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REFORMATION OF METALLIC SURFACES

John M. Bluth, 901 E. Walnut St., Burbank, Calif., and Jacob L. Sellers, 1108 Lemp Ave., North Hollywood, Calif.

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17 Claims. (Cl. 29—552)

This invention relates generally to the reformation of metallic surfaces presenting substantially contiguous, relatively sharp microscopic crests, points or ridges, and depressions, or valleys, which may result from any of various formings, workings or machinings of the metal, and which may adversely affect the metal in rendering it susceptible to such conditions as galling by severed particles, fretting, failure at points of sharp discontinuity, excessive coefficient of friction and wear rates, accelerated corrodability and impaired lubricant retentiveness.

The invention finds applicability to the surface conditioning of various ferrous and non-ferrous metals and their alloys, of which steels, aluminum, titanium, manganese, alloys of iron, nickel, chromium, beryllium, magnesium, carbide ceramets, and brass are illustrative. In any instance, the condition requiring reformation of the metal is manifested by such surface contours as microscopically fine, sharp edge craters, machine tool ridging, burrs or semi-free particles, any of which are creative of one or more of the adverse properties mentioned above. In this connection, it may be observed that the surface condition to be overcome, or improved, may have resulted from blasting with sand or other abrasives that sharply pit and weaken the skin strength of the metal, and increase its susceptibilities to other undesirable influences or effects.

Our general object is to obviate or improve these surface conditions by a process involving essentially, selective cold working and displacement of the metal forming the irregularities, to give a final surface finish, the exactness of which is controllable as will later appear, all without distortion of thin sections and without significant alteration of the final tolerances of the workpiece. Of particular importance is the capacity of the process to accomplish these results as applied to parts that may have become corroded, soiled or otherwise contaminated so that their true surface conditions, defects and probable weaknesses cannot be observed. The present invention makes possible not only corrective surface working of the metal, but assures also the opportunity for visual inspection of the treated surface in the true color of the metal, which affords the most favorable condition for detailed revelation of its physical condition, including the presence or absence of defects.

Intricate and thin metal shapes can be worked to a surface condition which cannot be achieved by conventional shot peening practices, and by the present process it is possible to satisfactorily work surfaces which respond adversely to impact by conventionally blasted shot or abrasives. In result, the comparison is that in accordance with the invention, excessive displacement of the metal in the impact area is obviated, and single effects or combinations thereof are obtained without distortion of thin sections or deterioration of work piece tolerances i.e. without significant alteration of original dimensions. Application of the process results in rounding or curving all sharp irregularities to a matte finish which serves as an improved surface for lubricant retention and exhibits improved resistance to corrosion and wear. Mitigation of surface porosity is obtainable for both base metals and plated coatings, and residual stresses from machining or other operations are converted to compressive stresses generally yielding greater fatigue life to parts subject

to repeated bending and torsion in actual service. Tubular or other shapes fabricated from thin gauge material can be conditioned on all surfaces to yield rigidity as well as enhanced reliability under service conditions.

Considering now the particular steps and materials involved in the process, the invention contemplates generally blasting the surface to be conditioned, with a high velocity stream composed of a dispersion in a liquid carrier of very small substantially spherical particles of bead-like form, the effect of the blast received by the work piece being to give rounding peening to the initially relatively sharp microscopic protuberances but without abrading or penetrating the metal surface in the manner resulting from the usual shot or abrasive particle blasting or peening practices commonly employed for such purposes as to deliberately roughen and excessively deform or work harden the metal surface. Accomplishment of our objects is predicated upon the use of a certain kind of small bead particles characterized by their having elastic properties ideally suited to accomplishment of the desired surface reformation, and further by their having in a liquid carrier, impact energy sufficiently great for the described limited working of the metal and yet sufficiently low as not to abrade or excessively displace or work harden the metal. We have achieved our objectives by the use of bead-like particles made of glass, which term is intended to include glasses in general, and vitreous or fused silicious particles whose density, elasticity and toughness or resistance to fracture in the small particle sizes, corresponds to glasses such as for example are used in the making of road striping spheres or glass fibers, from the production of which glass beads usable for our purposes may be obtainable as fines or by-product.

