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(54) ANTI-RUST TREATMENT USING KLEIN[00d6] GAS FLAME

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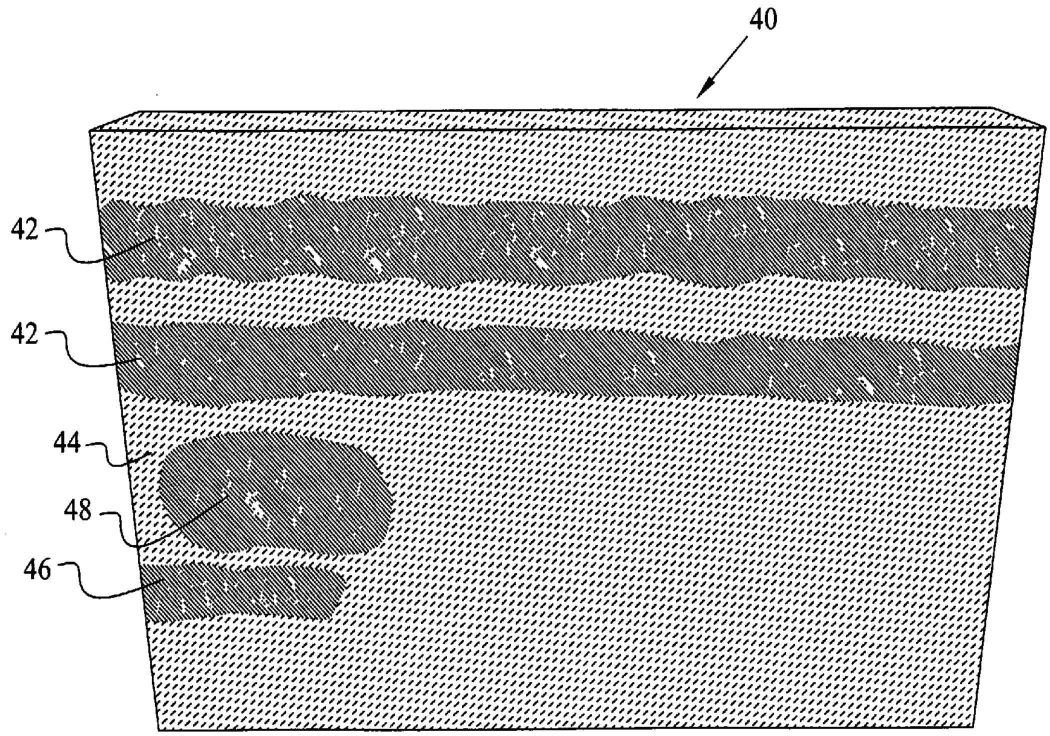
(57) **ABSTRACT**

A method to remove existing rust and to inhibit rust formation by treating steel surfaces with a flame produced by the combustion of a unique gas, that is, a hydrogen gas and oxygen gas mixture.



