April 14, 1959 B. DOUGLAS 2,882,213

GALVANIC ANODE

Original Filed Feb. 1, 1955 4 Sheets-Sheet 1

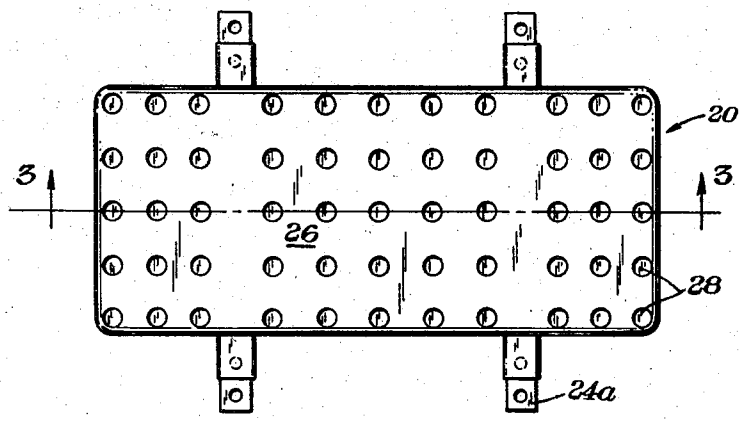


Fig. 1

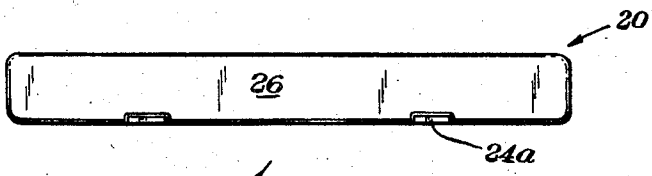


Fig. 2

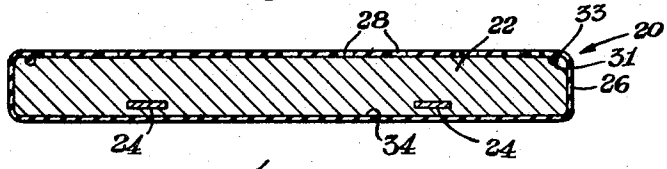


Fig. 3

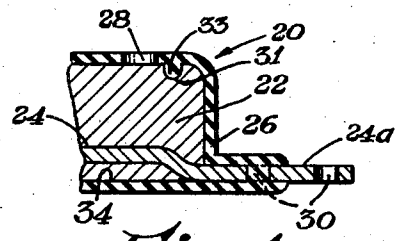


Fig. 4

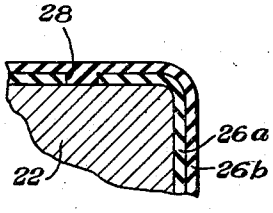


Fig. 15

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GALVANIC ANODE

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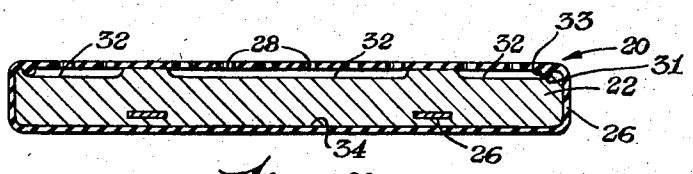