In addition to selection of glass as the bead material and blasting the spheres in a carrier liquid, accomplishment of our objectives requires limitation of the sphere sizes within the range of about 0.003 to 0.032 inch, the size range usable in the average instance being in the range of about 0.003 to 0.014 inch. As will appear, in the surface conditioning of a work piece having relatively coarse or large size irregularities, we may first blast the surface with a dispersion of beads predominately in the larger particle sizes of the 0.003 to 0.032 range, and then follow this initial treatment by one or more similar blasting with smaller or progressively smaller size particles, generally to conform the bead size in accordance with progressive reduction and shaping of the surface irregularities.

As to the liquid carrier, we preferably use a water base liquid because of greater economy, the desirable fluidity of water, the complete metal cleaning action of a compounded aqueous carrier, and the practicability of supplementing water with one or more materials promotive of uniform dispersion of the beads and protection to be given the metal surface against contamination, rusting or other forms of corrosion. The aqueous slurry is protective not only of the metal surface, but also of the beads themselves in that the liquid prevents the severe bead breakage that would occur if dry blasting of the beads were attempted. In preparing the bead dispersion we use a ratio of about 40 to 100 weight parts of beads in the stated size range to 100 weight parts of the total liquid, i.e. water together with any added non-aqueous liquid. As additive bead dispersing agents we may use any of various materials, particularly of a soluble and non-foaming, or non-ionic organic nature, known to be effective for dispersing finely divided solids in water without producing objectionable foaming. Of these, we prefer to use any of various non-ionics which have the property of forming inverted emulsions with water insoluble oils, typically light mineral oils in which the oil constitutes the disperse phase, so that the dispersant may be a prepared oil and water emulsion to be added to the solids and a greater amount of water. As illustrative organic dispersing agents we may use the alkyl polyethoxyl phenols such as Oronite Chemical Company's non-ionic dispersants sold as "Oronite Ni-W," which is the 12 ethylene oxide adduct of dodecyl phenol and "Oronite Ni-O," understood to be the 3 to 6 ethylene oxide adduct of dodecyl benzene. These may be used alone or together with a light oil such as kerosene, typically in the proportion of about 95% kerosene and 5% of "Oronite Ni-W" (2 parts) and "Oronite Ni-O" (1 part). An effective dispersant may consist of an emulsion of about 80% of the resulting mixture, with about 20% water. This emulsion may be added to a glass bead-water slurry, in an amount (less than 2% of the total materials usually being sufficient) required for good bead dispersion. Other organic dispersing agents in the ethylene oxide-to-aromatic adduct class are the Union Carbide "Tergitols." and the Rohm and Haas "Tritons."

As illustrative of other dispersants, we may use a bentonite of the aqua gel (minus 300 mesh) grade preferably with a small percentage of wetting agent, such as those mentioned above. Also usable is sodium or potassium carboxy methyl cellulose (e.g. Du Pont grade 2 WX—high viscosity) with a small percentage (under 1%) of non-ionic wetting agent.

Any of various known anti-corrosion or anti-rust agents may be used, the specific selection being uncritical. Typical, are mixtures of sodium benzoate and sodium nitrite, sodium dichromate and sodium nitrite, as illustrative of inorganic inhibitors, and such organic inhibitors as Union Carbide's "Amine 220," understood to be 1 hydroxyl ethyl 2-hepta decenyl glyoxalidine, and such amines as the di- or mono-cyclohexylamines.

As will be understood, appropriate dispersing agents may be used in quantities within the range of about .02 to 2 weight percent of the total water and dispersing agent, and ordinarily a suitable rust-preventing or anti-corroding material may be used in concentrations under one percent, e.g. from about .02 to 1 percent, of the total liquid. In some instances it may be desirable to increase appreciably the viscosity of the carrier liquid, for which purpose we may add thereto a water soluble alcohol or glycol whose viscosity is greater than that of water, or we may add other viscosity increasing materials such as solubilized mineral or vegetable oils providing that the carrier liquid will leave the treated metal surface clean in the respect that the surface will display the true color of the metal. Whether for purposes of viscosity control or for promoting suspension in the liquid of the dispersed beads, the carrier liquid may be compounded as an emulsion of water with a non-aqueous viscosity increasing agent, such as so-called solubilized mineral or vegetable oils, of which about kerosene weight mineral oil is preferred and may be used in quantities of about 0.1 to 10% of the total carrier liquid.