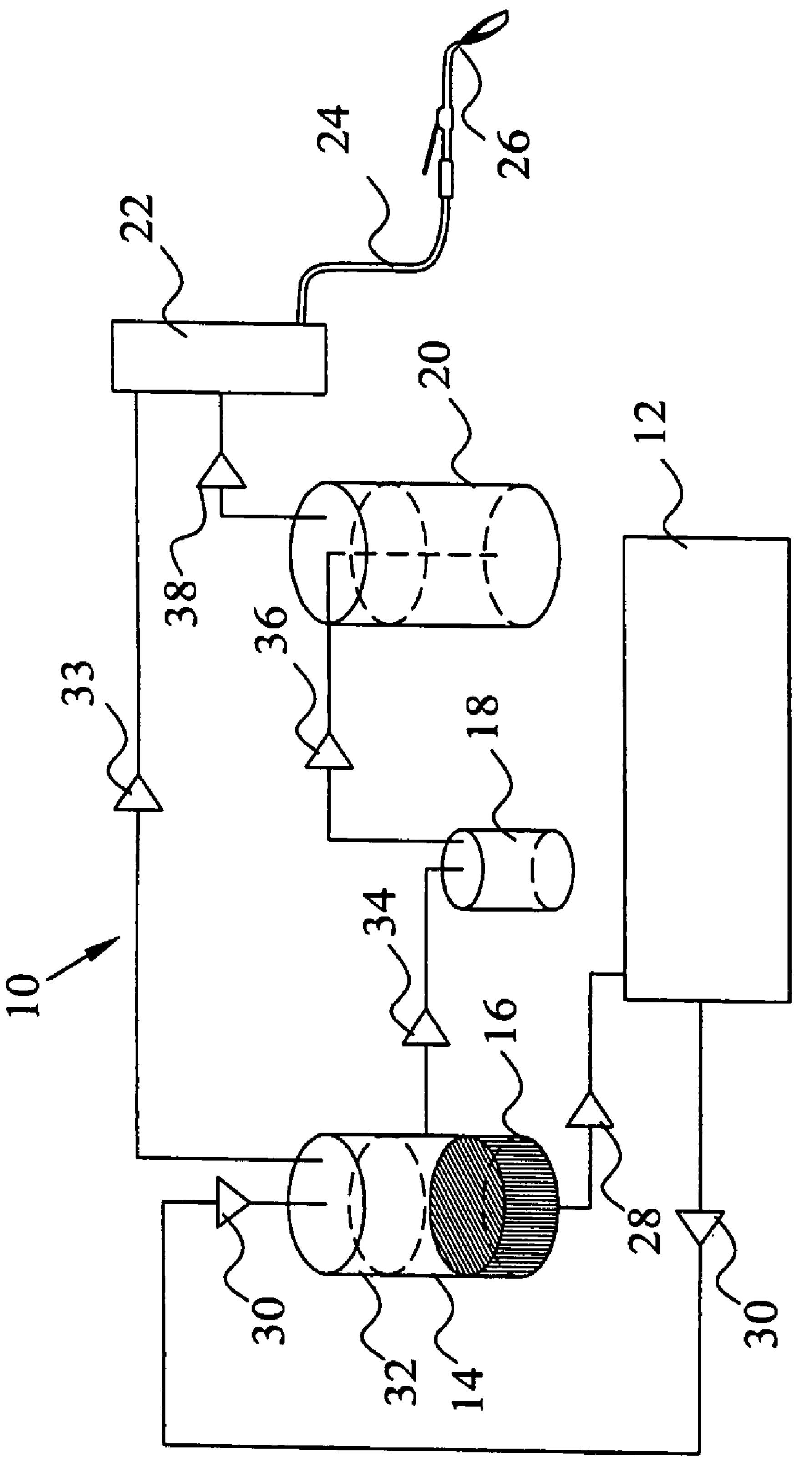


Fig.1

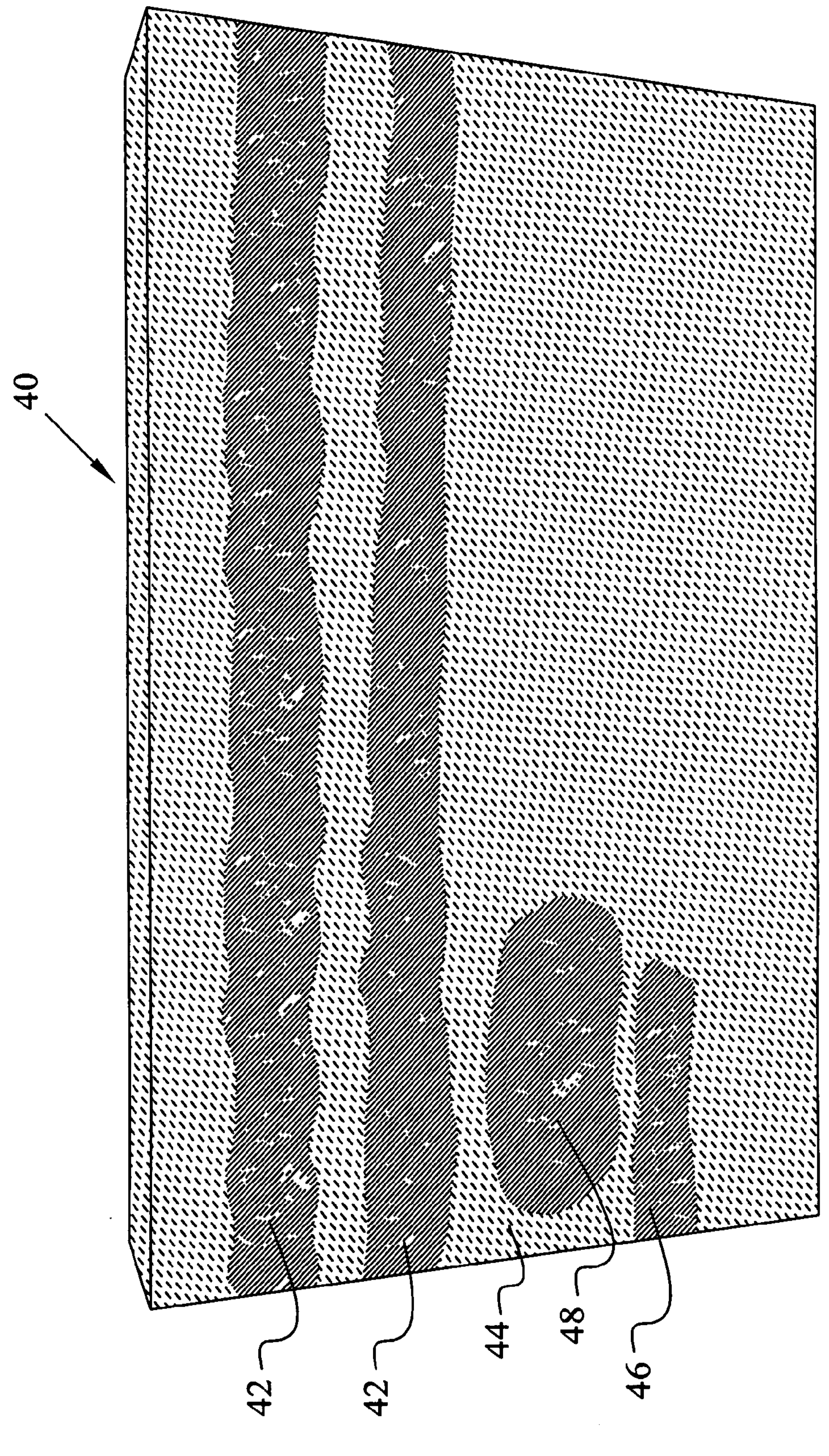


Fig.2

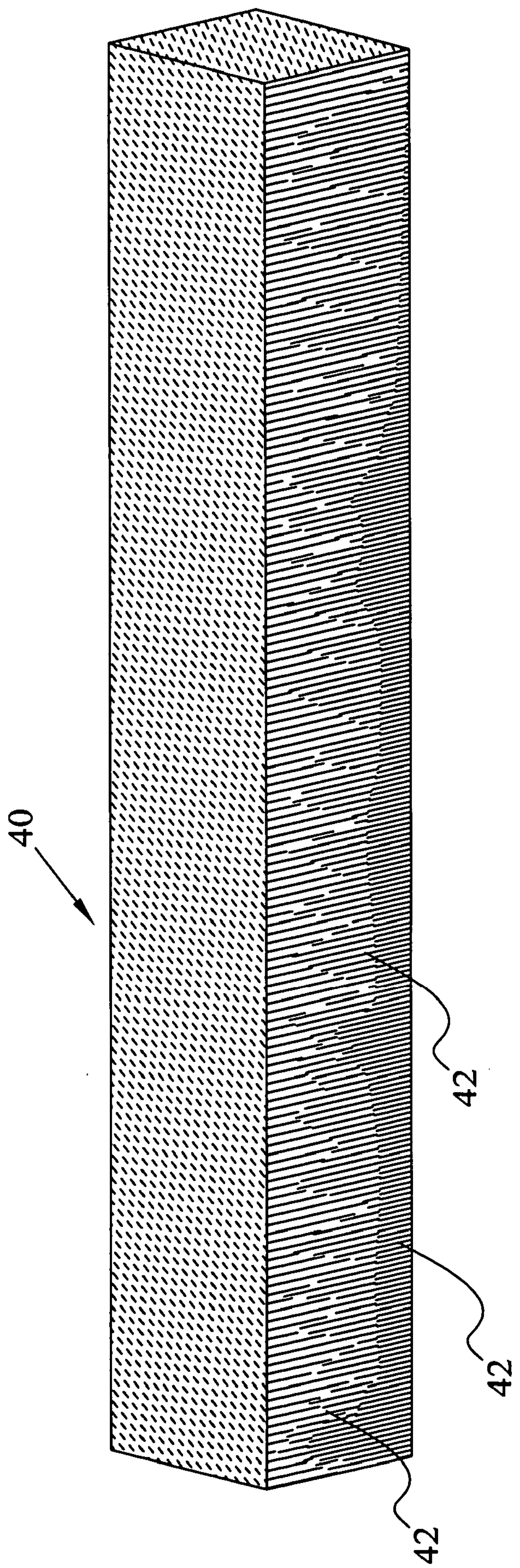


