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PREVENTION OF CORROSION

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The invention relates to the prevention of corrosion, particularly in an air conditioning apparatus employing a circulating hygroscopic solution which must be kept clear in order that the apparatus may function properly.

Many salts are corrosive, i. e., they form aqueous solutions that produce rapid corrosion when brought in contact with ordinary metals. It is believed that the presence of oxygen from the air in such solutions is a factor that contributes to their corrosive action upon metals.

In apparatus employing a salt solution for dehumidifying air, the solution contains an unusually large amount of dissolved oxygen, because it is continually aerated. Moreover, a solution used to extract moisture from air is usually regenerated or dehydrated by heating it at one point in its circuit. The temperature of the solution may be as high as 230° F. at one point in the circuit, and as low as 50° F. at another point. Then there is not only the sharply increased corrosiveness of the solution at high temperatures to be reckoned with, but also the augmented electrolytic action resulting from the variation of the temperature and concentration of the solution from one part of the system to another.

The severe corrosion that has been found to occur heretofore in air conditioning apparatus employing circulating salt solutions has not only caused structural failure at various points, due to the eating away of the metal, but has also caused the solutions in many cases to become so contaminated with products of corrosion as to hamper or prevent the operation of the apparatus.

Attempts have been made to render salt solutions noncorrosive by adding an oxidizing agent, such as a chromate, a permanganate, or a peroxide to the solutions. Although these oxidizing agents are known to reduce corrosion, especially when used in non-aerated solutions of corrosive salts at room temperatures or less, they have not been found to prevent the severe corrosion that occurs in air conditioning apparatus employing salt solutions. Many metals do not corrode rapidly when kept completely submerged in a hot solution of a corrosive salt if the solution contains an oxidizing agent such as a chromate. However, when the metals are only partly submerged, as they are in air conditioning apparatus, their unsubmerged portions are freely aerated, are exposed to spray and condensed vapor from the solution, and are thus severely corroded.

The effects of rapid corrosion are illustrated by the conditions encountered in one large commercial installation of air conditioning equipment employing a solution of lithium chloride and sodium chromate. The circulating solution in that apparatus became so contaminated with products of corrosion that the operation of the apparatus was severely hampered. Many parts of the apparatus became clogged, and a three-inch pipe used to conduct the solution at one point in the system was almost completely choked with sludge after six weeks of operation. In order to prevent the apparatus from becoming inoperative, it had to be shut down at the end of seven weeks, cleaned out, and refilled with clear solution. An intolerable amount of structural failure was produced by the corrosion. The steel piping used to conduct the solution where it was at the highest temperature, and the finned copper steam coils in contact with which the solution was aerated, in order to regenerate it, were completely eaten through in many places at the end of two months of operation. The portions of the steel piping that were not eaten through were reduced to the thickness of tissue paper.

Paint coatings cannot be used in such an apparatus to prevent corrosion of the metal parts, because they are destroyed by the hot solution. Asphalt paints, coal tar paints, plasticized pitches, rubber paints, phenolic resin varnishes, and other resin type paints are soon removed by the hot solution.

The principal object of the invention is the production of corrosion-resisting surfaces that can be used to line the circuit through which a salt solution flows in an air conditioning apparatus, in order to keep the solution clear and to prevent structural failure. More specific objects and advantages are apparent from the description, which merely discloses and illustrates the invention and is not intended to impose limitations upon the claims.

One material that can be provided with a corrosion-resisting surface in accordance with the invention is galvanized iron, which is manufactured by passing iron through a bath of molten zinc. After passing through the bath, the iron has an external coating of zinc, and an intermediate layer of iron-zinc alloy between the zinc coating and the iron itself. A coating of zinc may be applied to iron by electroplating or spraying without causing an intermediate layer of iron-zinc alloy to form. The life of iron that has been coated with zinc has generally been

found to be dependent upon the thickness of the zinc coating, but substantially independent of the method by which the coating is applied.

Galvanized iron is known to be resistant to atmospheric corrosion and certain types of under-water corrosion, but not to the attack of a hot solution of a corrosive salt. The protection afforded to iron by galvanizing has always been attributed to (1) the mechanical exclusion of air from the iron by the zinc coating, and (2) the greater activity of the zinc as compared with the iron, which prevents the iron from being corroded, after the zinc coating has been broken, until the coating has been entirely eaten away. Galvanized iron has always been found to corrode like ungalvanized iron as soon as the coating has been lost.