From the foregoing it will be understood that the process permits of a number of variable control factors from which may be selected the conditions best suited to the requirements of a particular job. Such factors include selection of a particular size range of the beads and in use at any one time or stage in the total metal treatment, variation of the solids to liquid ratio in the stated range, adjustment of the blast velocity as by variation of the later described mixing chamber pressure, duration of the blasting period, and variable selection of the carrier liquid viscosity. All other conditions remaining the same, increase of the viscosity may tend to reduce either or both the projected particle velocity and the effective energy of impact against the surface, thus to modify or lessen the degree of metal displacement resulting from the impact.

All the above mentioned features and objects of the invention, as well as the details of an illustrative procedure for its accomplishment, will be further understood from the following description of the accompanying drawing, in which:

FIG. 1 is a diagrammatic showing of a typical arrangement of equipment for practicing the process; and

FIG. 2 is a diagrammatic showing related to the spray pattern of the metal reforming blast.

Referring first to FIG. 1, one or more metallic work pieces to be surface conditioned and typified by the plate **10** which will be understood to have any of the previously described microscopically irregular surface conditions, may be accommodated within a chamber **11** in the nature of a spray booth, suitably supported as by clamp **12**. The part **10** is impinged by a high velocity blast or spray **13** composed of the carrier liquid dispersion of the small particle beads, projected from a nozzle **14** carried by a spray gun **15**. The gun **15** is connected to a hose **16** under control of a valve **17** which is to be regarded as illustrative of any suitable valve means for controlling the rate of the dispersion delivery to the gun and for shutting off the flow. The used fluid may be collected in the bottom **18** of the booth for return through line **19** past check valve **20** to a closed container **21**.

The container **21** serves as a pressure vessel containing a body **22** of the carrier liquid and bead mixture, compressed gas, preferably air, being delivered through line **23** past pressure regulating valve **24** into the chamber through line **25**, which may be so oriented in the chamber as to circulate and actively agitate the mixture **22** in order that complete and uniform dispersion of the glass beads will be assured. Valve **24** may be set to maintain the desired pressure within chamber **21**, ordinarily in the range of about 40 to 125 pounds p.s.i. gauge. Thus, as valve **17** is opened, the dispersion will be pressurized in this range to the nozzle **14** and projected in the spray **13** at a blast velocity controllable by the pressure in line **16**. When the content of chamber **21** is used and the pressure therein relieved, the used liquid compound may be returned to the chamber for recirculation, by down flow in line **19** past the check valve **20**.

It is to be understood that the requirements of chamber **21** and the pressurizing, outlet and return lines connected thereto, may be served by any of various specific kinds of available equipment, and that such equipment is known to be adaptable for automatic pressure maintenance and liquid return from the spray booth. In the interests of simplicity and directness insofar as the significant aspects of the present invention are concerned, it is considered unnecessary to show or describe the more complicated automatic equipment.

Conditions under which we have been able to achieve the results discussed in the foregoing, may be further described in relation to the projected spray **13**.

Referring to FIG. 2, highly satisfactory results have been achieved by projecting the dispersion at a pressure within the stated range, and commonly at a pressure of about 100 pounds p.s.i. gauge, through a nozzle orifice **14** ranging in size from about one-sixteenth to one-fourth inch. Consideration also is given the spacing from the nozzle and the relative position within the spray pattern **13** occupied by the work piece **10**. Where the work is too close to the nozzle, the effect of the blast may be unduly severe, creative of excessive erosion, surface metal displacement, deformation or even cavitation and drilling of some materials, such as softer relatively thin metals. Generally considered, the spacing of the work from the nozzle should be such as to afford a distribution or area density of beads impacting against the work metal surface, that will accomplish the desired crest-rounding peening effects within a shorter time as the requirements of the particular job will permit, while maintaining all other conditions compatible with that end result. In general, it has been further fully practicable to satisfactorily work the metal surface when positioned at distances within the range of about 6 to 15 inches from the nozzle, as represented by the lines **26** and **27**.