Fig.3

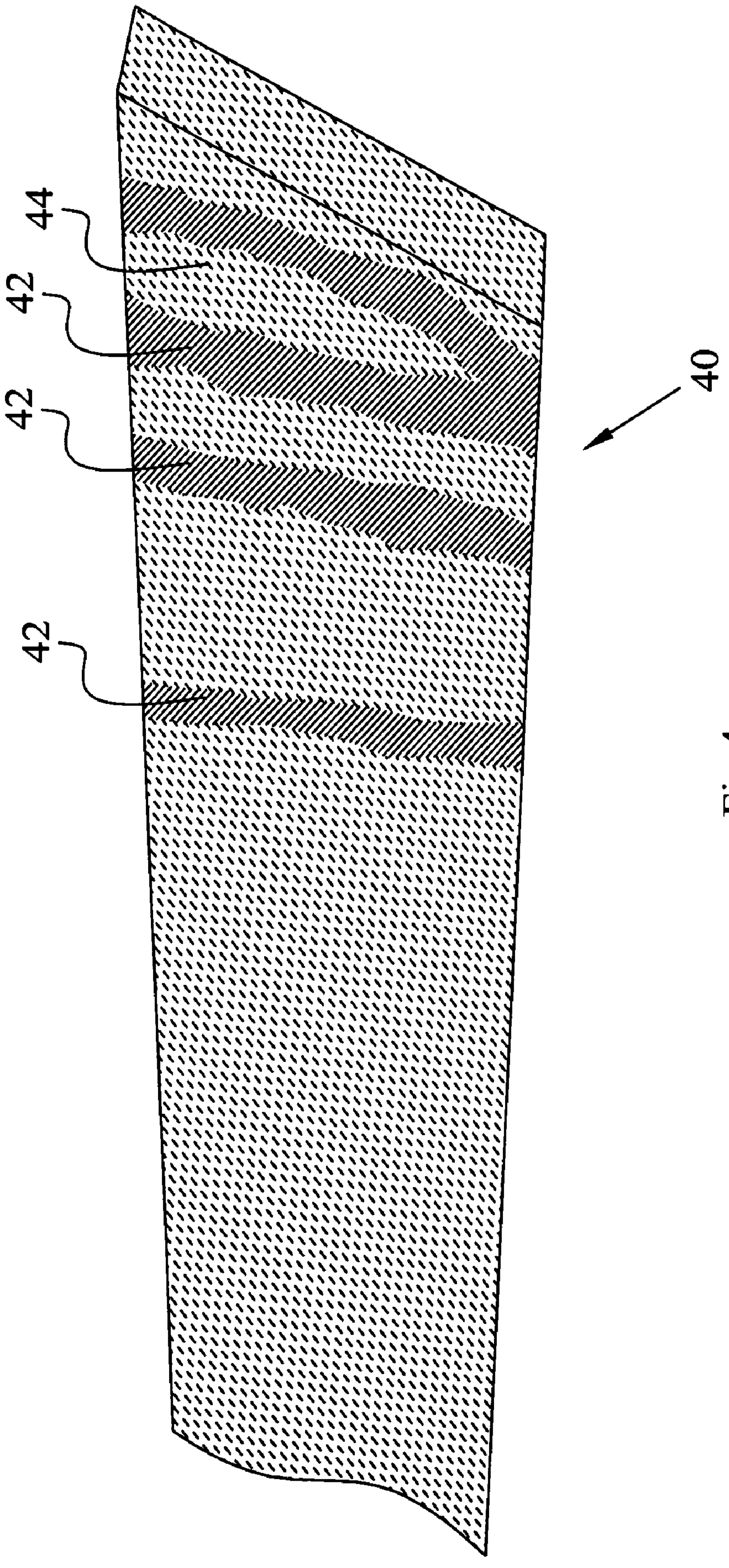


Fig.4

ANTI-RUST TREATMENT USING KLEIN[00d6] GAS FLAME

RELATED APPLICATION

[0001] This application claims priority from U.S. Provisional Patent Application 60/601,798 filed Aug. 16, 2004.

