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J. F. KREML

2,765,271

ELECTROLYTIC CLEANING METHOD

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FIG. 1

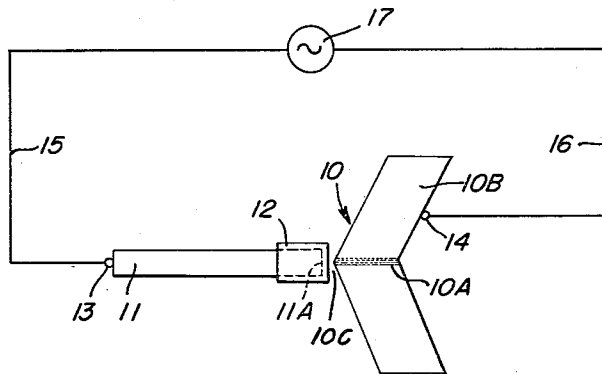


FIG. 2

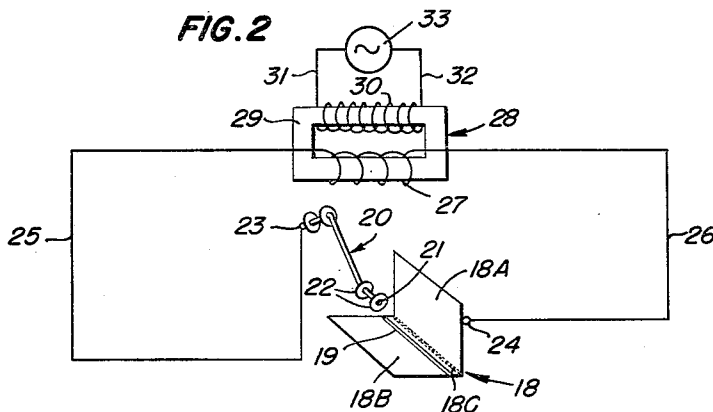
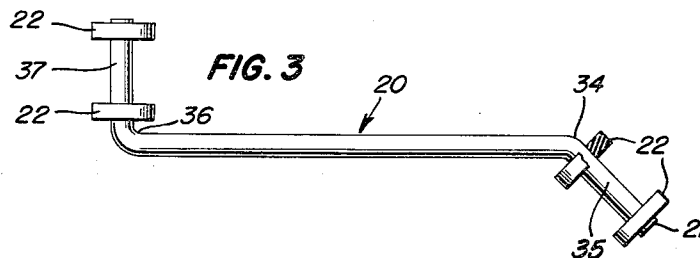


FIG. 3



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ELECTROLYTIC CLEANING METHOD

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1 Claim. (Cl. 204—145)

My invention relates to the problems of cleaning metal products such as are encountered in everyday practice in the sheet metal shop, and more particularly concerns a new method and apparatus for electrolytically cleaning weld-discolored products of stainless steel and other metals. The invention has particular adaptability to the effective cleaning of those welded joints which heretofore have been extremely difficult to clean through the use of abrasives and the like.

One of the objects of my invention is to provide a new method for the electrolytic cleaning, through the use of alternating current supply, of stainless steel and other metal products, which is at once simple, effective, entirely reliable, rapid and certain, involving minimum investment in both plant, power pack and labor requirements, the latter of but moderate skill, and which produces desired good finish on the metal work-piece in the region of the discolored weld, which is in close conformity with the original surface of the workpiece.

Another object is to provide an electrical circuit and apparatus for the electrolytic cleaning of weld- and other discolored stainless steel workpieces, employing alternating current supply of low voltage and high current densities in effective, efficient, certain and highly economical manner, using only readily available, comparatively low-cost electrical service, and functioning at high operating speeds, with easy maintenance, small space requirements and superior serviceability.