When galvanized iron is subjected to the action of a hot solution of a corrosive salt the zinc coating is rapidly eaten away, and rapid rusting of the iron takes place after the coating has disappeared. Oxidizing agents in general do not prevent the dissolving of the zinc coating and subsequent rapid corrosion of the bare iron in a hot solution of a corrosive salt.

The present invention is based upon the discovery of a peculiar action of a solution of a corrosive salt containing a chromate that is different from the action of solutions containing other oxidizing agents. When galvanized iron is subjected to the action of a corrosive salt and a chromate in the presence of moisture, the zinc coating is rapidly eaten away in the usual manner to expose the layer of iron-zinc alloy that lies immediately beneath the zinc. Under ordinary conditions this layer of alloy is less resistant to corrosion than the zinc.

In accordance with the invention, however, a corrosion-resisting surface is formed by the action of a corrosive salt and a chromate upon the iron-zinc alloy in the presence of moisture, so that corrosion is arrested as soon as all the unalloyed zinc has been removed. Apparently a resistant film is formed on the iron-zinc alloy that increases in strength with continued exposure to the chromate and corrosive salt in the presence of moisture.

The corrosion-resisting surface is formed on the iron-zinc alloy even when the metal is partially immersed in a hot aerated solution of a chromate and a corrosive salt. The formation of the corrosion-resisting surface on the iron-zinc alloy is in contrast to the effect of such a solution upon other metals, such as iron, steel, copper and stainless steel alloys, which corrode rapidly when partially immersed therein. It has been found that the resistant surface formed on iron-zinc alloy in accordance with the invention is extremely adherent. It cannot be destroyed by vigorous scrubbing with a wire brush.

Although galvanized iron is the cheapest material that can be treated in accordance with the invention, it is obvious that any material having a layer of iron-zinc alloy on or near its surface can be similarly treated. Annealed galvanized iron has a heavier intermediate layer of iron-zinc alloy than ordinary galvanized iron, and is, if anything, more suitable for treatment in accordance with the invention. Sherardized iron, which consists of iron having a surface layer of iron-zinc alloy, can be provided with a corrosion-resisting surface in accordance with the invention, and has no other coating of zinc to be eaten away before the layer of alloy is reached. When a zinc coating has been applied to iron by spraying or electro-plating, however, the metal cannot be rendered resistant to corrosion by the present method, because no intermediate layer of iron-zinc alloy exists.

The present invention is particularly advantageous for air conditioning systems employing circulating solutions. Aqueous solutions of hygroscopic halides, such as lithium chloride, calcium chloride, zinc chloride, calcium bromide and lithium bromide are usually employed in such systems. In the practice of the invention, the circuit for the solution should be lined substantially throughout with an iron-zinc alloy so that the liquid can be kept clear and structural failure can be prevented by maintaining a chromate in solution. When the vessels and conduits for the liquid are made of galvanized iron, the coating of unalloyed and zinc quickly disappears to expose the layer of iron-zinc alloy, and then corrosion ceases and the solution remains clear. If metals other than an iron-zinc alloy are used for lining the circuit or if the circulating solution does not contain a chromate, however, the apparatus rapidly chokes up with a sludge consisting of products of corrosion.

The concentration of chromate in a solution used in carrying out the invention should be sufficient to give the desired degree of protection against corrosion. Solutions at lower temperatures require lower concentrations of chromate to furnish any given degree of protection, because cooler solutions are less corrosive. It has been found that concentrated solutions are often less corrosive than dilute solutions. For example, a 20 per cent aqueous solution of lithium chloride containing ½ per cent of sodium chromate is much less corrosive at 120° F. than at 230° F., and a 40 per cent solution of lithium chloride containing ½ per cent of sodium chromate is less corrosive than a 20 per cent solution containing ½ per cent of sodium chromate. Concentrations greater than about ¼ per cent of a chromate in a solution of a corrosive salt have been found satisfactory for producing a corrosion-resisting surface on an iron-zinc alloy. Only slight improvement results from the use of more than about one per cent of a chromate.