FIELD OF INVENTION

[0002] This invention involves basic aspects of metallurgy, but it appropriately is in the field of rust and corrosion prevention and remediation, and more specifically it discloses and illustrates a method of remedying and of metals, mainly rusting of steel.

BACKGROUND OF THE INVENTION

[0003] Steel in various forms is the most widely used metal throughout the industrialized world. It is produced from various forms of iron ore, most commonly hemite (Fe_2O_3) under high temperatures in blast furnaces. In terms of the production of steel, the critical step and key reaction is the reduction of elemental iron and carbon dioxide gas at about 1540° C. to yield liquid, elemental iron and carbon dioxide gas.

$$Fe_2O_3+3CO\rightarrow 2Fe+3CO_2$$

[0004] The resultant metal product is common cast iron or pig iron. It contains approximately 1% carbon and is highly susceptible to rusting and other corrosive forces. Iron alloys tend to resist corrosive processes. Stainless steel, an alloy with up to 30% chromium and a small fraction of nickel is highly rust and corrosion resistant. Steel with higher concentrations of carbon are harder than pig iron but tend to be susceptible corrosion to and formation of rust.

[0005] World-wide, the annual production of steel is approximately 800 million tons. Up to approximately 20 percent of the steel produced in the United States is used to repair or replace steel structures and products that have been weakened or damaged by corrosion. In addition to the obvious cost of replacement, preventative measures, frequently starting with physically scrapping or otherwise removing rust deposits and deteriorated paint represent major maintenance costs, as for example the continuous scrapping and painting of San Francisco's Golden Gate Bridge.

[0006] Rust is the product of corrosion, the oxidative deterioration of metal. Empirically, the process is relatively simple. Iron (Fe^{3+}) is oxidized to yield hydrated iron (III) oxide, of the form approximately $Fe_2O_3.H_2O$.

[0007] In spite of the significance of corrosive forces, the rusting process has not been fully explained. Several key points are known. Rusting requires both oxygen and water. In addition, although the process involves pitting the surface of the metal, the rust is not deposited at the pitting site, suggesting that rust is not formed as a direct reaction of iron and oxygen.

[0008] Based on what is generally accepted, rusting is well explained by a relatively simple electro-chemical model. A minute galvanic cell is formed by a droplet of water extending over a pit on the surface of a piece of iron. Different areas of the surface covered by the droplet act as anode regions and cathode regions. Oxidation occurs at the anode region with electron flow through the metal to the cathode region. The droplet of water provides an aqueous phase which provides for the movement of iron (Fe^{2+}) from the anode region to be accumulated and deposited in its oxidized form as hydrated iron oxide ($Fe_2O_3.H_2O$). For a more complete discussion of the process and model, see, Murray, John and Robert C. Fay. Chemistry, 4^{th} Ed. Prentice Hall, Upper Saddle River, N.J., incorporated herein by reference in its entirety by reference.

[0009] From the above described corrosive process, essential steps to reduce corrosion (rusting) are obvious, even if in practice specific reactions or process are not apparent. Simply described, rust prevention is accomplished by distributing the formation of the minute galvanic cell, or by destroying such cells before a significant magnitude or degree of corrosion occurs.

[0010] Rusting appears to be a cumulative, accelerating process. The initial formation or deposition of rust accelerates the rate of continued deposition. This is in part explained by the roughened surface of rust accumulation resulting in, among other things, increased sites for the formation of galvanic cells and exposure to oxygen owing to increased surface area of the rusted surface.

[0011] Rust prevention most frequently involves applying a protective coating to iron surfaces to inhibit the aqueous phase of the galvanic process. Frequently, physical removal (scraping, sanding, or buffing) of existing rust accumulations to smooth surfaces and remove accumulations of rust precede the coating process. The most common coating is some form of metal, rust inhibiting paint that protects the metal surface for exposure to oxygen and minimizes droplet formation directly on the iron surface. Other coating processes are used, including applying coatings of other, less rust susceptible materials such as zinc, to yield galvanized steel, or the use of stainless steel, which is iron with a relative high content of chromium plus a small amount of nickel. Although iron with high carbon content is harder than pig iron, it is not markedly less susceptible to corrosive forces.

