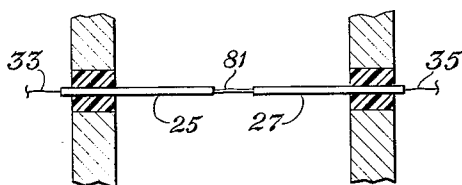
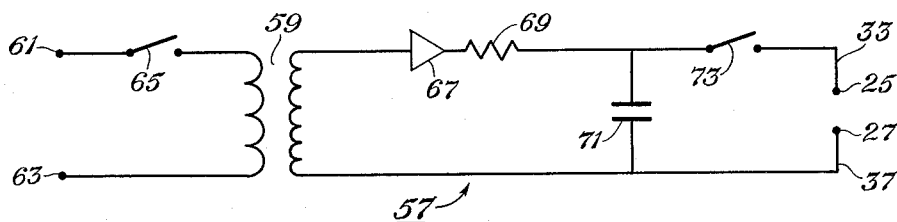
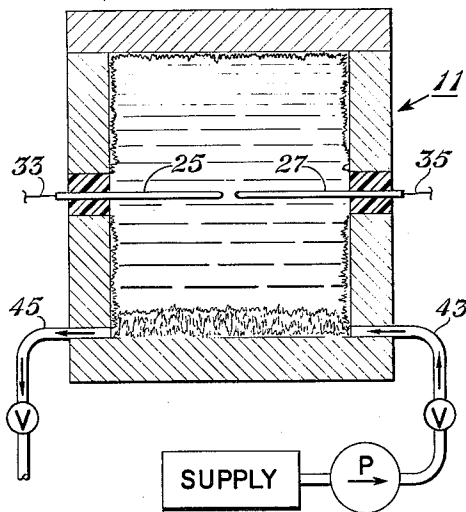
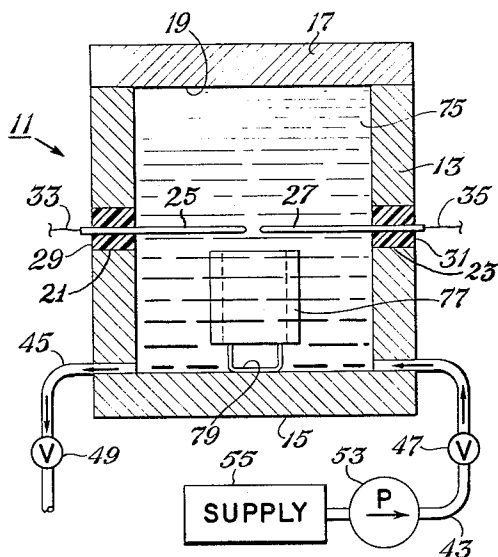


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COATING AND IMPREGNATION OF ARTICLES BY
SPARK GENERATED SHOCK WAVES
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1

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COATING AND IMPREGNATION OF ARTICLES BY SPARK GENERATED SHOCK WAVES

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This application is a continuation-in-part of U.S. application Serial No. 154,240, filed November 22, 1961, now abandoned.

My present invention relates to improved methods of transferring materials from non-gaseous fluid media and for depositing such materials on or within selected articles. More particularly, my invention relates to improved methods of coating and impregnating of articles, plating of articles, and removing of constituents from solutions.

It is the general object of this invention to provide improved methods for the transfer of materials from selected non-gaseous fluid media and depositing these materials upon or within selected articles.

Another object of my invention is to provide methods whereby the surface of articles may be plated with a selected metal or metals.

Another object of my invention is to provide methods whereby surfaces of selected articles may be coated and impregnated with a substance having desirable characteristics, such as good lubricating ability, for example.

Another object of my invention is the provision of methods whereby constituents may be removed from solutions.

These and other objects of my invention will become apparent from the following description, taken in accordance with the accompanying drawing, in which:

FIG. 1 is an elevational view in cross section, illustrating schematically apparatus having particular utility in the coating or plating of articles.

FIG. 2 is a schematic electrical diagram, showing a power unit that is suitable for use with the FIG. 1 apparatus.

FIG. 3 is another elevational view in cross section, illustrating schematically apparatus that is particularly useful in the reduction and recovery of materials from solution. The power unit shown schematically in FIG. 2 may also be used with this apparatus.

FIG. 4 is a fragmentary elevational view showing the electrodes of FIG. 1 or FIG. 3 with a filament extending between said electrodes.

