **80** and leakage around the anode is prevented by two electrically insulating seals made by the sleeve **87** and the washer **91**.

The upper portion of the fitting **82** may have a bore of smaller diameter therethrough and be internally threaded to receive a plug **92**. The lower end portion of the plug **92** may have a hollow bore lined with an elastic insulating sleeve **93**. A metal sleeve **94** is forced into the elastic sleeve **93** to compress it radially and hold both of the sleeves **93** and **94** in place in the plug **92**. The central portion of the plug **92** may have a hollow bore of slightly reduced diameter for receiving a resistor **96** of appropriate electrical resistance. The upper end portion of the plug **92** may have a still smaller bore therethrough for an insulated electrical conductor **97** that is connected to one terminal of the resistor **96** and passes out of the upper end of the plug **92**. The opposite end of the resistor **96** is connected to an electrical conductor **98** that projects through and slightly beyond the lower end of the metal sleeve **94** and is soldered thereto by a button of solder **99** constituting a second terminal for the resistor that is electrically insulated from the plug **92** by the insulating sleeve **93**.

In this case, a core wire **101** in the anode **84** preferably projects upwardly a short distance beyond the upper end of the anode for positioning a helical spring **102**, of low electrical resistance, in spaced relationship with the inner walls of the metal fitting **82**. After the anode is threaded into the lower end of the fitting **82**, the spring **102** is dropped into place through the upper end of the fitting, and the plug **92** is then threaded into the upper end thereof to compress the spring between the end of the anode and the solder button **99**.

The resistor **96** is preassembled in the plug **92** by inserting it into the lower end of the plug with its conductors **97** and **98** attached, and then inserting the insulating sleeve **93** and metal sleeve **94**. Thereupon the solder button **99** is applied to complete this preassembled unit. If desired, the upper end of this assembly may be closed about the conductor **97** by filling the cavity in the plug **92** above the resistor **96** with a sealing wax or the like (not shown). Such preassembled units may be made and stocked with different resistors mounted therein, units having the proper resistance being selected for installation to limit the maximum galvanic current as required by waters of different electrical conductivity. Where the resistance of the ammeter A is high enough for this purpose, the resistance of the resistor **96** may desirably be virtually zero, and the resistor may function strictly as a conductor; or the resistor **96** and conductor **98** may be eliminated and the conductor **97** connected directly to the solder button **99**.

Thus, the insulated conductor **97** is connected through an easily replaceable resistor **96** to the anode **84**. By connecting the conductor **97** to one terminal of the ammeter A, and by connecting the other terminal of the ammeter through a conductor **103** to any suitable electrical contact on a wall of the tank **80**, a galvanic circuit is completed with the metallic connections of the ammeter to the tank and to the anode being entirely accessible from outside the tank and sealed from direct contact with the water in the tank.

As will be apparent, the anode mounting structure of FIGS. 9 and 10 may be used in multiple anode tanks, if desired, and is particularly useful in any installation where it is considered advantageous to dispense with an access

opening into the tank. Similarly, of course, the general arrangement of FIGS. 1–8 may be used for a single anode installation, as well as for a multiple anode installation utilizing any desired number of anodes.

From the foregoing description of illustrative embodiments of the present invention, it will be apparent that simple and effective means have been provided for achieving the various objects and advantages of the invention. It will also be apparent that many equivalents of the specific structures disclosed may be employed while utilizing the essential features and principles of the invention. Accordingly, the invention is intended to include all such equivalents.

Having described my invention. I claim:

1. A method of affording a continuous galvanic protection to the interior surfaces of a metal water storage tank during use of said tank comprising the steps of mounting within a metal water storage tank a sacrificial metal anode that is anodic with respect to the metal of the interior of said tank, mounting on said tank an ammeter having a current responsive indicator movable along a path of travel in proportion to the current passing through the ammeter over the current range to which the ammeter is responsive, electrically connecting said ammeter in series relation between said tank and said anode so that movement of said indicator along its path of travel will indicate the progressive stages of decomposition of said anode, providing said ammeter with stop means operative when said ammeter is demounted from said tank to hold said indicator against movement past a location along its path of travel corresponding to a predetermined minimum galvanic current, and demounting said ammeter from said tank to render said stop means operative before electrically disconnecting it for replacement of said anode.

2. A method of affording galvanic protection of the interior surfaces of a metal water storage tank during the use of said tank comprising the steps of mounting within a metal water storage tank a sacrificial metal anode that is anodic with respect to the metal of the interior of said tank, detachably mounting on the exterior of said tank an ammeter having an indicator movable along a path of travel in proportion to the current passing through the ammeter over the current range to which the ammeter is normally responsive, electrically connecting said ammeter in series relation between said tank and said anode so that movement of said indicator along its path of travel will indicate progressive stages of decomposition of said anode, blocking movement of said indicator in either direction past a predetermined location in its path of travel when demounting said ammeter from said tank, electrically disconnecting said ammeter, and replacing said anode.

3. In a water storage tank assembly comprising a metal water storage tank and a sacrificial metal anode within the tank that is anodic with respect to the metal of the interior of the tank, the combination therewith of: means mounting the anode on the wall of the tank, said mounting means including means electrically insulating the anode from the tank, an ammeter mounted on the exterior of the tank and including a current responsive indicator mounted for movement along a path of travel in proportion to the current passing through the ammeter over a current range to which the ammeter is normally responsive, conductors electrically connecting the ammeter in series between the tank and the anode, and means mounted on the ammeter and operative when the ammeter is demounted from the tank for restraining movement of said indicator past a point corresponding to a predetermined minimum galvanic current.

4. In a water storage tank assembly comprising a metal water storage tank and a sacrificial anode within the tank that is anodic with respect to the metal of the interior of the tank, the combination therewith of: means mounting the anode on a wall of the tank, said mounting means including means electrically insulating the anode from the tank, an ammeter mounted on the exterior of the tank and including a current responsive indicator mounted for movement along a path of travel in proportion to the current passing through the ammeter over the current range to which the ammeter is normally responsive, electrical conductors connecting the ammeter in series between the tank and the anode, and means mounted on the ammeter for movement into the path of travel of said indicator at a predetermined location in said path in response to demounting the ammeter from said tank for blocking movement of the indicator past said location in either direction.

5. In a water storage tank assembly comprising a metal water storage tank and a sacrificial metal anode within the tank that is anodic with respect to the metal of the interior of the tank, the combination therewith of: means mounting the anode on the wall of the tank, said mounting means including means electrically insulating the anode from the tank, an ammeter mounted on the exterior of the tank and including a current-responsive indicator mounted for movement along a path of travel in proportion to the current passing through the ammeter over the current range to which the ammeter is normally responsive, electrical conductors connecting the ammeter in series between the tank and the anode and stop means mounted on the ammeter for normally blocking movement of said indicator past a predetermined location along its path of travel in either direction, said stop means including means responsive to mounting engagement of said ammeter with said tank for rendering said stop means inoperative.

References Cited in the file of this patent

UNITED STATES PATENTS

2,150,836	Lamb	Mar. 14, 1939
2,308,687	Harrison	Jan. 19, 1943
2,486,871	Osterheld	Nov. 1, 1949
2,508,171	Kaufman	May 16, 1950
2,568,594	Robinson	Sept. 18, 1951
2,656,314	Osterheld	Oct. 20, 1953

FOREIGN PATENTS

412,322	Canada	May 4, 1943