[0012] Although not always immediately obvious in practice, accepted methods of rust prevention all directly reduce the formation of galvanic cells suggested as fundamental to rusting. Painting minimizes water droplet formation on the surface of the metal, and sanding and scraping remove rust accumulations thereby smoothing the metallic surface and reducing the number of sites for the initiation of the rusting process. Scrapping and sanding along with painting or other coating also minimize exposure to oxygen, thereby also reducing oxidative process and electron flow initiated in the anode region of a potential rust formation site where oxidative process occur.

[0013] Rust remains a significant economic and safety problem. Many current efforts focus on surface treatments to inhibit rust formation. For example, U.S. Pat. No. 6,562,474 issued May 13, 2003 to Yoshimi, et al. describes and claims both a method of coating steel sheets with a zinc or zinc alloy material to reduce corrosion and the resulting protected steel sheets. Uramoto, et al. in U.S. Pat. No. 4,642,011 issued Feb. 10, 1987 described a composition comprising an organic silicon compound that inhibited rust formation of threaded metal elements to which it was applied.

[0014] Thus, there remains room in the art of rust and corrosion prevention and remediation for methods and devices that reduce the rate and extent of corrosive process, remove existing deposits of corroded (rusted) materials, minimize weakening of structures as a result of treatment and do not require the application of coating, but act to disrupt the fundamental galvanic process at a fundamental level.

SUMMARY OF THE INVENTION

[**0015**] A purpose and objective of the invention is a method to inhibit rust formation of steel materials by exposing the material to a flame produced by unique hydrogen fuel or gas.

[**0016**] An additional purpose and objective of the invention is a method to remove rust from corroded iron materials by exposing such materials to a flame produced by a unique hydrogen fuel or gas.

[**0017**] A still further purpose and objective of the invention is a method to inhibit galvanic processes on the surface of iron that contribute to the formation of rust or to corrosive processes.

[**0018**] These and other purposes and objectives are realized by a method of treating iron materials that requires heat treatment of the metal surface by a flame produced with unique hydrogen fuel or gas, whereby the surface of the iron material is modified so as to inhibit galvanic process that result in the corrosion or the formation of rust on the surface of the iron material, the flame being delivered by a gas generator system and applied with a welding tip of a specific size, held at a desired distance from the surface of the metal suitable for applying the flame on the steel material, and passed over the surface area at a desired rate. One example of such a system is that described in U.S. Pat. No. 6,689,259 to Klein, which is hereby incorporated by reference in its entirety in this disclosure.

[**0019**] Generally, the invention is a method to remove and/or to inhibit corrosion of steel materials comprising: providing means for delivering a flame to a steel material, said means including a hydrogen and oxygen gas generator system; generating said hydrogen and oxygen gas as a source of fuel for the flame; treating said steel material by applying a flame to a desired area of the steel material to be treated; and traversing the area of the steel material to be treated with said flame at a desired rate sufficient to remove surface rust, if any, and to inhibit corrosion of said steel material, wherein said treating of the steel material causes changes in said treated areas of the steel material so as to inhibit galvanic processes that cause corrosion. The flame is applied using a welding tip of a predetermined size. The flame is applied from a predetermined distance above the area of the steel material to be treated. When the treated steel material is exposed to a corrosive environment over a continuous period of several months, the galvanic process that cause corrosion continues to be inhibited.

[**0020**] The method is made clear by reference to accompanying descriptions, descriptions, examples, drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[**0021**] **FIG. 1** schematically describes the general features of a mixed gas generator that that produces and utilizes the hydrogen and oxygen gases used in the present invention.

[**0022**] **FIG. 2** schematically illustrates rust removal and prevention results on a carbon steel sample in response to a flame treatment using the unique gas produced from the mixed gas generator similar to that schematically depicted in **FIG. 1**.

[**0023**] **FIG. 3** schematically illustrates rust removal and prevention along a cut edge of a sample of pig iron in response to the flame treatment method of the present invention.

[**0024**] **FIG. 4** schematically illustrates rust removal from the surface of a sample of carbon steel and the resultant inhibition of rust formation in conditions normally favoring corrosion.

DETAILED DESCRIPTION OF THE INVENTION

[**0025**] Gas welding systems that combine oxygen and acetylene gas to produce a variable temperature flame for gas welding are well known to those of average skill in the art. The present invention utilizes a flame produced by a novel gas produced in a novel manner. Treatment of metal (iron) surfaces with the flame produced by KLEIN gas, that is, hydrogen and oxygen gases generated by a system similar to that depicted in **FIG. 1** and in U.S. Pat. No. 6,689,259, removes existing rust and inhibits the formation of rust.