Fig. 5

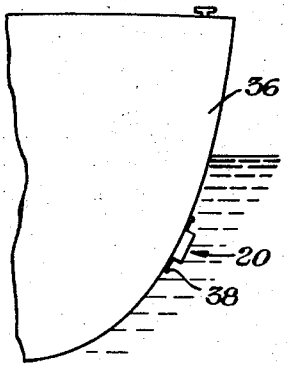


Fig. 6

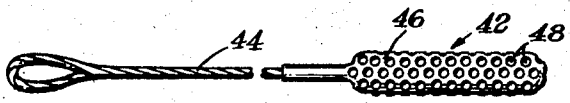


Fig. 7

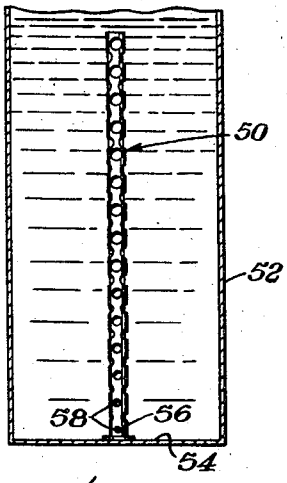


Fig. 8

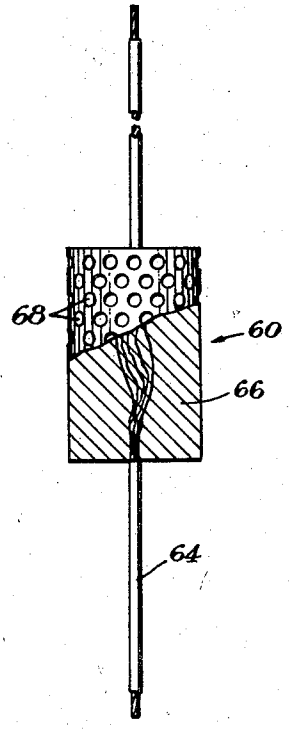


Fig. 9

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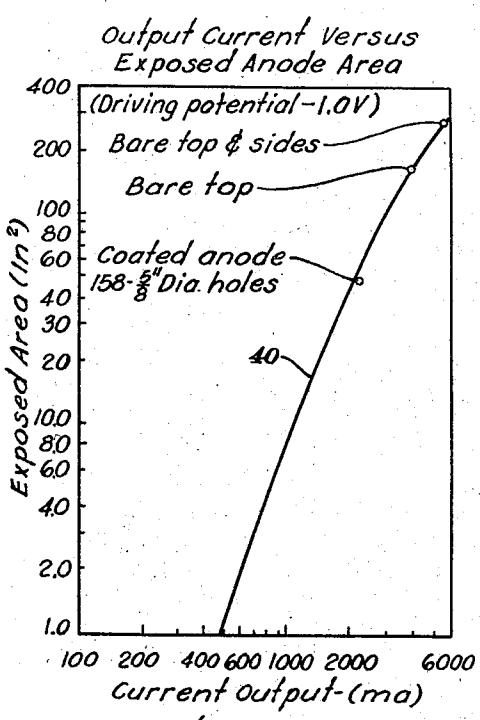


Fig. 10

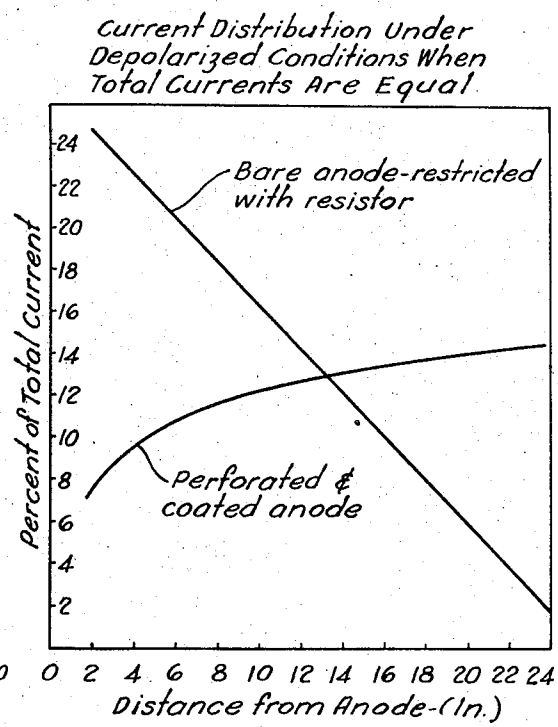


Fig. 13

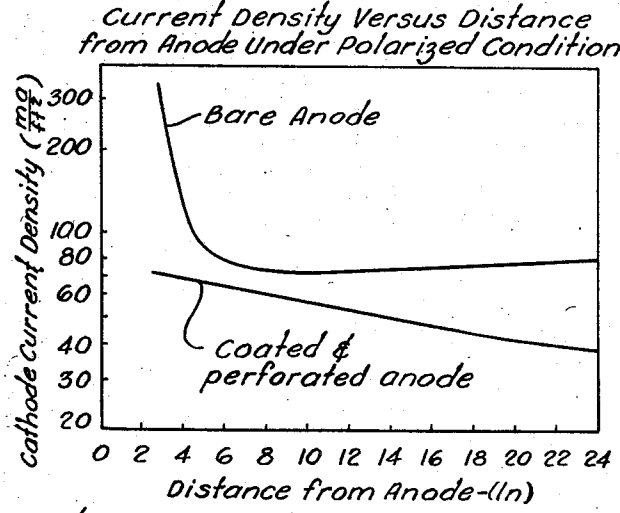


Fig. 14

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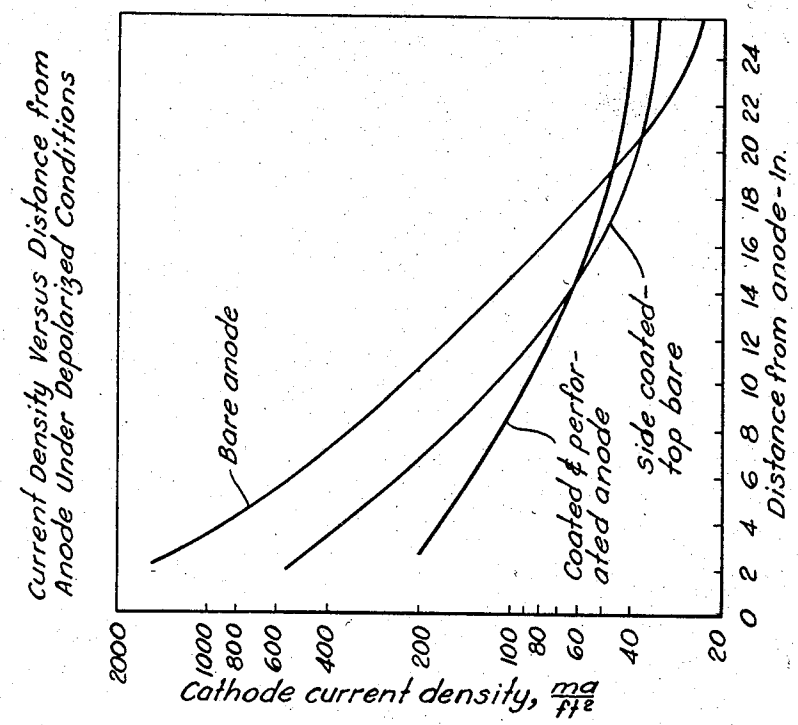


Fig. 12

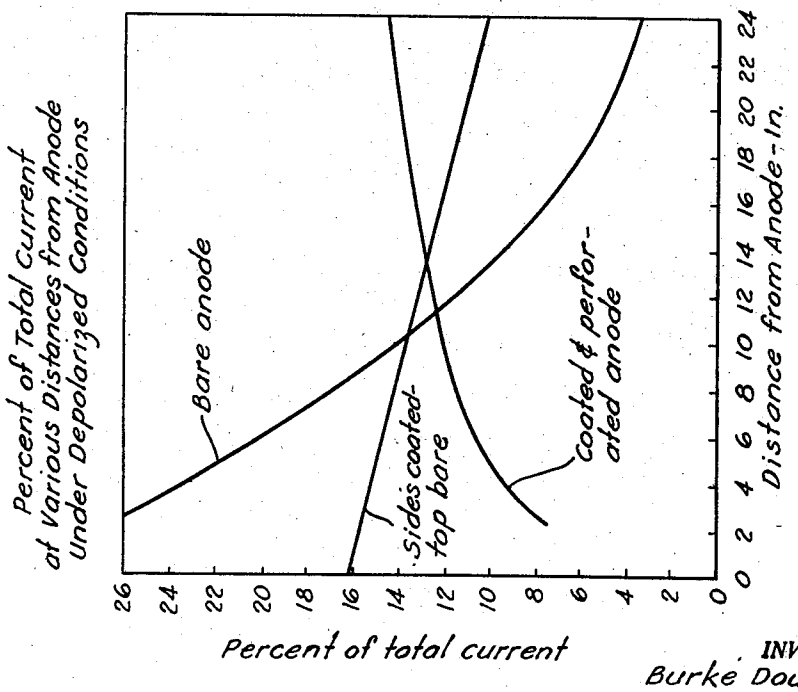


Fig. 11

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2,882,213

GALVANIC ANODE

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Original application February 1, 1955, Serial No. 485,373. Divided and this application May 6, 1957, Serial No. 657,446

6 Claims. (Cl. 204—197)

This invention relates to the cathodic protection of metals and particularly to improved consumable anodes for use in cathodic protection systems.

Cathodic protection systems are well-known in which a metal immersed in an electrolyte is protected from corrosion by means of a sacrificial or consumable anode which is immersed in the electrolyte and is electrically connected to the (cathodic) metal which is to be protected.

Sacrificial or consumable anodes comprise a metal which is anodic to the metal surface to be protected and some means, such as a metal core strap, rod or cable to attach the anode to the surface to be protected. When the anode and the surface to be protected, or cathodic surface, are in an electrolyte and are electrically connected together, the resulting flow of current between the two electrodes greatly reduces the rate of corrosion of the cathodic surface.

The cathodic protection of pipe lines, ship hulls, metal sea walls, and water tanks are examples of uses made of sacrificial anodes, such as magnesium anodes, for example. For many applications the expense of replacing anodes represents a substantial part of the cost of the protective system. Further, in the case of anodes attached to ship hulls, for example, the anodes may be replaced conveniently only at infrequent intervals, such as when the ship is in dry dock.

To avoid costly and frequent replacement of anodes, the use of large anodes which have a long useful life has become common. Large anodes, however, tend to provide larger currents than are needed for the protection of the cathodic surface and to that extent defeat their purpose of providing long-lived protection. Further, in marine service the larger anodes produce greater drag or resistance to the water passing the anodes than do smaller anodes and for this reason are undesirable for use on ships.

Resistance elements have been used in series with the electrical circuit between the anode and the cathodic surface to limit the current flow therebetween. Resistance elements give only a partial answer to the problem of extending anode life, however. Anodes are consumed as a result of chemical attack as well as by current flow, and the resistance element does not affect the rate of chemical attack. Thus, anode circuits including a resistance element operate at a lower efficiency (measured in ampere hours per pound of anode) than do anodes which are operated in systems not having series resistance elements included therein.

Anode efficiency, however, is but one criterion by which an anode is judged. Another indication of the worth of a galvanic anode is its throwing power or, stated differently, the cathodic area in which the anode provides adequate cathodic protection. The throwing power of anodes which are mounted close to the cathodic surface is quite limited since much of the current from the anode is used to protect areas of the cathodic surface which are closely adjacent to the anode. Thus,

the close-in areas are over-protected (by excessive current) and remote areas are inadequately protected. Resistor anodes, while limiting the total current, do not change the proportional distribution of the available current.

