

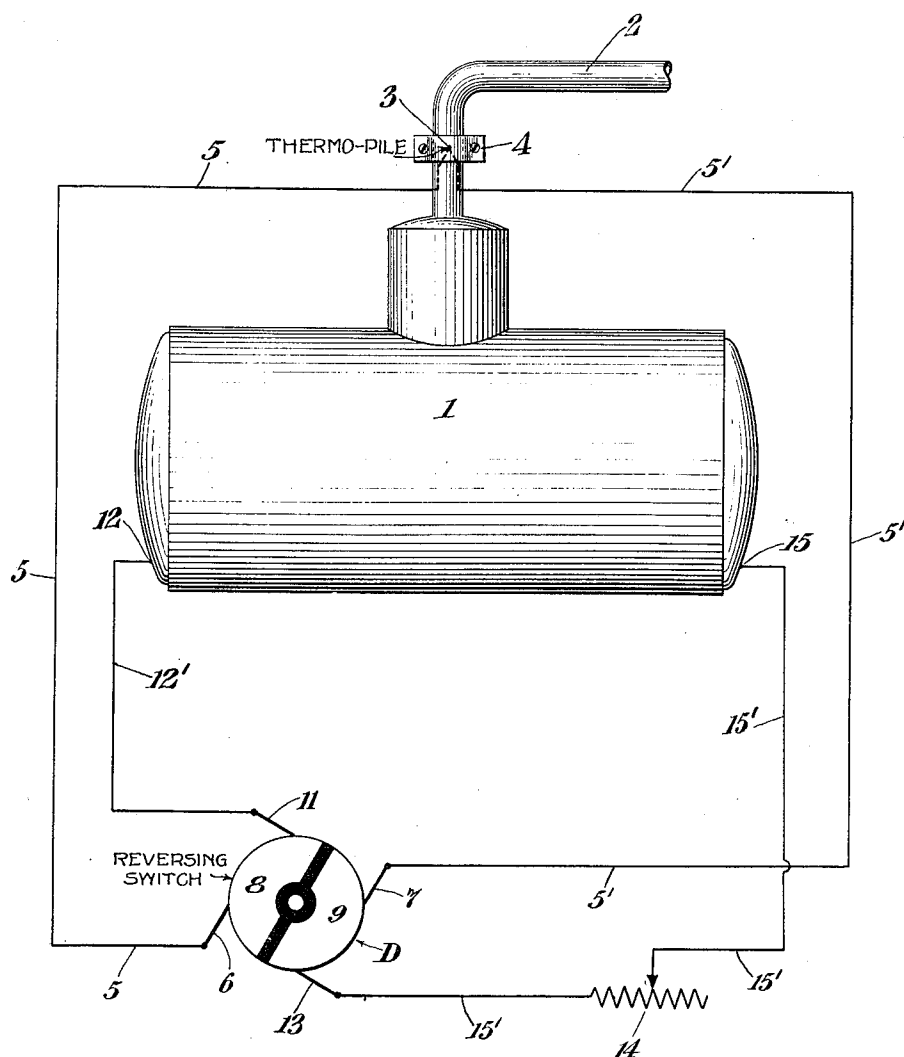
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METHOD AND APPARATUS FOR PROTECTION OF METALLIC SURFACES

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UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR PROTECTION OF METALLIC SURFACES.

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To all whom it may concern:

Be it known that we, GUY H. ELMORE and HENRY J. CREIGHTON, the former being a citizen of the United States, and a resident of Swarthmore, county of Delaware, and State of Pennsylvania, and the latter being a subject of the King of Great Britain, and a citizen of the Dominion of Canada, residing at Swarthmore, county of Delaware, and State of Pennsylvania, have invented certain new and useful Improvements in Methods and Apparatus for Protection of Metallic Surfaces, of which the following is a specification.

Our invention relates to a method and apparatus for preventing or eliminating the scaling or encrusting of metal in contact with fluid, a special and important embodiment and application of our invention being apparatus and a method whereby containers or conduits such as boilers, evaporators, economizers, condensers, cold and hot water pipes and the like are protected against the formation of scale from sediment or precipitates in the fluid therein contained and being processed.

The fact that scale or encrustation forms upon metallic surfaces that are in contact with fluid, particularly when the fluid is undergoing a change of character or temperature, is well known and the fact that under such condition electrolytic corrosion of the metal takes place is also well known, such corrosion being hereinafter referred to as normal or natural electrolytic corrosion, an example thereof being the rusting or pitting of a steam boiler.