The following are illustrative usable glass bead slurry formulations, in which the non-ionics "Ni–W" and "Ni O" are the Oronite Chemical Company wetting agents referred to hereinabove:

Example I

Glass beads (0.003–0.005 in. size)	lbs.	50
Water	lbs.	70
"Ni W"	oz.	½
"Ni O"	oz.	¼
Sodium nitrite	oz.	½
Sodium dichromate	oz.	½

Example II

Glass beads (0.005–0.010 in. size)	lbs.	50
Water	lbs.	95
"Ni W"	oz.	¾
"Ni O"	oz.	½
Kerosene	pts.	½
Sodium nitrite	oz.	½
Sodium dichromate	oz.	½

Example III

Glass beads (0.12–0.027 in.)	lbs.	50
Water	lbs.	100
"Ni W"	oz.	1¼
"Ni O"	oz.	2
Kerosene	pts.	1
Bentonite (aqua gel grade)	oz.	3
Sodium benzoate	oz.	½
Sodium nitrite	oz.	½

In preparing kerosene-containing formulations such as are given in Examples II and III, it is generally preferred to form first an emulsion of the organic dispersing agent or agents and kerosene with a small percentage of the total water, and to add the emulsion thus formed to an agitated mixture of the water and glass beads. The anti-corrosion agent or agents may initially be put into the preformed emulsion or the aqueous bead slurry. The following further example will illustrate the use of such preformed emulsions.

Example IV

"Ni W"	oz.	2½
"Ni O"	oz.	1½
Kerosene	qts.	3
Water	pts.	1½
Sodium nitrite	oz.	½
Sodium dichromate	oz.	½

This mixture is agitated to form a milky emulsion in which the water appears to constitute the dispersed phase. One quart of this emulsion is then added to:

	Lbs.
Glass beads (0.003 to 0.027 in. range)	50
Water	75

In the surface treatment of metal parts that may carry mineral oil or grease, the latter tends to cause some foaming of the slurry. Prompt suppression of the foam can be accomplished by adding to the slurry from time to time as foaming occurs, a small amount of the preformed kerosene and water emulsion.

We claim:

1. The method of reforming a metallic work piece surface containing contiguous microscopic irregularities, the metal being of the class consisting of steel, aluminum, titanium, manganese, carbide cermets, brass and alloys of iron, nickel, chromium, beryllium and magnesium, that includes blasting said surface with a dispersion in a carrier liquid of solid particles which are substantially free from angular abrasive surface shapes and consist essentially of substantially spherical glass beads in the size range of about 0.003 to 0.032 inch, said carrier liquid being composed of water and an essentially non-foaming organic water soluble bead dispersing agent, and thereby displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface while maintaining substantially constant the tolerances of the work piece.

2. The method of reforming a metallic work piece surface containing contiguous microscopic irregularities, the metal being of the class consisting of steel, aluminum, titanium, manganese, carbide cermets, brass and alloys of iron, nickel, chromium, beryllium and magnesium, that includes blasting said surface with a substantially uniform dispersion in water of solid particles which are substantially free from angular abrasive surface shapes and consist essentially of substantially spherical glass beads in the size range of about 0.003 to 0.032 inch, said water containing between about 0.02 and 2 percent of a dissolved essentially non-foaming organic bead dispersing agent, and thereby displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface while maintaining substantially constant the tolerances of the work piece.

3. The method of reforming a metallic surface containing contiguous microscopic irregularities, the metal being of the class consisting of steel, aluminum, titanium, manganese, carbide cermets, brass and alloys of iron, nickel, chromium, beryllium and magnesium, that includes blasting said surface with a dispersion in a carrier liquid of solid particles which are substantially free from angular abrasive surface shapes and consist essentially of substantially spherical glass beads in the size range of about 0.003 to 0.032 inch, and thereby displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface, said carrier liquid being composed of water and an essentially non-foaming organic water soluble bead dispersing agent, recirculating and reblasting said dispersion while maintaining the dispersion free from oily or other contaminants that could appreciably change the true color of said surface.