[**0026**] The fuel source for the welding flame is the hydrogen and oxygen gas mixture produced by a hydrogen gas and oxygen gas generator, which is part of the welder/flame generating system described above. An electrolyte solution is processed by the generator to yield oxygen gas and hydrogen gas. The two gasses are transferred to and stored as a single gas from which they are delivered (pumped) as a sole fuel source to a welding torch with a specific tip. Gas is delivered at a specific pressure and rates compatible with the tip in use. The incorporated U.S. Pat. No. 6,689,259 provides full and complete details of all aspects of a welder/flame generating system, including pumps, valves, and pressure control means from which **FIG. 1** provides a brief summary as background material in explanation in part of Examples 1, 2, and 3 as illustrated by **FIGS. 2, 3** and **4** respectively.

[**0027**] Generally, the device or system **10** comprises a hydrogen oxygen generator **12**, an electrolyte reservoir **14** with an electrolyte **16**, a gas storage tank **18**, gas reservoir **20**, welder unit **22** with gas delivery hose **24** and welding handle and tip **26**. Electrolyte **16** is pumped from the electrolyte storage reservoir **14** to the hydrogen and oxygen gas generator **12** as indicated by arrow head **28**. The hydrogen and oxygen generator splits gas water in the presence of the electrolyte **16** to yield hydrogen gas (H_2) and oxygen gas (O_2). The mixed gasses are transported **30** to the upper region of the electrolyte chamber **32**. Hydrogen and oxygen gas mixture may be delivered **33** to the welder **22** and transmitted by the hose **24** for combustion at the tip **26**, or transmitted **34** for storage to a tank **18**, thence **36** to the gas reservoir **20** from which the gas may be transmitted **38** to welder **22** for combustion as previously described. Unlike the traditional oxy-acetylene gas welder, the fuel is delivered as a single mixture of oxygen gas and hydrogen gas in a fixed proportion of approximately 2:1 hydrogen to oxygen.

[0028] In one modification of the invention, a second hose may deliver oxygen that is not used in the combustion process, but is used to "blow" debris (slag) from the work area.

EXAMPLE 1

[0029] **FIG. 2** is presented to illustrate the effects of the treatment of metal (iron) on rust removal and formation resulting from a flamed fueled by the gas described above and supplied by a gas welder system essentially as depicted in **FIG. 1** and the accompanying descriptions.

[0030] The flame produced was passed across the surface of a sample **40** of rusted carbon steel approximately 0.75 in (1.9 cm) thick. The flame was delivered by vector brazing tip size 0. No pretreatment was applied at ambient temperature of 81° F. (94.5° C.) and relative humidity exceeding 50 percent. No other gas was used in any phase of the treatment or as a post-treatment. Gas was delivered at 25 PSI and the flame moved across the surface of the sample at about 0.25 inches every 3 seconds, or 11 cm per minute.

[0031] The speed of the passing of the flame over the surface of the steel can typically vary with the tip size adapted to the torch. Torch speed can also vary depending on the amount of rust/corrosion present on the metal to be treated, for example new carbon steel with little oxidation could be treated quickly, or as part of production process as a pre-corrosion process to prevent or stop the normal rust/corrosion that occurs.

[0032] The initial rusted surface **44** is contrasted by a bright, silver-white surface **42** essentially the width of the flame applied along the full length of the application. Note shorter segments of treatment **46** and **48** illustrated the same silver-white sheen. Removal of the rust was essentially instantaneous. The rust inhibiting effect is illustrated by the fact that the rust-free areas depicted by regions (treated surfaces) **42**, **46** and **48** maintained the appearance for 30 months following treatment based on observations with 10× macroscopic observation to confirm observations of freedom from rust, and based on observations with the unaided eye. Untreated areas **44** continued to accumulate rust during the 30 month observation period following the flame treatment. The observed post-treatment samples were exposed to "normal" ambient, corrosive, conditions of Florida. Note that for illustrative purposes, in lieu of supplying actual photographs, the drawings **FIGS. 2-4** are submitted and the dotted or short dashed areas denote rusted areas of the surface of the sample of steel and areas denoted by cross-hatching or striations are symbolic of areas of the sample of steel where the surface was a bright shiny silver-white corrosion free appearance.