It has heretofore been proposed to protect a metallic surface that is in contact with a fluid against the formation of scale or encrustation by passing an electric current through the metallic body of which the surface is to be protected, or by introducing the current to the metallic body and withdrawing it from the fluid or vice versa. And, it has been proposed heretofore to employ electric current of low voltage. In accordance with our invention we propose to introduce an electric current to and with-

draw it from the metallic body of which the surface is to be protected without directly introducing the current to or withdrawing it from the liquid that is in contact with that surface. We have found that the prevention and elimination of the formation and adhesion of scale or encrustation upon the surface of the metallic body that is in contact with the fluid can not be prevented merely by regulation of the voltage of current that is passed through the metallic body; and we have found that protection of such a surface against the formation of scale or encrustation may be effected by proper regulation of the amount of current flowing through the metallic body of which the surface is to be protected and that the voltage of that current must be properly regulated in order that the natural or normal electrolytic corrosion of that surface may not be appreciably augmented or accelerated by the means employed to prevent and eliminate scaling and encrustation.

In accordance with our invention the terminals of a source of electric current are connected to remote points of the metallic body of which the surface is to be protected against the formation and adhesion of scale and encrustation. The potential difference between the points at which the source is so connected is so regulated in accordance with our invention that the potential gradient, i. e., the ratio of the total potential difference between the points at which the source is connected to the distance between those points, will be low enough that the natural or normal electrolytic corrosion of the surface will not be appreciably accelerated or augmented. If the surface to be protected is of such form that points widely spaced along that surface are nevertheless in such proximity that current might flow through the fluid between those two points, the points of the surface which are to be connected with the terminals of the source of current are so selected as to avoid such straying or diversion of the current through the fluid. The value of the potential gradient that may be maintained along the extent

of the body of which the surface is to be protected will vary with the conditions to which that surface is subjected. The conductivity of the fluid in contact with the surface to be protected, the character of that fluid, for example, the chemical activity thereof with respect to the surface to be protected, the temperature of the surface to be protected, and the proximity of portions of the surface are conditions that may control the value of the potential gradient that must be employed and the points at which the source of current is to be connected thereto. In determining the proper potential gradient to be used, under the particular conditions surrounding the surface to be protected, and the points at which the source of electric current is to be connected to that surface, the controlling factor is that the normal or natural electrolytic corrosion shall not be appreciably augmented or accelerated beyond that which would take place if no electric current from an external source were passed through the body of which the surface is to be protected. We have found that, in some cases at least, the potential gradient should be lower with fluids of higher conductivity. The potential gradient having been ascertained the amount of current passing through the metallic body of which the surface is to be protected is to be brought to such value that formation and adhesion of scale or encrustation will ordinarily be prevented and in most cases previously formed scale will be removed. The amount of the current flowing through the body of which the surface is to be protected is not, in accordance with our invention, to be determined by a measurement of only the amount of current flowing but is to be determined by ratio of that current to the cross-sectional area of the metallic body of which the surface is to be protected. In other words it is the cross-sectional density of the current that is the measure by which the amount of current is to be regulated. If it be found that with a given potential gradient a certain amount of current will protect the surface of a given metallic body the current necessary to protect the surface of another metallic body of a similar metal under the same conditions must be such that the cross-sectional density of the current is substantially the same in both bodies.

Certain metallic bodies of which the surface is to be protected, for example, a steam boiler, have a current flowing in them that is produced by a thermo-electric or thermocouple effect in the metallic body itself, by reason of variations in the temperature and chemical composition throughout the metallic body, or by galvanic action due to contact of the metal with liquid or by some other cause, such a current being herein referred to as inherent current. In order to

insure the flow in those bodies of the necessary and effective cross-sectional density of current the direction of flow is determined of such inherent current, if any, between the points to which the terminals of the external source of current are to be connected. The source of current is then so connected to those points that the current therefrom will flow in the metallic body in the same direction as the inherent current. Otherwise, it may not be possible to produce within the metallic body a sufficiently high cross-sectional density to effect the desired result without the use of a potential gradient that will appreciably accelerate or augment the natural or normal electrolytic corrosion.

Having set forth a general rule whereby the potential gradient and current value are to be determined, we set forth as a specific example for the purpose of assisting in the practice of our invention, but with the understanding that our invention is not limited thereto, our observation that in connection with a steam boiler using water of medium hardness the objects of our invention are attained if the potential gradient is maintained at or slightly below one millivolt per foot of the length of the boiler and the current value is maintained at or slightly above one-third milli-amperes per square inch of the cross-sectional area of the metal of the boiler when the boiler is made of the usual boiler steel. We have found that so long as the potential gradient of the current is maintained at a sufficiently low value the current may be varied between fifteen milli-amperes per square foot of cross-sectional area of metal and several hundred milli-amperes per square foot thereof in order that sufficient current will flow to effect elimination of encrustation.