Yet another object is to provide an electrode for electrolytic cleaning of metal surfaces which is highly efficient, permitting effective contact thereof, at high current density, only on desired small regions of the workpiece, and which is effectively relieved of possibility of unintended contact of other parts thereof against the workpiece, and which at the same time is extremely simple, of low first cost, has long useful life, and can be readily replaced at but minimum expense, should occasion demand.

Other objects and advantages in part will be obvious and in part more fully pointed out hereinafter, during the course of the following disclosure, taken in the light of the accompanying drawings.

Accordingly, my invention may be considered as residing in the several parts, elements and features of constructions, and in the various manipulative and procedural steps, as well as in the relation and combination of each of the same with one or more of the others, the scope of the application of all of which will be more fully set forth in the claim at the end of this specification.

In the several views of the drawings, wherein like reference characters denote like constructional parts, Figure 1 discloses a circuit combination in accordance with my invention wherein I employ that type of electrode best suited for a workpiece displaying convex curvature in the region of cleaning;

Figure 2 is a schematic view, somewhat similar to that of Figure 1, but wherein the workpiece displays concave

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curvature in the region of cleaning; the electrode being best adapted for that particular construction;

Finally, Figure 3 is a fragmentary view, on enlarged scale, partly in elevation and partly in section, disclosing some of the details of the electrode according to Figure 2.

As conducive to a more ready and thorough understanding of my invention, it may be noted at this point that considerable problem has been interposed by, and considerable research has been directed towards, the removal of the discoloration occasioned for various reasons and by various circumstances on the surface of metal products in the production and fabrication thereof. Particularly has such difficulty been encountered in the removal of such surface staining from stainless steel products. An especial difficulty has been encountered as a result of discoloration attendant upon welding operations involving stainless steel metals. It is, of course, desired to remove this disfiguring weld-staining, and to restore, to the extent possible, the original pleasing surface finish of the metal. Much attention has been directed to this problem, throughout various fields of the industry, and this over a long period of years.

At first it was considered imperative in the cleaning operations undertaken, that the metal workpiece be submerged bodily in a bath of suitable electrolyte, with an electric current passed from a suitable electrode across the electrolyte to the workpiece. This of course, however, introduced substantial practical limitations. First of all, the plant demand was excessive. Large space requirements existed. Careful attendance and supervision was required. The existence of electrolyte in such large quantities presented a hazard at all times. Important practical limitations were placed upon the size of metal workpiece which could be operated upon in such baths. And frequently it was necessary to undertake to clean only a small portion of the workpiece at a time, bodily moving the same in the bath from time to time to expose new portions. Electrolytic action was selective, and no assurance of predictable uniform results existed. Moreover, practical limitations were placed upon the selection of the electrolyte which could be effectively employed. Whereas, many electrolytes are particularly suited for particular types of metals and particular operations on such metals, it nevertheless was found that where a large bath was employed, severe practical limitations existed as to the effective use of such selective electrolytes.

When attention was directed to employing only a small quantity of electrolyte and this over only a small region of the workpiece, the associated electrode being moved bodily over a small region of the workpiece, or the workpiece being moved to a limited extent relative to the associated electrode, it was found that the choice of electrolyte used was widened markedly. However, several practical difficulties attended upon such technique, for the reason that so far as was known, only direct current supply could be employed. It was thought to be impracticable, and in fact detrimental, to employ an alternating current supply. Anodic current supply was considered imperative. This involved, of course, the necessity of initial heavy investment in electrical plant, including either a direct-current generator; or if the available electrical service supplies were employed, then the conventional and expensive motor-generator set had to be interposed between the service leads and the electrolytic circuit. All in all, it was considered totally impractical, in such electrolytic circuits, to depart from the necessity of anodic treatment.

It was well recognized, however, that provided it were possible to employ an alternating current supply in such cleaning processes, an important advance in the art would

be achieved, attended by very real and material savings. Accordingly, much attention has been directed over a period of years to a proper development of an alternating current cleaning method. For one reason or another, however, all such attempts have fallen singularly short of success, when viewed from a practical standpoint.

An important object of my invention therefore, is to provide a method, together with suitable apparatus for carrying such method into operation, for effectively cleaning stainless steels and other metal products through the use of alternating current supply of required low voltage and high current ratings, and this with minimum investment, both originally and in subsequent maintenance of plant, labor, and the like, all with marked savings in cleaning time, and with important other practical advantages.

Thus, in accordance with the practice of my invention, I have found that highly advantageous results can be achieved by associating with the workpiece to be cleaned, a suitable electrode of high electrical conductivity. This electrode, of small dimensions, is moved bodily over the surface of the workpiece in the region to be cleaned. Great care must be observed, throughout the cleaning process, to ensure that no direct contact occurs between the electrode and the workpiece, so that shorting and arcing can not occur. Provision must be made that there is always interposed between the two electrodes, a thin layer of suitable electrolyte, the nature of which will be discussed later herein.

I impress across the two electrodes comprised of the electrode proper and the workpiece, a suitable source of alternating current supply, ranging ordinarily from about 4 to about 24 volts impressed voltage across the electrode terminals, with high current rating, say in the order of 3 to 5 amperes.

It will be noted that I have given a practical voltage working range of about 4 to 24 volts. While higher voltages can be employed, allowing shorter time cycles in the operation, I find that, generally speaking, higher voltages are not practical. This is due, at least in part, to the limited quantity of electrolyte employed. With the small quantities of electrolyte employed, then at higher impressed voltages some fuming and spattering of the electrolyte occurs and in general, danger of shorting is enhanced. Conversely, while lower voltages can be employed, this has practical disadvantage, due to the much longer time cycle required, which is roughly proportional to the diminution in voltage.

The form of electrode which I associate with the workpiece may assume any desired configuration, within practical limits, depending upon the specific application for which it is intended. Thus, such configuration and dimensions are in part determined by the contour of the parts to be cleaned and as well by the area to be cleaned, having always in mind, the permissible current densities required.

Generally speaking, however, the electrode I find most practical for general work is readily formed from say, an 8 inch section of round or flat material. This material, usually copper, may have say, a 1/4 inch diameter. About 1 to 2 inches from the end thereof this electrode conveniently is bent to a 45° angle. Where desired the other end thereof is given a 90° right-angle bend. The working end of the electrode thus may be selected to accommodate the particular job. I protect the working end of the electrode with one or more narrow bands of rubber, fiber or other insulating material. And the electrode with insulators, or bumpers, is particularly suited for use with workpieces having regions to be cleaned which are generally in the shape of a pocket or the like, having a generally concave curvature, so that the electrolyte can be pocketed therein.

Where, however, the workpiece has an externally rounded or convex curvature, so that no pocket or reservoir for the electrolyte can conveniently be provided, then

the electrode may be partly or completely covered with a suitable insulating material capable of holding a small quantity of electrolyte, such for example, as glass wool cloth, asbestos cloth, or some other porous and electrically insulating material. The requirement in common of such materials is that they positively insure electrical separation of the electrode proper from the workpiece, and at the same time will hold a sufficient quantity of electrolyte to insure the interposition of the same between the two electrodes in the electrical system.

Either this electrode may be dipped into the electrolyte prior to starting the electrolytic action, and be replenished from time to time by dipping technique, or the electrolyte may be fed thereto in small quantities, either intermittently or continuously, as by dripping throughout the cleaning operation. I find that with the use of alternating current electrical supply, and due to electrolytic action upon the electrode itself, it may be necessary, very occasionally, to replace the electrode, due to the gradual loss in size resulting from the high current density carried. When this is required, it is but a matter of a moment, and involves only small cost, to replace the electrode, whereupon the electrical apparatus is again ready for service.