Another difficulty encountered in connection with galvanic anodes is that the anode consumption often follows a pattern such that the magnesium anode body (for example) becomes loosened from its mounting means or core while the body weight is still a significant percentage of the anode weight when installed. For cathodic protection purposes, the anodic metal is wasted which remains after the electrical contact between the core or anode mounting means and the anode body is broken or becomes a high resistance contact.

The labor cost for mounting anodes often represents a substantial part of the cost of the cathodic protection system, since men having several basic skills, such as welders, boiler makers, and painters may be used in mounting the anodes on a ship hull, for example. An anode which requires workers having only a single skill or trade to mount would therefore result in a saving in the cost of the cathodic protection system.

Difficulties due to uneven consumption of the anode in different parts thereof have likewise been encountered when one part of an anode is closer to a cathodic surface than is another part of the anode. A cathodically protected water heater in which the magnesium anode rod is inserted from either the top or the bottom of the tank is an example of an anode use in which the anode is subject to the above difficulty.

In such water heaters (or water softeners or similar tanks), the current flow to the supporting wall of the tank, which is very close to the attached end of the anode, is often excessive. The result is that the attached end of the anode may be entirely consumed long before the remainder of the anode is depleted. This irregular depletion of the anode is undesirable because it will result in anode inefficiency.

A principal object of this invention is to provide an improved galvanic anode which has a longer useful life per unit weight of anode material.

Another object of this invention is to provide an improved galvanic anode having improved current distribution to the cathode.

A further object of this invention is to provide an improved galvanic anode structure which needs no separate insulating means to separate the anode from the cathodic surface.

Yet another object of this invention is to provide an improved galvanic anode structure having means for selectively controlling the rate of anode consumption in various parts of the anode body.

In accordance with the invention, there is provided a galvanic anode comprising a consumable body portion and core means by which electrical connection between the anode and a cathode surface may be made, the anode being enclosed in an insulating covering or casing. When the anode is ready for use, the casing is provided with a plurality of apertures in at least one surface thereof.

The invention, as well as additional objects and advantages thereof, will best be understood when the following detailed description is read in connection with the accompanying drawings, in which:

Fig. 1 is a plan view of a plastic coated anode in accordance with the invention;

Fig. 2 is a side elevational view of the anode shown in Fig. 1;

Fig. 3 is a sectional view taken along the lines 3—3 of Fig. 1;

Fig. 4 is a fragmentary sectional view, on an enlarged

scale, showing the plastic coating extending over the mounting strap;

Fig. 5 is a sectional view taken along the lines 3—3 of Fig. 1 and showing the anode consumption pattern after partial consumption of the anode shown in Fig. 1;

Fig. 6 illustrates an anode of the type shown in Fig. 1 as mounted on the side of a ship hull;

Fig. 7 is an elevational view of a plastic coated anode in accordance with the invention which is especially adapted for use with small metal-hulled craft and which requires no underwater connection to the hull of the craft;

Fig. 8 illustrates an anode in accordance with this invention which is adapted for use in water heaters or like uses;

Fig. 9 illustrates a cable-cored coated anode in accordance with the invention;

Fig. 10 is a graph showing output current as a function of exposed anode area;

Fig. 11 is a graph showing the percent of total anode current at various distances from the anode under initial operating conditions;

Fig. 12 is a graph showing current density versus distance from anode for three types of anodes under initial operating conditions;

Fig. 13 is a graph showing the current distribution (under initial conditions) of a perforated anode in accordance with this invention and a bare anode restricted with a resistor when the total current outputs of each anode are equal;

Fig. 14 is a graph showing current density versus distance from the anode for a bare anode and a coated and perforated anode under conditions of continued operation (i.e., after 24–30 hours of operation), and

Fig. 15 is a fragmentary sectional view showing an anode having a laminated or multi-layered covering.

Referring to Figs. 1 through 4 there is shown a galvanic anode indicated generally by the numeral **20** and comprising a consumable body **22**, made of magnesium, for example, and having a metal core **24** (such as steel) embedded in the magnesium and bonded thereto and extending therefrom as a mounting strap **24***a*. The anode is encased in a plastic cover **26** which fits closely about the anode body **22** and mounting straps **24***a*. The top of the plastic cover **26** contains a plurality of apertures **28** which are illustrated as being round although apertures of other configurations may be used. It should be noted that no apertures **28** appear in that part of the plastic coating which lies directly above the cores **24**.

Referring particularly to Fig. 4, the plastic cover **26** extends along at least a part of the mounting straps **24***a*. The mounting straps **24***a* usually contain a plurality of bores **30** which serve two purposes. The bores **30** in the straps provide a convenient means by which the anode **20** may be bolted to a supporting structure. Also, the plastic cover **26** which extends on each side of the straps **24***a* flows through at least one of the bores **30**, causing the plastic on opposite sides of the strap to be bonded to itself. Such bonding of the cover **26** lessens the likelihood that the plastic cover **24** will tear off the mounting straps **24***a* and thence tear off the anode body **22**. In practice, the plastic cover **26** may entirely cover the mounting straps **24***a*, but may be cut back to the desired point when the anode **20** is to be mounted.

The plastic cover **26** is a dispersion resin coating of dispersion grade polyvinyl chloride resin or vinyl chloride copolymer resins plus plasticizer and stabilizer. Such anode coatings are electrically insulating and are physically tough. A coating thickness of ⅛ inch has been found to be sufficient for most applications.

A specific coating formulation which may be used comprises:

60 parts by weight of polyvinyl chloride plastisol
40 parts by weight of di-octyl phthalate
1 part by weight of stabilizer such as "Thermolite 31" which is an organo-tin chemical sold by the Metal and Thermit Co. of New York, N.Y.
5 parts by weight of mineral spirits such as Apco thinner

The plasticizer used is one which is relatively ineffective at room temperatures. However, when an anode which is heated to 350° to 400° F., for example, is dipped into the dispersion, the heat increases the activity of the plasticizer and a resinous coating is formed on the hot surface of the anode.

While the coating of the general type described above proves very satisfactory, other coatings may be used. For example a coating may be applied by hot dipping an anode into an ethyl cellulose gel lacquer. Alternatively, the anode may be coated with neoprene which has an advantage in that such a coating would be relatively immune to attack by light hydrocarbons. Specifically neoprene coated galvanic anodes are well adapted for use in cathodically protecting gasoline tanks or compartments in tank ships.

As cast, dip coated anodes in accordance with this invention often contain a groove **31** in their top surface **32** which is disposed about ¼ inch from the peripheral edge of the anode body. The groove **31** is about ⅛ inch wide and about ⅛ inch deep. When the coating or cover **26** is applied by dipping (or spraying, painting, etc.) the groove **31** becomes filled with a rib **33** of the coating material. During use, the rib **33** of coating which extends into the groove **31** lengthens the ion path through the electrolyte to the upper edge of the anode body **22**. As the anode body **22** is consumed, the peripheral surface portion of the body tends to remain as a shell to keep the plastic cover **26** tightly in place over the anode body **22**. The result is a neater anode which has more resistance to tearing of the cover **26** from the anode body **22** than does a partly consumed anode in which the sides of the anode body **22** are consumed and the cover becomes loose.

One of the advantages of anodes made in accordance with this invention is illustrated in Fig. 5. As the plastic covered anode **20** is consumed during use, the surface **32** of the anode which lies below the apertures is primarily consumed, leaving relatively untouched the anode surface under that part of the cover **26** where there are no apertures **28**. While the entire upper surface of the anode body **22** will eventually be consumed, the surface area under the apertures **28** in the cover **26** will be "eaten away" the fastest. The result is that the magnesium anode body **22** will remain firmly bonded to the cores **24** even though the distance between the surface **32** and the bottom **34** of the anode on either side of the cores **24** is less than the space between the core **24** and the bottom surface **34** of the anode. In an anode **20** of the above type, almost the entire body weight of the anode gives useful cathodic protection.

Fig. 6 illustrates an anode **20** of the type shown in Fig. 1 as attached to a ship's hull **36**. The anode is attached by welding the ends of mounting straps as at **38** to the hull. Because anodes made in accordance with this invention require no additional insulation device or electrical control to separate them electrically from the cathodic surface, the cost of the anode installation, particularly the labor cost, is materially reduced as compared with the cost of installing a bare anode.

The theory concerning the operation of the anodes of this invention is not fully understood. As has been observed, for an electrolyte of given electrical conductivity and assuming a cathodic surface to be protected which is large with respect to the anode, the current output of the anode **20** may be controlled by regulating the number and size of the apertures, thus controlling the flow of current from the surface of the anode **20**. The top surface of the anode is conveniently used for this purpose. It is also known that the current output of various parts of the anode surface may be controlled by the size and num-

ber of apertures 28 above the various parts of the anode surface.

Data is given concerning operation of anodes of this invention under both depolarized and polarized conditions. As the term is used herein, depolarized conditions are those in which the anode and cathode are each at their natural potential while uncoupled in sea water. Under polarized conditions, as the term is used herein, the anode is at its natural potential while the cathode is at a potential which is a function of both the current density and the length of time the current from the anode has been flowing to the cathode. In the tests made for the purpose of gathering data for the graph in Fig. 14, it was found that after 24–30 hours the potentials tended to remain constant as if a steady state condition of operation had been reached.

The graph shown in Fig. 10 shows the relationship between the anode current (in milliamperes) and the "exposed anode surface area" (measured in square inches of opening in the cover 26) for different types of anodes. The term "exposed anode surface area" as used herein refers to the area of the apertures in the coating. It is realized that in partly consumed anodes, however, the surface area exposed to electrolyte may be larger than the aperture area. The ion path to the cathode remains the same (i.e., through the apertures). The coated anode data for the graph in Fig. 10 were obtained by varying the number of 5/8 inch diameter apertures 28 in the top surface 32 of a coated anode. However, the current line 40 in Fig. 10 is approximately the same when apertures 28 of other diameters (but of the same total area) are used.

As a practical matter, the aperture diameter is chosen depending upon at least two factors. First, the strength of the covering 26 of the anode should be maintained at a high value in order to lessen the tendency of the cover 26 to tear away from the anode body 22 when subjected to external forces. Secondly, the apertures 28 must be large enough to permit the anode corrosion product to be washed out of the casing. The anode material may influence the characteristics of the corrosion product.

For anodes used in moving water, cover apertures 28 which are 5/8 inch in diameter have proven very satisfactory. The thickness of the cover 26 may vary according to the material used and the installation of the anode, that is, whether the anode will be used in quiet or fast moving electrolyte. In anodes coated with a polyvinyl chloride type coating a thickness of .09 inch proved satisfactory for use in water moving at a speed of 25 feet per second.

In tests of bare anodes and coated anodes placed in sea water under the same operating conditions, it has been found that substantially no calcareous coating builds up on the cathodic surface around a coated anode mounted against a steel bulkhead in sea water while a substantial calcareous coating is built up around an uncoated or bare anode.

While the existence of a calcareous coating is evidence of excessive current, it is also evidence of paint damage and unsightliness. To the owner of small sea-going craft, the physical appearance of such craft is of prime importance. Anode currents strong enough to cause calcareous deposits cause the deterioration of the paint on that portion of the hull which is in the high current density area. The results have been that most ship owners have heretofore been reluctant to solve their hull corrosion problems at the expense of having an unsightly hull or damaged paint.

As is clearly seen from Figs. 11, 12 and 14 the current density on the cathode close to the coated anodes is only a small fraction of the current density on the cathode close to the bare anode under both polarized and depolarized conditions of operation. As shown in Figs. 11 and 13, the use of a perforated coated anode results in a substantial saving in "close-in" current over a resistor restricted bare anode of equal current output.

Fig. 11 shows the percent of total current versus distance from the anode under depolarized conditions. It may be seen from this graph that although coating the sides of the anode results in a considerable saving in current at distances close to the anode, the coated and perforated anode of this invention results in a further and substantial reduction of the current to cathodic surfaces which are close to the anode. Bare anodes are even more wasteful of their current output.

The anode test setup used in securing the data for the graphs of Figs. 11–14 comprised a series of concentric annular cathode segments made of steel with the test anode mounted in the center of the annular cathode segments. The cathode segments were insulated from each other and each had a flat top surface approximately 3 inches wide (as measured radially from the center of the annulus). The test setup included 8 of such cathode segments, mounted concentrically as stated above. When the graphs of Figs. 11–14 inclusive are read, it should be remembered that the current density readings are actually for areas rather than for points as might be assumed from the distance scales on the graphs.

In the gathering of the data for Figs. 11–14, a steel cathode was used and all the anodes used in the tests were identical in size and shape. The anodes were cylindrical in shape, having a diameter of 3 inches and a height of 4 inches, and were made of cell grade magnesium. One anode was bare, one anode had its side coated and top bare, and one anode was entirely coated and contained all the 5/8 inch diameter perforations which could conveniently be made in the top surface thereof with 5/16 inch spacing between adjacent apertures. The bottom surface of each of the anodes was coated to protect that surface from the cathodic surface to which the anode was mounted. The measurements were made with the anodes immersed in sea water moving at a rate of approximately 6 ft./minute. In those graphs where current values are given, no attempt should be made to relate the currents to that current which is necessary to protect the cathodic surface. The experimental data shows only current distribution from the anode without regard to the current required to achieve protection. Obviously, if more current is needed, larger anodes may be used.

Fig. 12 shows current density versus distance from anode under depolarized conditions of operation. The graphs of Figs. 11 and 12 were plotted using the same experimental data. It should be noted in Fig. 12 that the current density close to the anode (3 inches from the anode) is about 7 times as high for a bare anode as for a perforated and coated anode, in which the perforations were placed as described above. Also, a perforated and coated anode puts a larger part of its output current farther away from the anode than does the bare anode. This larger far-out current tends to increase the cathode area protected by a coated anode as compared with bare anodes of similar current capabilities. It should be realized that in the graphs of Figs. 11 and 12 the total output current of each of the anodes is different from the output current of the others.

The graph shown in Fig. 13, however, shows current distribution under depolarized conditions in the case of equal total currents of a bare anode whose current output is restricted by a series resistor and a perforated coated anode. It should be noted that the "close-in" current of the perforated coated anode, that is, the current going to the cathodic surface which is closely adjacent to the anode, is considerably lower than the close in current of the resistor-restricted anode. This graph indicates that the resistor in the resistor-restricted anode apparently restricts only the total current output of the anode and has little effect on the current distribution pattern of the anode. Compared with Fig. 11, the percent of current output curve for the bare anode is very similar to the corresponding curve for the resistor-restricted anode. Referring again to Fig. 13, it may be seen that in the case

of the coated and perforated anode only about 8 percent of the total current was used within 3 inches of the anode whereas about 23 percent of the total current of the resistor-restricted anode is utilized in the same area within 3 inches of the anode.

Considering the current distribution curve of Fig. 13, it appears to now be feasible to install anodes on surfaces which remain depolarized and still achieve long lived protection. Previously on such continually depolarized surfaces, such as on a ship's rudder, the anodes were quickly depleted due to the excessive close-in current. Anode life of bare anodes in such installations was much less than the anode life of bare anodes when installed adjacent to polarized surfaces. Since ship anodes may be installed conveniently only when the ship is in dry dock, the result has been that ship hulls have not been protected as uniformly as desired because of inability to replace anodes which were rapidly depleted. The coated and perforated anode provides an answer to this problem by providing a controlled distribution of current and thereby making possible more uniform protection of a ship's hull or other cathodic surface.

A comparison is shown in Fig. 14 between a coated and perforated anode and a bare anode of equal size regarding current density versus distance under polarized conditions of operation. Fig. 14 shows that the close-in current of the bare anode at 3 inches distance from the anode is about 4 times the close-in current of a coated and perforated anode. Thus, even under polarized conditions of operation, the bare anode is quite wasteful in the usage of its current output in providing close-in protection to a cathodic surface.

It should further be remembered that under conditions where the cathodic surface is in rapidly moving electrolyte, as for example on the hull of a ship, the hull seldom becomes completely polarized.

Another practical advantage accrues to the use of coated and perforated anodes which is not apparent from the graphs. Often the cathodic surface to be protected is coated, as by painting, and the coating effectively reduces the area of the exposed cathodic surface so far as anode current requirements are concerned. However, when high close-in currents occur, the coating peels off and an enlarged, bare cathodic surface is presented to the anode. The bare surface in return requires more total current from the anode in order that the bare surface be adequately protected. Because of the substantial reduction in close-in current when anodes of this invention are used, the paint or coating on the cathodic surface is relatively unaffected. It should be realized, however, that a very few brands of paint that were tested peeled off with even very low current to the cathodic surface.

To cite an example of the different current requirements for equal area surfaces, a galvanized water tank may, and often does, require 10 times the anode current for effective protection as does a glass lined water tank of equal size. A painted surface would not be as good as a glass lined surface in reducing the current required for protection. However, it can be appreciated that any loss of paint from the cathodic surface would increase the anode current demand and, if effective protection is to be maintained, would shorten the effective life of the anode. Thus, the fact that paint is not removed from the cathodic surface when coated and perforated anodes are installed results in further important advantage in extending the life of the anode.

The galvanic anode structures thus far described have been of the type which are bolted, welded, or otherwise fixedly attached to a structure which is to be cathodically protected. Referring to Fig. 7, there is shown a plastic coated galvanic anode **42** of generally cylindrical form. A metal mounting strap or cable **44** extends from the anode body and is bonded therein. The plastic coating or covering **46** of the anode is provided with perforations **48** (apertures) in order to regulate the current flow from the anode as previously described in connection with other coated and perforated anodes. The plastic coating **46**, as illustrated, usually extends at least part way along the mounting strap or cable **44**. The plastic coating or covering of the anode **42** also provides an anode which is cleaner to handle than is a bare anode. It is anticipated that anodes of the type shown in Fig. 7 will find use as readily demountable anodes for use on small vessels. In this type of application, the anodes would normally be stowed away except when the vessel was anchored or tied up at a dock or pier. The anode strap would then be fastened to a cleat mounted on the metal hull of the vessel completing the protective electrical circuit. Such an anode arrangement has merit for small craft use, since many pleasure craft are docked or anchored far more hours than are operated. The demountable anode provides cathodic protection, yet may be removed easily so there is no extra "drag" in the water. The plastic covered anode is neater and more desirable, from a housekeeping standpoint, than is a bare anode. Further, since galvanic anode surfaces become roughened during their consumption and often have small, sharp edges, the plastic coating over the anode results in an anode assembly which is safer to handle than a bare anode. The anode structure may be included as part of or combined with the fenders of the vessel if desired, thus eliminating a separate object to be stowed while the vessel is in use. The covering **46** of the anode **42** need not be applied by dipping the anode body in liquid plastic, but may comprise a permanent casing in which bare anodes may be disposed. Anodes and casings of this general type are described and claimed in applicants' copending application, Serial No. 485,438, filed February 1, 1955.

While the advantages of the coated and perforated anodes of this invention have been described mainly in connection with ship hulls, such anodes have many other applications.

For example, coated anodes having no perforations may be stock piled and stored without shelter from the weather for long periods of time without loss of anode weight by corrosion. Such anodes are provided with perforations of the required number and size at the time they are sold (or are to be used) for the particular installation in which they will be utilized.

Different corrosion prevention applications require anodes of many different varieties of performance characteristics. To stock all types of anodes would place a considerable financial burden on a distributor or dealer. However, when a distributor stocks coated but unperforated anodes in accordance with this invention, a minimum number of anode types and sizes serves to supply the anodes for a wide variety of application situations when the anodes are given the required perforation pattern.

The availability of an unperforated coated anode is also attractive to corrosion engineers who prefer to maintain some degree of secrecy about their ideas as to what is the best solution to a particular corrosion problem.

Coated and perforated anodes may be used in many applications where resistor-restricted anodes or bare anodes are now used. Pipe line cathodic protection systems can make use of the anodes of this invention by mounting the anodes closer to the line than heretofore has been practical because of the excessive local current to the nearby pipe.

The use of a coated and perforated anode in a water tank is illustrated in Fig. 8. The anode, indicated generally by the numeral **50**, extends upwardly from the bottom of the tank **52**, but could be mounted to extend downward from the top of the tank. In either method of mounting, excessive current usually flows to the mounting end of the tank because the surface **54** from which the anode **50** is mounted is closer to the mounting end of the anode **50** than are the sides of the tank **52**. Thus,

the lower end of the coating **56** on the anode **50** in the tank has smaller apertures **58** than appear in the coating over the remainder of the anode. The smaller apertures **58** near the bottom end of the anode restrict the current which flows from that part of the anode, thus causing a more uniform expenditure of the anode than would occur if the anode apertures were all uniform in size. Such selective current flow from the anode **50** would not be possible in a resistor-restricted anode. In addition, the coating **56** provides physical support for the anode **50**.

Fig. 9 illustrates a cable-core coated and perforated anode, indicated generally by the numeral **60**, made in accordance with this invention. The anode coating **62** extends along the mounting cable **64** for a considerable distance from the anode body **66** to prevent strong local current flow between the anode and the nearby mounting cable **64**. Such cable anodes are well adapted to be clamped to a submersible metallic net, for example. The size and number of perforations **68** of the anode may be varied to accommodate a wide variety of corrosion control situations.

Any of the anode assemblies described above may be coated with an anti-fouling coating in addition to or as a substitute for the previously described coatings. An anti-fouling coating which is suitable for use on anodes for use in sea water is a copper salt of polyacrylic acid. Such coatings can be made relatively insoluble by controlling the degree of polymerization of the coating material. The coating is physical tough and has a double anti-fouling action. The copper is toxic to small marine oragnisms and since the surface of the coating dissolves at a slow rate, the organisms cannot readily adhere to the coating.

As a precaution against baring the anode due to the dissolving of the anti-fouling coating, or because of the electrical properties of some coatings it is sometimes advisable to provide an under coating of normally insoluble material (such as described previously herein, for example), prior to applying the anti-fouling coating.

Another anti-fouling coating may be provided by dispersing copper particles through the non-soluble coating materials.

Another use of slowly soluble coating materials is to provide a delayed action anode for use in installations where mounting the anodes is expensive or can be done only at infrequent intervals. Thus, an immediately operative anode and a "delayed action" anode may be installed together with a coating on the delay action anode which is calculated to expose the galvanic metal of that anode at approximately the time of the end of the useful life of the immediately operative anode.

Fig. 15 illustrates an anode **22** having a coating consisting of two layers or laminations **26*a***, **26*b***. The layer **26*a***, which, as illustrated, contains one or more apertures **28**, is the less soluble of the two layers. The outer layer **26*b*** is the more soluble layer, covers the inner layer **26*a*** and fills in the aperture or apertures **28**.

It is now customary to attempt to achieve long-lived cathodic protection by the use of larger and larger anodes. Larger anodes, while providing protection over a longer period than do smaller anodes, have higher current flow and thus are inefficient. Two small anodes, one of them a delayed-action anode, may be used to provide continuous protection without the inefficiency of a single large anode.

Among the suitable coatings which will slowly dissolve are polyacrylic acid (or salts thereof), polyvinyl alcohol, methyl cellulose plus enzyme, or natural gums plus bacteria. Arayakraya is an example of a natural gum which may be used. It is relaized that not all the above coating materials are suitable for use in mobile installations such as ships. However, many stationary or seldom moved metals in sea-water or other saline electrolyte may be given long range protection by such delayed action anodes.

Delayed action anodes may likewise be used in tanks which are used to store or transport petroleum products or other materials. The anode coating for such delayed action use is chosen from substances which have low solubility rates in the electrolyte to which they will be exposed.

Thus, it is apparent that the present invention provides improved galvanic anodes which have longer life, have better current distribution, are easier to store, and are more adaptable to a wide variety of corrosion control situations than are conventional bare anodes or resistor-restricted anodes.

This is a division of my copending application, Serial No. 485,373, filed February 1, 1955.

I claim:

1. An article for use in the cathodic protection of metal surfaces immersed in an electrolyte, comprising a galvanic anode assembly including a galvanic anode body, a metal core bonded into said body, and a closely fitting, electrically insulating covering surrounding said anode body, said covering being a laminated covering having an inner layer and an outer layer, said covering being soluble in said electrolyte, the inner layer being substantially less soluble in the electrolyte than is the outer layer, the outer layer entirely covering said anode body.

2. An article in accordance with claim 1, wherein said inner layer is composed of vinyl dispersion resin and said outer layer is composed of polyacrylic acid.

3. An article in accordance with claim 1, wherein said inner layer is composed of vinyl dispersion resin and said outer layer is composed of polyvinyl alcohol.

4. An article in accordance with claim 1, wherein said inner layer contains a plurality of apertures.

5. An article in accordance with claim 4, wherein each of said apertures has an area exceeding the area of a circle having a diameter of one-eighth inch.

6. An article for use in the cathodic protection of a metal surface immersed in an electrolyte, comprising a galvanic anode assembly including a galvanic anode body, a metal core bonded into said body, and a closely fitting, electrically insulating covering surrounding said body, said covering being a laminated covering having an inner layer of vinyl dispersion resin and an outer layer composed of a copper salt of polyacrylic acid.

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