In accordance with our invention the flow of current through the metallic body of which a surface is to be protected is preferably effected by connecting the terminals of the source of current to remote points of the metallic body so that the metallic body completes the electric circuit and current will flow through it without being directly introduced to or directly conducted out of the fluid that is in contact with the surface to be protected. The potential gradient between the points of connection is brought down to or below a value that will not cause appreciable acceleration of the normal electrolytic corrosion of the surface. We have found that thermo-couples provide a convenient source of current that will produce the desired potential gradient between points that are not too far removed from one another. In accordance with our invention the current is so regulated that the value of the ratio of the current to the cross-sectional area of the body of which the surface is to be protected, i. e., the cross-sectional current

density, will be great enough to prevent the formation and adhesion of scale or encrustation, care being taken, however, that the inherent current, if any, flowing within the body by reason of its contact with the liquid, or for any other reason, does not negative the effect of the current supplied from the external source, and care being taken that the potential gradient is not increased to a value that will appreciably augment or accelerate the natural electrolytic corrosion of the surface to be protected.

It may be desirable to interrupt or reverse at various intervals the flow of current that is employed in the practice of our invention.

Understanding that we are not limited to any theory of the operation of our invention, it is our belief that the prevention of the formation and adhesion of scale is effected in accordance with our invention by neutralization or reversal of ordinary electrolytic corrosion action and by the formation of gas whereby scale or encrustation is prevented from forming and adhering. It may be, however, that the elimination of the formation of oxide or other compounds of the metal of the surface to be protected or the reduction of such compounds prevents the formation and adhesion of scale or encrustation, the admixture of products of electrolytic corrosion with precipitates or sediment in the fluid during the formation of scale or encrustation tending possibly to cause or increase the adhesion of the scale to the surface to be protected. With the same understanding but desiring to make full disclosure of our invention it is our belief that the flow of current through the body of which a surface is to be protected, when properly regulated and controlled, effects protection of the surface as follows: The electrons coming from the negative pole of the source of electric current attract to metallic [electro-positive] areas of that part of the surface of the container that is in contact with the fluid that is being processed therein, positive-charged hydrogen ions of the fluid that is being processed, and those hydrogen ions take up electrons from such surface and are set free as hydrogen atoms. The consumption of electrons reduces the flow of electrons to the positive pole of the source and negatively charged hydroxyl ions from the fluid that is being processed are therefore attracted to an electro-negative area [e. g., an impure spot in the iron] and they discharge there and restore the flow of electrons. The discharged hydroxyl ions are incapable of separate existence and decompose to form water and gaseous oxygen. The oxygen, or some part of it, collecting between the container or conduit surface and any scale thereon will ultimately exert sufficient force to loosen the scale from the metallic surface. The hydrogen atoms pro-

duced when the hydrogen ions are discharged, are consumed by the oxide of the metal of the container that has been formed [e. g., iron oxide]. The removal of the hydrogen from the liquid also prevents the accumulation of gaseous pressure of the hydrogen and permits the above described electrolytic action to proceed at such low voltages as may, without destructive action on the container, be employed. The removal of the hydrogen permits the continued separation in the fluid being processed of hydrogen ions and hydroxyl ions [i. e., dissociation of water] at the many places where impure and pure metal of the container are adjacent. The requirement that the cross-sectional density of the current shall have a certain value in accordance with our invention appears to indicate that in the theory above set forth there must be a certain density of distribution of electrons over the surface to be protected and that such density of distribution is produced by maintaining the cross-sectional density of the current at the proper value. The theory above set forth appears to require the presence of metallic oxide in order that removal of scale by gas pressure may proceed and thereby indicates the apparent desirability of an interruption of the current flow in order to permit the formation of sufficient oxide to produce, through its reduction, a necessary amount of gas to remove scale where the removal of scale is the desired end.

To assist in the understanding of our invention we have shown diagrammatically in the single figure of the drawings, apparatus embodying and whereby our invention may be practised.

A boiler 1 is provided with the usual steam outlet pipe 2. The junction 3 of the thermo-couple is held in contact with the steam pipe 2 by means of the collar 4, as a convenient means of heating the junction of the thermo-couple. The leads 5 and 5' of the thermo-couple conduct current to the brushes 6 and 7 of a reversing device comprising a disk D composed of conductive parts 8 and 9 separated by an insulating member 10, the disk being mounted for rotation. Brush 11 that bears on the disk is connected to one end of the boiler at 12 by the lead 12' and brush 13 is connected through a variable resistance 14 to the other end of the boiler at 15 by means of the lead 15'. The disk D may be continuously or intermittently rotated in order to effect a reversal of the flow within the body to be protected of externally supplied current, or, if there is a flow of current within the body to be protected by reason of its contact with the liquid, for example, from the point 12 to the point 15 or vice versa, the disk D may be rotated to a position that will cause the current from the thermo-couple 3,

or other source of current, to flow through the boiler 1 or other body to be protected in the same direction as the current therein that is due to its contact with the liquid.