It may be properly inferred from the foregoing that the operational procedure itself is not involved. One pole of the electrical service is connected to the workpiece, while the other pole is connected to the associated electrode. Upon the application of alternating current through the electrical circuit the cleaning action begins when the circuit is completed through the electrolyte by placing the electrode on the surface of the workpiece in the region where cleaning is desired. The end or tip of the electrode is thereupon rubbed gently on the discolored area, great caution being observed to avoid contacting the bare center of the electrode rod directly with the workpiece.

Preliminarily, however, all slag is removed from the weld prior to the cleaning operation, as by wire-brushing or chipping. I find that cleaning is rapid and effective, and is under excellent control.

Different techniques are employed in the use of my method, depending upon whether the workpiece displays convex or concave curvature in the region of the weld. Where concave curvature exists, thereby providing a pocket for a small amount of the electrolyte, then the open rubber bumper type electrode, such as I have disclosed in Figure 3 of the drawings, is most practical.

Where convex surfaces or outside surfaces are to be cleaned, however, then I prefer the electrode of Figure 1. In this embodiment, the electrode there shown is best suited for cleaning outside corners, butt welds, vertical or overhead welds or areas that will not provide a suitable pocket for the electrolyte. In this embodiment glass cloth or asbestos cloth wrapped around the electrode is found to be an extremely satisfactory holder for the electrolyte. Briefly stated, the covered electrode is dipped into a container holding the electrolyte, and is then rubbed gently on the discolored area, the while being kept moistened with the electrolyte. Following cleaning, of course, the workpiece is thoroughly rinsed with water.

While any suitable electrolyte may be employed, I find that electrolyte which is most practical for cleaning weld discoloration from welded stainless steels is a 50% by volume solution of commercial phosphoric acid, that is, of 70% to 85% concentration. Variations in the concentration of the solution can be effectively employed to produce different desired results. Illustratively, a semi-lustrous or bright surface can be produced by employing a phosphoric acid solution of higher concentration, say up to a 100% solution of 70% to 85% acid, and employing a somewhat longer time span. Conversely, lower concentrations of the solution, say down to 20% by volume of the 70% to 85% phosphoric acid, will remove the weld discoloration, but will produce a somewhat dull color

on the workpiece, which may be likened roughly to an etching action. Effective concentration, determined in the actual practice of the invention in ready manner, will enable the worker to match rather exactly the cleaned areas with the original surface.

It is entirely within the province of my invention to use other effective and advantageous electrolytes, such for example, as nitric acid, hydrochloric acid, or sulfuric acid. These all will effectively remove the weld discoloration according to the practice of my invention. However, I find that they fume more readily, or may cause pitting. Generally speaking, they are more difficult to handle. All in all, therefore, I find that a 50% solution by volume of 70% phosphoric acid gives the best all around results in effectively removing the discoloration and this without attendant odors and fuming of the acid, while giving good uniformity of color of the cleaned area, and making it possible to match this cleaned area with the original surface of the metal. Where a less active attack on the metal surface is desired a less concentrated solution of phosphoric acid may be used as noted above.

The time cycle for weld cleaning in accordance with the practice of my invention is found to depend upon a number of factors, and upon the correlation of the same. Illustratively, these include the relative area of the work made active, the current applied, the current density and the intensity of discoloration. It is apparent that the small amount of electrolyte used limits the flow of current. Accordingly, I find it to be highly advantageous to construct the electrode small in bearing area on the workpiece, thereby permitting transmission of high current density to the work.

And now having reference to the several embodiments of apparatus which can be advantageously employed in the practice of my invention, but which obviously have practical pertinency aside from the particular method herein described, it will be seen upon consideration of Figure 1 that the workpiece, indicated generally at 10A. Discoloration on the convex surface 10B thereof is to be removed through electrolytic action. For this purpose, therefore, I employ a cleaning electrode indicated generally at 11. It will be recalled that since the convex surface 10B of the workpiece 10 will not permit the formation of a pocket for the electrolyte, it is therefore necessary that the electrolyte be carried in some other manner. In the practice of my invention the working tip or end 11A of the electrode 11 is applied against that surface of the metal workpiece 10 which is to be cleaned. A thin layer of suitable electrolyte, such as the phosphoric acid solution hereinbefore described, is interposed between the electrode and the workpiece. This I accomplish by providing a layer of suitable insulating material, porous and absorbent in nature, about the electrode 11 which retains an absorbed amount of the electrolyte. Such electrode-holding material is indicated generally at 12, and may comprise glass wool, asbestos cloth or similar suitable material wrapped closely about the electrode 11. The covered electrode 11 is then dipped into the container holding the electrolyte whereupon it is rubbed gently upon the discolored area.

Workpiece 10 and electrode 11 are connected to opposite poles 13 and 14, of an alternating current electrical circuit. This circuit comprises leads 15 and 16 energized by a suitable source of alternating current electrical supply indicated generally at 17. It will be noticed that the source 17, leads 15 and 16, poles 13 and 14, electrode 11 and workpiece 10 are connected together in series connection, along with the narrow gap or space indicated generally at 10C extending between the two electrodes, and which is normally bridged by the electrolyte.

It will of course be seen that when an electrical supply rated at ordinary frequencies, say 60-cycle, is impressed across these electrodes, the polarity of direction of current flow will alternate twice during each cycle of such current flow. For the first half of the cycle the workpiece

10 is made the cathode and the electrode 11 the anode, while during the next succeeding half-cycle, the polarity of these two are reversed.

Whereas heretofore this has been considered totally impractical from an operational standpoint because of expected etching, I find that in actual practice and with proper choice of voltage and of current density, not only are the results which are achieved equal to those heretofore obtained by direct-current practice, but in fact, and surprisingly enough, superior cleaning results are obtained, and this in less time than heretofore has been the case.

The voltage impressed by the alternator 17 on the terminals 10 and 11 can be adjusted in known conventional manner to desired value, but typically are maintained within the range of 4 to 24 volts, while current densities are maintained comparatively high, within the range of say $\frac{1}{2}$ ampere to 5 amperes per square inch of electrode area bearing on the workpiece.

In the typical embodiment here disclosed, it was found, for example, that the glass wool-covered electrode, soaked in a 50% solution of 70% phosphoric acid, enabled effective cleaning of the workpiece at the rate of two-thirds of one linear foot per minute. Of course, variation in this rate can be achieved by a variation in the voltage and by variation in the current density, as by the use of a rheostat or other current limiting means, illustratively a choke coil or the like.

While the Figure 1 embodiment has been directed to the treatment of workpieces having convex curvature in the neighborhood of the weld, the Figure 2 embodiment is directed primarily to that form of the apparatus best suited for carrying out my new method in those cases where the workpieces have concave curvature in the region of the weld so that a pocket is provided for storing and carrying the electrolyte. In this case, with the electrolyte provided directly on the metal workpiece, it is unnecessary to carry the electrolyte in a cloth or other container about the electrode surface.

In this latter embodiment the workpiece is indicated generally at 18, and is here shown as being somewhat V-shaped in section, so as to provide two sides 18A and 18B. A concave cavity or inside corner 18C is provided at the junction of the two sides. Here is housed a suitable and small quantity of electrolyte 19, which illustratively, in the cases of stainless steel, may be the same electrolyte as that described with respect to the Figure 1 embodiment, namely, a 50% water solution of 70% commercial phosphoric acid.

Associated with the workpiece 18, and as the other electrode of the electrical circuit hereinafter to be described, is the electrode proper, indicated generally at 20. This is in the nature of an elongated pencil. While it may have any suitable dimensions and may be formed of any suitable metal of high electrical current carrying capacity, in the preferred embodiment here illustrated it comprises a copper rod approximately 8 inches long and say, of $\frac{1}{4}$ inch diameter, having say, a one square inch working area. A working tip or the like 21 is employed at the leading end of the electrode and it is this working tip which has the one inch bearing area. In use, the electrode is rubbed gently across the workpiece 18 in the region of the weld-discoloration. It is of course essential, however, that the electrode be suitably shielded from inadvertent short-circuit against the workpiece 18, so that at all times the electric circuit is established through the electrolyte. I accomplish this, as shown in Figure 3, by the use of a buffer or bumper indicated generally at 22. This bumper effectively shields the electrode 20 from contact along the extent of the workpiece 18.