The preferred solution for forming a corrosion-resisting surface on an alloy of iron and zinc in accordance with the invention contains about 40 parts of lithium chloride, about 60 parts of water, and about 1 part of sodium chromate. Its pH is 6½ to 8½. Of course, a strongly acid solution cannot be used in carrying out the invention. The lithium chloride used in making up the solutions for which formulae are given was only about 90 per cent pure, and contained up to about 5 per cent of calcium chloride and up to about 5 per cent of sodium chloride.

In order to maintain a proper concentration of chromate in a lithium chloride solution, a soluble chromate may be kept in contact therewith. The chromate may be kept in contact with the solution by placing it in a bag suspended in the solution, or the solution may be allowed to trickle over the chromate in lump form at one point in the system. Since sodium chromate is infinitely soluble in hot water, it might be expected that a greatly excessive concentration of chromate would be maintained in the solution by keeping a bag of sodium chromate suspended therein. However, the concentration of sodium chromate thus produced in a 40 per cent lithium chloride solution is in practice only about two percent.

In place of sodium chromate, any other chro-

mate may be employed which is sufficiently soluble so that an appreciable concentration of chromate in the solution can be obtained. For example, zinc chromate may be used with a lithium chloride solution. The results obtained by the addition of zinc chromate to a lithium chloride solution are equally as good as the results obtained by the addition of sodium chromate. However, the use of oxidizing agents other than chromates in conjunction with corrosive salts does not produce a corrosion-resisting surface on iron-zinc alloy.

The corrosive salt or mixture of corrosive salts employed in carrying out the invention should not be such that the chromate is prevented from dissolving. For example, zinc chloride should not be used alone as the corrosive salt. However, a solution consisting of 3 parts of zinc chloride, 36 parts of lithium chloride, 1 part of sodium chromate, and 60 parts of water, or a solution consisting of 9 parts of zinc chloride, 28 parts of lithium chloride, 1 part of sodium chromate, and 62 parts of water is perfectly satisfactory for the forming of a corrosion-resisting surface on an iron-zinc alloy. A solution containing 8 parts of lithium bromide, 24 parts of lithium chloride, 1 part of sodium chromate, and 67 parts of water, or a solution containing 20 parts of lithium bromide, 1 part of sodium chromate, and 79 parts of water may also be used.

The corrosion-resisting surface formed on iron-zinc alloy at temperatures of about 230° F. in accordance with the invention is dark gray, and the surface formed at lower temperatures has a mottled appearance. Such surfaces may advantageously be used on hardware and other ornamental articles. The invention may also be used for imparting a corrosion-resisting finish to iron or steel that is to be used for applications in which there is danger of corrosion. If desired, paint or other protective coatings may be applied on top of the treated iron-zinc alloy surface. Iron and steel that have been treated in accordance with the invention may be used on seagoing vessels, and in various structures that are subject to the action of salt water.

Various other applications of the invention may be devised to meet various requirements.

Having described my invention, I claim:

1. A method of forming a corrosion-resisting surface that comprises subjecting an alloy of iron and zinc to the action of an aqueous solution containing a chromate and a substantial concentration of a corrosive hygroscopic salt.

2. A method of forming a corrosion-resisting surface in an air conditioning apparatus that comprises subjecting an alloy of iron and zinc to the action of a hot aqueous solution containing a chromate and a substantial concentration of a hygroscopic halide.

3. A method of forming a corrosion-resisting surface that comprises continuously subjecting an alloy of iron and zinc to the action of an aqueous solution containing a substantial concentration of a hygroscopic halide, in which more than about one-fourth per cent by weight of a chromate is dissolved.

4. A method of forming a corrosion-resisting surface that comprises continuously subjecting an alloy of iron and zinc to the action of an aqueous solution containing a chromate and a substantial concentration of lithium chloride.

5. A method of forming a corrosion-resisting surface in an air conditioning apparatus that comprises continuously subjecting an alloy of iron and zinc to the action of a hot aqueous solution containing a substantial concentration of lithium chloride, in which more than about one-fourth per cent by weight of a chromate is dissolved.

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