5 It is to be understood that with different forms of boilers or other bodies of which the surface is to be protected, the points at which the source of current are connected may be varied in accordance with the
10 principles set forth herein and the source of current may be other than a thermo-couple or it may be a plurality of thermo-couples connected in such a way as to meet the requirements of our invention as herein set forth.

15 What we claim and desire to secure by Letters Patent of the United States is:

1. The process of protecting a surface of a metallic body against encrustation or scaling which comprises passing an electric current through the body and maintaining
20 throughout the body of which the surface is to be protected a potential gradient below that which will accelerate normal electrolytic corrosion thereof while maintaining a cross sectional density of current in the body
25 whereby encrustation and scaling of the surface will be eliminated.

2. The process of protecting a surface of a metallic body against encrustation or scaling which comprises passing an electric current through the body and maintaining
30 throughout the body of which the surface is to be protected a potential gradient below that which will accelerate normal electrolytic corrosion thereof while causing the
35 current flowing through the body to be of such strength as to eliminate scaling and encrustation of the surface.

3. The process of protecting a surface of a metallic body against encrustation or scaling which comprises maintaining the flow of an electric current through the body of such strength as to eliminate scaling and encrustation of the surface while maintaining
45 the voltage of the current below that which will augment or accelerate the normal electrolytic corrosion of the surface to be protected beyond what would occur in the absence of the current so passed through the
50 body.

4. The process of protecting a surface of a metallic body against encrustation or scaling which comprises connecting the terminals of a source of electric current directly to
55 spaced points of the body, regulating the current flowing in the circuit so formed and thereby eliminating scaling and encrustation of the surface while maintaining the potential difference between said points of connection below that which will augment or
60 accelerate the natural corrosion of the surface to be protected beyond what would occur in the absence of the circuit so formed.

5. The process of protecting a liquid-contacting surface of a metallic body against

encrustation or scaling which comprises connecting the terminals of a source of electric current to spaced points of said body and thereby completing an electric circuit including a part of said body, so regulating
70 the direction of current flowing from said source that current from said source produces in said body between said points a flow of current in the same direction as the inherent current in said body, and regulating
75 the current between said points and thereby eliminating scaling and encrustation.

6. The process of protecting a liquid-contacting surface of a metallic body against encrustation or scaling which comprises connecting the terminals of a source of electric current to spaced points of said body and thereby completing an electric circuit including a part of said body, so regulating the direction of current flowing from said
80 source that current from said source produces in said body between said points a flow of current in the same direction as the inherent current in said body, and regulating the current between said points and thereby
85 eliminating scaling and encrustation while maintaining the potential gradient between said points below that which will accelerate normal electrolytic corrosion of the surface.

7. The process of protecting a liquid-contacting surface of a metallic body against encrustation or scaling which comprises connecting the terminals of a source of electric current to spaced points of said body and thereby completing an electric circuit including a part of said body, so regulating the direction of current flowing from said
90 source that current from said source produces in said body between said points a flow of current in the same direction as the inherent current in said body while maintaining the potential gradient between said points below that which will accelerate normal electrolytic corrosion of the surface.

8. In apparatus for the elimination and prevention of scaling and encrustation of a surface of a metallic body, a source of current, electrical connections between the respective terminals of said source and remotely spaced points of the body of which
100 the surface is to be protected, said connections including a variable resistance and polarity reversing means.

9. In combination with a steam boiler, thermo-electric means, the junction of which is heated by heat from the boiler and connections between the respective terminals of said thermo-electric means and spaced points of the boiler, said connections including a
105 variable resistance and polarity reversing means.

10. The process of protecting against encrustation or scaling a surface of a metallic body in contact with liquid, which comprises passing an electric current through the body
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between spaced points thereof and maintaining in the body between said points a potential gradient below that which will accelerate normal electrolytic corrosion thereof while causing the current flowing through the body to be of such strength as to eliminate scaling and encrustation of the surface and intermittently reversing the direction of current flow between said points at suitable frequency. 10

In testimony whereof, we have signed our names to this specification.

GUY H. ELMORE.
HENRY J. CREIGHTON.