Poles 23 and 24 connect leads 25 and 26 to the low tension secondary 27, made up of a few turns of large diameter wire of the step-down transformer indicated generally at 28. The conventionally shown iron core 29 thereof has the high tension primary winding 30 thereof wound on its other leg. This secondary winding is of course,

made up of a comparatively large number of turns of comparatively fine diameter wire and in turn is energized by leads 31 and 32 connected across a suitable source of alternating current supply of conventional voltage rating, indicated generally as source 33.

In the use of the Figure 2 embodiment, the joint 18C was prepared by inert-gas, tungsten-arc welding. The inside of the weld was cleaned through the used of the electrode 20 and with a 50% phosphoric acid electrolyte. The electrode, having the 1 square inch working area described, and operating at 3 amperes current impressed by 8-volt secondary supply, enabled the complete removal of weld-discoloration at the rate of 4 square feet per minute. This I find to be substantially in excess of that heretofore obtained using prior art practices, as for example by the use of apparatus employing direct current supply.

While it has been discussed hereinbefore that the electrode can be adapted for any particular problem, one practical for general work is that shown in Figure 3. Here the electrode 20 is formed of one-quarter inch round or flat material of about 8 inch over-all length. At a point 34 about one or two inches removed from the tip 21, the leading portion 35 of the electrode, and which has thereon the contact tip 21, is bent downwardly at a suitable actuate angle, here shown as being approximately 40°. Similarly, the remote end is bent at 36, into a right angle, to form a leg as shown at 37, at a point approximately one or two inches from the end thereof.

I have discussed hereinbefore that a bumper or the like 22 is provided on the working end 21 of the electrode 20, so as to guard the latter against inadvertent direct short-circuiting against the workpiece. This bumper 22 may assume any desired shape and may be formed of any conventional material. Here, it is shown as a radially extending collar or annulus formed of rubber. It may, however, have any other configuration and may be formed of any other suitable material, such as synthetic rubber, hard rubber, or generally similar material. These I have included under the generic name rubber-like material.

It is apparent from the foregoing that my new method, and the apparatus and the electrode for carrying the same into execution, for the first time makes it possible to employ the limited electrolyte practice into commercial use, while employing alternating current supply. Important practical advantages attend upon this practice. The

power pack is simple, compact, of low cost and is readily serviced. It displays long, useful life. The necessity of motor-generator is avoided. Costly resistors, with attendant cooling problems, are no longer required. Impressive savings are achieved, in the time required. Surface appearance can be closely controlled, the surface discolorations on metal objects are effectively removed, both in stainless steel and other metal products, and particularly, so in the case of those discolorations resulting from welding techniques.

It is apparent from the foregoing that once the broad aspects of my invention are disclosed, many embodiments thereof will readily suggest themselves to those skilled in the art, and all falling within the scope of my disclosure. Similarly, many modifications of the presently-disclosed embodiments will likewise suggest themselves. Accordingly, I intended the foregoing disclosure to be considered as simply illustrative; it is not to be construed by way of limitation.

I claim as my invention:

A method of cleaning a weld-discolored stainless steel workpiece, comprising moving an electrically-conductive electrode bodily across the workpiece in the region of the weld with the interposition therebetween of electrolyte comprising approximately 20% to 100% by volume of a water solution of phosphoric acid of about 70% to about 85% concentration, and impressing thereacross an alternating current of about 60 cycles per second operating at voltage ranging from about 4 to about 24 volts and at high current density.

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