My invention derives from the discovery that the discharge of a selected quantity of electric energy within a selected time interval and at a selected discharge current level from electrodes immersed in an appropriate non-gaseous pressure transmitting media within a closed chamber or cavity is capable of the transfer of materials from said non-gaseous media and depositing these materials upon or within selected articles. For example, a lubricating fluid, if retained in a cavity and subjected to the discharge of electric energy in the manner generally described above, will coat and impregnate the surfaces of articles placed in the cavity. This is one aspect of what is called a "coating technique," as will be explained later. Moreover, if the fluid in the cavity is a solution of a metallic salt or a suspension containing a metal, a metal plating will be formed on surfaces of articles in the cavity when electric energy is discharged in the cavity in the manner generally described above. In addition, constituents may be removed from chemical compounds when subjected to the phenomenon described above.

Thus, my invention has three rather distinct areas of application and these areas will be discussed separately in the following detailed description in the interest of clarity and convenience. The coating technique (which

2

encompasses impregnation with nonmetallic substances, such as lubricants) will be discussed first, then plating, and then solution constituent removal.

Apparatus which may be used to practice the coating technique will now be described. Referring to the drawing, FIG. 1 illustrates a treatment receptacle 11 that includes sidewalls 13, a bottom 15 and a removable top 17, all of which define a chamber or cavity 19 within the receptacle 11. The sidewalls 13 and bottom 15 are preferably integrally formed and have a substantial thickness, for a purpose that will be disclosed hereinafter. The top 17, though removable, also has a substantial thickness for the same purpose and, when it is in place on the walls 13 of the receptacle 11, it may be secured and sealed thereto in any appropriate manner. In the sidewalls 13 is provided a pair of opposed openings 21, 23 through which a pair of electrodes 25, 27 extend into the cavity 19. The electrodes are electrically insulated from the sidewalls 13 by means of suitable insulating inserts 29, 31, or in any other suitable manner. The electrodes 25, 27 are located in any convenient position, but for most purposes, are preferably located in the central region of the cavity 19. Attached to the electrodes 25, 27 are conductors 33, 35 respectively, which are connected in the output circuit of a suitable electric power unit (as will be explained later in connection with FIG. 2).

A first fluid conduit 45 communicates with the cavity 19 and is connected to a first valve 49. A second conduit 43 communicates from a supply reservoir 55 via a fluid pump 53 and a second valve 47 to the cavity 19.

A typical electric power unit 57 is diagrammatically shown in FIG. 2. The power unit 57 includes a transformer 59, the primary winding of which may be connected at terminals 61, 63 to a source of alternating current via a suitable switch 65. The secondary winding of the transformer 59 is connected in series with a suitable rectifier 67, a current limiting resistor 69 and a capacitor bank 71. The capacitor bank 71 is connected in series with a second switch 73 and the electrodes 25, 27 by means of the electrical conductors 33, 35. For a more detailed description of an electric power unit that is also suitable in practicing the present invention, reference may be made to Patent No. 3,093,770, issued June 11, 1963, to Richard H. Wesley et al.

The coating and impregnating method of my invention will now be described, with lubricants being utilized as examples of the coating and impregnating materials.

A suitable lubricant 75 is received within the chamber 19; such lubricant may be of any desired type, organic, inorganic, or a mixture of the two, such as an inorganic material carried in an oil or grease. For instance, organic material such as a paraffin based oil, a naphtha based oil, a grease (mineral oil and soap) or an animal, vegetable or fish oil may be utilized, according to the lubricating property desired. The paraffin based oil would provide a firmly adhering film, not subject to carbonization, while the naphtha based oils would provide a heat resisting lubricant, having considerable fluidity at reduced temperatures. Inorganic materials that might be used would include graphite, vermiculite, wax, soapstone, and molybdenum disulfide. Such lubricant is in the form of a non-gaseous fluid, which may be in the nature of a liquid, or it may be a powder. Insofar as this invention is concerned, liquids and powders have the same characteristic fluidity, and therefore whenever the term "non-gaseous fluid" is hereinafter used, it will be understood as applying to either a liquid or a powder.

The viscosity of the fluid lubricants is relatively unimportant, and may range anywhere from 135 to 2500 seconds Saybolt, at 100° Fahrenheit, depending upon the job requirement. Generally, specific gravity of the oil

used will be approximately 0.80 to 0.86, with an approximate Saybolt viscosity of 135 to 210.

As shown in FIG. 1, the part 77 to be coated and impregnated with a lubricant is then placed upon support 79 within the chamber 19 and thus submersed in the lubricant 75. It is to be recognized that the particular material of which the parts to be coated or lubricated are made is relatively unimportant and that they may be of any characteristic hardness. For instance, in the case of tool steels, these may be of carbon steel, alloy steel, etc. In the case of bearings, they may be of chromium irons and steels. Surface impregnation with a lubricant may likewise be effected on parts made of materials such as ceramics, aluminum, magnesium, etc.

Next, a selected quantity of electric energy is discharged across the electrodes 25, 27 inside cavity 19. To achieve an electric discharge with the apparatus shown in the drawings, the switch 65 (see FIG. 2) is first closed and a quantity of electrical energy is stored within the capacitor 71. Then switch 73 is closed and a selected quantity of electrical energy is discharged across the electrodes 25, 27. The primary factors involved in the production of effective and satisfactory electric energy discharge effects are: the quantity of stored electrical energy available for each energy pulse; the amount of electric current; the time of discharge of the energy and the volume of the cavity, or chamber, in which the energy is discharged. The primary effect of the energy discharge insofar as the present invention is concerned is thought to be the production in the pressure transmitting medium of a high intensity steep wave-front shock wave accompanied or immediately followed by a very high pressure build-up. It is emphasized that the shock wave just mentioned is of a mechanical nature and is not an electric shock.

In a typical instance, where the pressure transmitting substance is water, preferably at atmospheric conditions and ambient temperature, a quantity of electrical energy in the range of between 2500 and 22,000 joules may be required in a chamber having a volume of about one gallon capacity. That is to say, the required energy per unit volume may be selected from values proportional to the values within the range of 10 to 96 joules per cubic inch. Moreover, the discharge current should be at least 1500 amperes, and the time of discharge should be less than one millisecond. The energy-volume value will, as mentioned, vary proportionately with the size of the chamber and the current, in amperes, may vary between about 1500 and 300,000, with a preferred minimum value of about 5,000. For a given chamber volume, the intensity of the shock-wave impulse and the pressure build-up may be controlled, to a large extent, by the quantity of stored energy and the discharge interval of time; it being understood that a shorter discharge time interval produces a more intense and sudden shock-wave impulse and pressure build-up. Consequently, preferred discharge time interval may be within the range of between 50 and 300 microseconds, but, in any event, it should be not more than one millisecond.

The consequences of the electrical discharge across electrodes 25, 27 will effect coating and impregnation of the parts with the lubricant in which they are submerged. There will be a primary impregnation of the part 77 and an incidental impregnation of the inner surfaces of the receptacle 17. The impregnation of part 77 with lubricants is of course extremely beneficial when the part is used under conditions necessitating the presence of lubrication.

The above detailed description is directed in general to coating and impregnating with nonmetallic materials, and in particular, with a lubricant. It should be understood, however, that my coating method is applicable to the coating of articles with any nonmetallic substance that may be contained in fluid, including solutions and suspensions. For example, a suspension of the thermoplastic

resin polytetrafluorethylene (marketed under the trademark "Teflon") has been utilized in practicing the method of my invention, resulting in the coating and impregnating of articles to provide significantly improved durability characteristics.

The plating technique will now be discussed. This area of my invention is similar in many respects to the coating technique described above. It should be remembered that the coating technique will accomplish coating and impregnating of articles with the non-gaseous fluid in the form of a chemical compound and additionally with non-gaseous fluids containing nonmetallic substances. When the non-gaseous fluid is a chemical compound the coating and impregnating on the article placed in the receptacle is accomplished without any apparent changes in the deposited fluid. That is, for example, when a lubricant is used as the non-gaseous fluid in the receptacle, the articles placed in the container become coated and impregnated by the method, while the lubricant retains its original form. Of course, repeated electrical discharges in a lubricant, especially in an organic lubricant, sometimes causes the lubricant to break down. Nevertheless, the articles placed in the receptacle 11 become coated and impregnated by the lubricant in its original form. Also, when the coating and impregnating fluid is a suspension containing a nonmetallic substance, the deposited material includes such substance without any change in its chemical form. In plating, when the plating fluid is a suspension containing a metal, the metal is deposited without any change in its chemical form. However, when the plating fluid contains a metallic salt solution, the practice of the method of my invention actually results in a change in the chemical form of the metallic salt, with metal being actually separated from the salt and deposited on the articles to be plated.

The plating is effected by placing the article to be plated inside the receptacle 11 of FIG. 1. Then a fluid, for example, a metallic salt solution is introduced into the receptacle. Then switch 65 (see FIG. 2) is closed, thus storing electrical energy within the capacitor 71. The switch 73 is closed and a quantity of electrical energy is discharged across the electrodes 25, 27. The steep front pressure wave generated in the fluid in receptacle 11 by the sudden discharge of electric energy separates the metal from the metallic salt solution and deposits this metal on the surface of the article, plating same.

An example of a successful plating procedure is as follows:

A plating solution consisting of one pound of copper sulfate, six ounces of 95 percent sulfuric acid and enough water to produce one gallon of solution was prepared. The parts to be plated (these included parts fabricated of aluminum, titanium, stainless steel and zircoloy) were placed in a receptacle having a capacity of one liter. The receptacle was completely filled so that no air remained therein. Electric energy of about 15,000 joules was discharged over a time interval of about 40 microseconds, with the discharge current being in excess of 5,000 amperes. Plating having a thickness of about .00075 inch was deposited on the parts upon each discharge of electric energy.

The required electrical energy, discharge times and discharge current levels for plating are generally the same as those stated above for coating and impregnating.

It is believed that any metallic salt solution and any non-gaseous fluid containing a metal suspension will respond to the plating technique of my invention.

The third area of application of my method is in the removal of constituents from fluids containing chemical compounds. It may be helpful to understanding to consider first the conventional technique of recovering metals or other materials from rock by the leaching method. The central concept of the leaching method is to dissolve such materials as copper from copper bearing ores by soaking the ore with sulfuric acid. The acid, of course, reacts with the copper to form copper sulfate solution,

Then the copper is extracted from the solution containing the copper sulfate by such methods as electrolysis or precipitation by metallic iron, both of such methods being well known.

I have discovered that metals, for example, copper, may be recovered from metallic salt solutions by the discharge of a selected quantity of electric energy within a selected time interval and at a selected discharge current level from electrodes immersed in a said solution within a closed chamber or receptacle. For example, upon the application to a copper sulfate solution of such electric energy, copper will be removed from the salt and will be deposited within the receptacle.

This constituent removal technique is closely related to the plating technique. As is apparent in FIG. 3, the equipment may be identical with that used in the plating method (see FIG. 1), including the receptacle 11, the electrodes 25, 27, the conduits 43, 45 and a suitable electrical power unit, such as that shown in FIG. 2, connected with the electrical conductors 33, 35.

The required electrical energy, discharge times, and discharge current levels for the constituent removal technique are generally the same as those stated above for the coating and impregnating technique.

In actual practice as an example utilizing a solution of copper sulfate like that set forth by the above example concerning plating, 30 to 35 percent by volume of copper was removed as the result of a single discharge of electrical energy; the energy quantity, discharge time, and current level being the same as that of the above example concerning plating. Additional electric energy discharges in the same solution produced removal of additional copper.

I have also discovered that the constituent removal technique can be quite effectively applied to organic chemical compounds. I have successfully removed carbon from hydrocarbon for example, kerosene, by subjecting the kerosene to discharge of electrical energy in the same manner as above described.

In the practice of the methods herein disclosed, the electrical discharge may be initiated across the electrodes, without a filament, as shown in FIGS. 1 and 3. It is preferable, however, to utilize a filament between the electrodes, as indicated by FIG. 4. It is understood that the filament 81 of FIG. 4 may be utilized with the electrodes 25, 27 of either of FIGS. 1 and 3.

The foregoing disclosure and the showings made in the drawing are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense.

I claim:

1. The method of transferring materials from selected non-gaseous fluid media and depositing these materials upon selected articles, said method comprising the steps of:

- (a) filling a receptacle with a selected non-gaseous fluid of which at least one constituent thereof is to be deposited;
- (b) sealing said receptacle; and
- (c) discharging from electrodes immersed in said non-gaseous fluid in said receptacle a quantity of electrical energy amounting to at least 10 joules per each cubic inch of volumetric capacity of said receptacle, with said discharge taking place within a time interval between 25 and 300 microseconds and with the initial discharge current being between 5,000 and 300,000 amperes, said discharge producing in the non-gaseous fluid a shock wave and pressure build-up.

2. The method of transferring materials from selected non-gaseous fluid media and depositing these materials upon selected articles, said method comprising the steps of:

- (a) filling a receptacle with a selected non-gaseous fluid of which at least one constituent thereof is to be deposited;
- (b) sealing said receptacle; and

- (c) discharging from electrodes immersed in said non-gaseous fluid in said receptacle a quantity of electrical energy amounting to at least 10 joules per cubic inch of initial volumetric capacity of said receptacle, with said discharge taking place within a time interval of less than one millisecond and with the discharge current being at least 1500 amperes.

3. The method of coating and impregnating a selected article with a non-gaseous fluid, said method comprising the steps of:

- (a) filling a receptacle with a selected non-gaseous fluid with which said article is to be coated and impregnated;
- (b) placing said article in said receptacle;
- (c) sealing said receptacle; and
- (d) discharging from electrodes immersed in the non-gaseous fluid in said receptacle a quantity of electrical energy amounting to at least 10 joules per each cubic inch of volumetric capacity of said receptacle, with said discharge taking place within a time interval between 25 and 300 microseconds and with the initial discharge current being between 5,000 and 300,000 amperes, said discharge producing in the non-gaseous fluid a shock wave and pressure build-up.

4. The invention as defined by claim 3, wherein the non-gaseous fluid is an organic lubricant.

5. The invention as defined by claim 3, wherein the non-gaseous fluid is an inorganic lubricant.

6. The invention as defined by claim 3, wherein the non-gaseous fluid contains polytetrafluoroethylene.

7. The method of coating and impregnating a selected article with a non-gaseous fluid, said method comprising the steps of:

- (a) filling a receptacle with a selected non-gaseous fluid with which said article to be coated and impregnated;
- (b) placing said article in said receptacle;
- (c) sealing said receptacle; and
- (d) discharging from electrodes immersed in the non-gaseous fluid in said receptacle a quantity of electrical energy mounting to at least 10 joules per cubic inch of initial volumetric capacity of said receptacle with said discharge taking place within a time interval of less than one millisecond and with the discharge current being at least 1500 amperes.

8. The invention as defined by claim 7 wherein the non-gaseous fluid is an organic lubricant.

9. The invention as defined by claim 7 wherein the non-gaseous fluid is an inorganic lubricant.

10. The invention as defined by claim 7 wherein the non-gaseous fluid is a suspension of a thermoplastic resin.

11. The invention as defined by claim 7, wherein the non-gaseous fluid is a solution containing a thermoplastic resin.

12. The invention as defined by claim 7, wherein the non-gaseous fluid contains polytetrafluoroethylene.

13. The method of metal plating which comprises the steps of:

- (a) filling a receptacle with a selected non-gaseous fluid which is a solution that contains a metallic salt;
- (b) placing the article to be plated in said receptacle;
- (c) sealing said receptacle; and
- (d) discharging from electrodes immersed in the non-gaseous fluid in said receptacle a quantity of electrical energy amounting to at least 10 joules per each cubic inch of volumetric capacity of said receptacle, with said discharge taking place within a time interval between 25 and 300 microseconds and with the initial discharge current being between 5,000 and 300,00 amperes, said discharge producing in the non-gaseous fluid a shock wave and pressure build-up.

7

14. The method of metal plating which comprises the steps of:

- (a) filling a receptacle with a selected non-gaseous fluid which is a solution that contains a metallic salt;
- (b) placing the article to be plated in said receptacle;
- (c) sealing said receptacle; and
- (d) discharging from electrodes immersed in the non-gaseous fluid in said receptacle a quantity of electrical energy amounting to at least 10 joules per cubic inch of initial volumetric capacity of said cavity, with said discharge taking place within a time interval of less than one millisecond and with the discharge current being at least 1500 amperes.

15. The method of metal plating which comprises the steps of:

- (a) filling a receptacle with a selected non-gaseous fluid that contains a metal in suspension;
- (b) placing the article to be plated in said receptacle;
- (c) sealing said receptacle; and
- (d) discharging from electrodes immersed in the non-gaseous fluid in said receptacle a quantity of electrical energy amounting to at least 10 joules per each cubic inch of volumetric capacity of said receptacle, with said discharge taking place within a time interval between 25 and 300 microseconds

8

and with the initial discharge current being between 5,000 and 300,000 amperes, said discharge producing in the non-gaseous fluid a shock wave and pressure build-up.

16. The method of metal plating which comprises the steps of:

- (a) filling a receptacle with a selected non-gaseous fluid that contains a metal in suspension;
- (b) placing the article to be plated in said receptacle;
- (c) sealing said receptacle; and
- (d) discharging from electrodes immersed in the non-gaseous fluid in said receptacle a quantity of electrical energy amounting to at least 10 joules per cubic inch of initial volumetric capacity of said cavity, with said discharge taking place within a time interval of less than one millisecond and with the discharge current being at least 1500 amperes.

References Cited by the Examiner

UNITED STATES PATENTS

1,315,540	9/1919	Curme	-----	204—171
1,720,910	7/1929	Longhi	-----	204—171
1,744,173	1/1930	Longhi	-----	204—171

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