4. The method of reforming a metallic surface containing contiguous microscopic irregularities, the metal being of the class consisting of steel, aluminum, titanium, manganese, carbide cermets, brass and alloys of iron, nickel, chromium, beryllium and magnesium, that includes blasting said surface with a dispersion in water of solid particles which are substantially free from angular abrasive surface shapes and consist essentially of substantially spherical glass beads in the size range of about 0.003 to 0.032 inch, said organic water containing a non-ionic water soluble wetting agent as a bead dispersing agent, and thereby displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface.

5. The method of reforming a metallic work piece surface containing contiguous microscopic irregularities, the metal being of the class consisting of steel, aluminum, titanium, manganese, carbide cermets, brass and alloys of iron, nickel, chromium, beryllium and magnesium, that includes blasting said surface sequentially with dispersions in liquid of solid particles which are substantially free from angular abrasive surface shapes and consist essentially of larger size and then smaller size substantially spherical glass beads in the size range of about 0.003 to 0.032 inch, and thereby progressively displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface while maintaining substantially constant the tolerances of the work piece.

6. The method of reforming a metallic work piece surface containing contiguous microscopic irregularities, the metal being of the class consisting of steel, aluminum, titanium, manganese, carbide cermets, brass and alloys of iron, nickel, chromium, beryllium and magnesium, that includes blasting said surface sequentially with dispersions

in liquid of solid particles which are substantially free from angular abrasive surface shapes and consist essentially of larger size and then smaller size substantially spherical glass beads in the size range of about 0.003 to 0.032 inch, and thereby progressively displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface while maintaining substantially constant the tolerances of the work piece, said liquid being free from contaminates of said surface so that the reformed surface has the true color of the metal.

7. The method of reforming a metallic surface containing contiguous microscopic irregularities, the metal being of the class consisting of steel, aluminum, titanium, manganese, carbide cermets, brass and alloys of iron, nickel, chromium, beryllium and magnesium, that includes blasting said surface with a dispersion in an aqueous hydrocarbon emulsion of solid particles which are substantially free from angular abrasive surface shapes and consist essentially of substantially spherical glass beads in the size range of about 0.003 to 0.032 inch, said carrier liquid being composed of organic water and an essentially non-foaming water soluble bead dispersing agent, and thereby displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface.

8. The method of reforming a metallic work piece surface containing contiguous microscopic irregularities, that includes blasting said surface sequentially with dispersions in aqueous hydrocarbon emulsion of solid particles which are substantially free from angular abrasive surface shapes and consist essentially of larger size, and then smaller size, substantially spherical glass beads in the size range of about 0.003 to 0.032 inch, and thereby progressively displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface while maintaining substantially constant the tolerances of the work piece.

9. The method of reforming a metallic surface containing contiguous microscopic irregularities, the metal being of the class consisting of steel, aluminum, titanium, manganese, carbide cermets, brass and alloys of iron, nickel, chromium, beryllium and magnesium, that includes maintaining in a chamber a pressurized gas and an aqueous slurry containing solid particles which are substantially free from angular abrasive surface shapes and consist essentially of substantially spherical glass beads in the size

range of about 0.003 to 0.032 inch uniformly dispersed in the slurry, said slurry containing also an organic essentially non-foaming bead dispersing agent, blasting said surface with a high velocity spray of the slurry released from the chamber through a restricted orifice, thereby displacing the metal to give rounded contour to relatively sharp irregularities and resultant increased regularity to said surface, and recycling the slurry to said chamber.

10. The process according to claim 9, in which said bead dispersing agent comprises an essentially non-foaming wetting agent.

11. The process according to claim 9, in which said chamber is charged with air at a pressure of about 40 to 125 p.s.i. gauge, and said orifice has a diameter in the range of about $\frac{1}{16}$ to $\frac{1}{4}$ inch.

12. The process according to claim 9, in which said slurry contains a hydrocarbon and is composed of about 40 to 100 weight parts of said spheres to 100 parts of liquid.