[0033] The conversion was a direct function of the flaming treatment or application. When the flame did not traverse the full length of the metal sample, the bright, rust free region extended minimally beyond the path of the flame. The width of the rust free area was essentially equal to the width of the flame treatment. Apparently the achieved remediation/prevention is not the result merely of heating the metal in that there is no effect of radiation of heat, although iron is a very effective heat radiator. The hydrogen gas and oxygen gas flame treatment apparently destroyed some element essential for the galvanic rusting process to proceed. Macroscopic observation failed to reveal any sample, mechanical changes that might reduce sites for droplet formation and the production of the galvanic cell. Potentially, the unique flame could have affected the distribution of anode and cathode regions on the metallic surface, thereby disrupting essential electron flow; microscopic changes in the metal's surface cannot be excluded. In either case, one thing is certain, the result of the treatment is significant and dramatic.

EXAMPLE 2

[0034] **FIG. 3** illustrates the removal and inhibition of rust resulting from flame treatment similar to that of Example 1. The sample **40** is a piece of low carbon (pig) iron **1** in.×25 in.×0.75 in. (2.54×73×19 cm). Interest in this example is on the cut surface or treated surface **42** of the sample. The sample was cut from a uniform sheet of material using a cutting (welding) torch with a size 4 cutting tip and the gas delivered at 28 PSI. The cutting was accomplished approximately 25% faster than expected using standard oxy-acetylene technology. Of significant interest, the cut edge **42** displayed the same bright silver-white sheen described in Example 1. Moreover, at 30 months post-treatment, the cut edge remains essentially rust free with a bright, silver-white sheen. Untreated areas of the sample continue to accumulate rust under storage conditions of ambient temperature and humidity in Florida.

[0035] In Example 2 as in Example 1, the actual treatment, cutting in Example 2, was accomplished with a flame fueled exclusively with hydrogen and oxygen mixed gas generator described above; however, in Example 2, a separate hose delivered oxygen to the cutting site exclusively to "blow" slag and cutting debris from the work site. There is no reason to expect that the oxygen affected the cutting or rust prevention processes.

EXAMPLE 3

[0036] **FIG. 4** illustrates the effect flame treatment of metal on rust removal and prevention. The flame was fueled by the hydrogen and oxygen generated mixed gas and delivered by a welding device essentially as described for **FIG. 1**. The flame was applied with a size 0 victor tip with gas delivered at approximately 20 PSI. The cone of the flame was approximately 2 inches (5 cm) and the flame traversed the surface of the sample piece at a uniform distance of approximately 0.125 in. (0.3 cm) from the sample surface.

[0037] The sample piece **40** was a 0.75 in. (1.9 cm) carbon steel strip with a generally uniform rusted surface **44**. Exposing the steel surface to the gas flame resulted in essentially immediate removal of rust and the metal displayed the silver-white **44** sheen previously described in Example 2 and 3. Following treatment, the sample was submerged in a salt (sodium chloride) water solution at room temperature for 60 days. Upon removal, the treated areas appeared to be discolored, but not significantly rusted. The discoloration was removed by gently brushing with a tooth brush. Subsequently, no rust formed during the observation period of 30 months.

[0038] Preferred embodiments of the invention have been described using specific terms and examples. Such terms and examples are for illustrative purposes only and not as limitations on the scope, purpose, or goals of the invention. Those of ordinary skill in the elements of examples can be combined to yield still additional embodiments of the invention. Thus, the appended claims should not be limited to the examples and embodiments herein, but include varied adaptations hereby anticipated.

I claim:

1. A method to remove and/or to inhibit corrosion of steel materials comprising:

providing means for delivering a flame to a steel material, said means including a hydrogen and oxygen gas generator system;

generating said hydrogen and oxygen gas as a source of fuel for the flame;

treating said steel material by applying a flame to a desired area of the steel material to be treated; and

traversing the area of the steel material to be treated with said flame at a desired rate sufficient to remove surface rust, if any, and to inhibit corrosion of said steel material,

wherein said treating of the steel material causes changes in said treated areas of the steel material so as to inhibit galvanic processes that cause corrosion.

2. The method according to claim 1, wherein the flame is applied using a welding tip of a predetermined size.

3. The method according to claim 1, wherein the flame is applied from a predetermined distance above the area of the steel material to be treated.

4. The method according to claim 1, wherein when the treated steel material is exposed to a corrosive environment over a continuous period of several months, the galvanic process that cause corrosion continues to be inhibited.

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