13. The process according to claim 9, in which said slurry contains for each 100 weight parts of water and organic bead dispersing agent, from about 40 to 100 weight parts of said beads.

14. The process according to claim 10, in which bead dispersing agent also includes a light hydrocarbon oil emulsified with the slurry water.

15. The process according to claim 14, in which said slurry contains also a dissolved anti-corrosion agent.

16. The process according to claim 9, in which said slurry contains bentonite.

17. The process according to claim 9, in which said dispersing agent is of the class consisting of the 12 ethylene oxide adduct of dodecyl phenol and 3 to 6 ethylene oxide adduct of dodecyl benzene.

References Cited in the file of this patent

UNITED STATES PATENTS

392,556	Harris	Nov. 6, 1888
1,947,927	Vorwerk	Feb. 20, 1934
2,077,639	Minch	Apr. 20, 1937
2,276,594	Rowell	Mar. 17, 1942
2,426,072	Wall et al.	Aug. 19, 1947
2,460,918	Bodine	Feb. 8, 1949
2,462,480	Eppler	Feb. 22, 1949
2,463,010	Almen	Mar. 1, 1949
2,621,351	Piety	Dec. 16, 1952

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REFCRMATION OF METALLIC SURFACES

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Fig. 1.

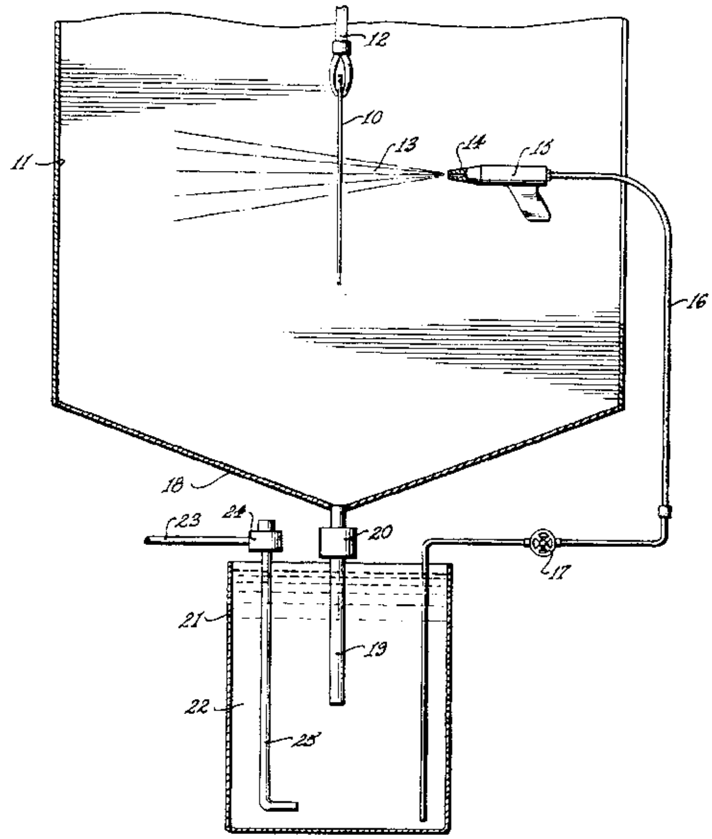
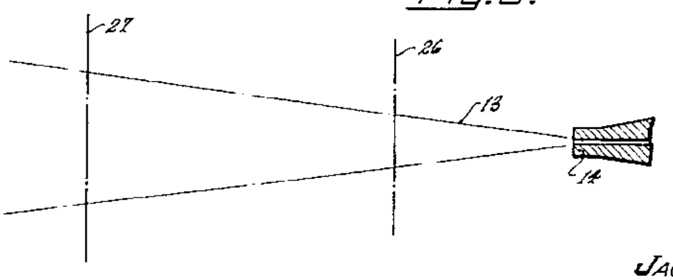


Fig. 2.



JACOB L. SELLERS
JOHN M BLUTH
INVENTOR.

BY White & Haefliger

ATTORNEYS

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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John M. Bluth et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 50, for "organic water containing a" read -- water containing an organic --; column 7, line 22, for "organic water and an" read -- water and an organic --.

Signed and sealed this 10th day of July 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents