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3,561,262

# WATER SOLUBLE DEVELOPER

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## ABSTRACT OF THE DISCLOSURE

A method for detecting flaws and other surface discontinuities by the liquid penetrant technique wherein an aqueous solution of a water soluble crystalline substance and a water dispersible surfactant serves as the developer for enhancing the visibility of flaw indications generated by the liquid penetrant. Said penetrant preferably contains a visible or fluorescent dye dissolved therein and is of an oily type which itself is not self-emulsifying and is substantially free of any added emulsifying agent. The developer, upon the evaporation or driving off of the water, forms an adherent film, or lattice layer, that is permeable to the liquid penetrant residue entrapped in any surface discontinuity so as to cause the penetrant residue to be drawn by capillarity or otherwise into said film and form therein flaw indications of high fidelity and resolution that may be easily detected upon inspection. The aqueous developer of this invention can optionally include film forming ingredients that effectively control the size of crystals formed upon drying; sequestering agents for use with hard water; and corrosion inhibiting agents; but the resulting film or lattice layer in all cases is entirely water soluble so that the surface of the test piece can be adequately cleaned by the use of water alone at the completion of the inspection step.

## CROSS-REFERENCE TO RELATED APPLICATION

This invention relates to an aqueous solution-type of developer that differs from the "water-dispersible high-sensitivity developer" of the Borucki application Ser. No. 589,517, filed Oct. 26, 1966, in that the developer of the pending application contains a suitable clay as the pigment that is suspended in the aqueous developer composition. The aqueous solution type developer is free from any pigment or other water-insoluble substance. This is an important distinction since in the case of a liquid pigmented developer, whether the liquid is water or an organic solvent, the pigment left behind on the surface of the test piece after development and inspection of any flaw indication is very difficult to remove and cannot be effectively and completely removed by a stream of water alone, as is true of the water-soluble residue left on the surface of the work piece upon evaporation of the water from the present aqueous solution-type developer.

## BACKGROUND OF THE INVENTION

The field of this invention is the art relating to the non-destructive method of detecting flaws and other surface discontinuities by the liquid penetrant technique. The De Forest et al. Patent No. 2,806,959, owned by the same assignee as the instant application, discloses the use of wet developers comprising suspensions of water-insoluble inorganic particles, such as talc, calcium carbonate, and the like in either an aqueous or an alcohol liquid suspending medium. Since the water-insoluble pigment of the prior art liquid type developers was relied upon to function as the developer by reason of its blotting effect upon the liquid penetrant entrapped in any flaws in the test piece surface, the total omission of any such pigments from the aqueous solution developer of the present invention is clearly an unobvious departure from what was heretofore known by workers in this art.



## SUMMARY OF THE INVENTION

In the liquid penetrant technique, to which this invention relates, the penetrant can be any of those described in the prior art, including the De Forest et al. Patent No. 2,806,959, but our invention is particularly applicable to the penetrant method in which the liquid penetrant is a water immiscible oil, such as a petroleum hydrocarbon, and contains either a visible or a fluorescent dye dissolved therein.

In accordance with the prent invention, an aqueous solution is prepared for use as a developer by dissolving in water a water-soluble crystalline substance and dispersing therein a surfactant that is compatible with the crystalline substance upon crystallization thereof by the evaporation of water from the solution to deposit upon the surface of the test piece a water-soluble film permeable by the penetrant residue to give it a flaw indication of enhanced visibility in the inspection thereof.

Since the term "water-soluble" is a relative term, the use of the term herein will be understood to represent a degree of solubility far in excess of that of the pigments that have heretofore been used in wet developers. In contrast to such pigments as calcium carbonate, talc, and silica, having a water-solubility in general less than about 0.001 gram in 100 cc. of water, the crystalline substances used in the present aqueous solution type developer have a solubility of at least 1 gram in 100 cc. of water at 20° C., and are used in our aqueous solution type developer in a concentration of at least one-half percent by weight up to saturation and even super-saturation concentrations. The surfactant used with the crystalline substance need not be completely in solution in the developer in the state in which it is used, since some surfactants useful for our purpose give slightly cloudy or even turbid properties to the resulting aqueous solution type developer, but in all cases the surfactant used is one that is compatible with the crystalline substance employed to give, upon evaporation of the water content, a dry deposit that is completely water-soluble. Accordingly, the residue of the dry-deposit formed on the surface of the test piece can be completely removed by washing with water alone, after the inspection step has been completed, so as to leave a clean surface.

In the broadest embodiment of our invention, the aqueous solution developer consists essentially of a water-soluble crystalline substance, which may be either inorganic, organic or metallo-organic, provided it is soluble at least to the extent of one percent by weight; a water dispersible surfactant within the range of from 0.1 to 5% by weight of the solution, which is compatible with the crystalline substance within the definition above given; and optionally a water-soluble film-forming substance within the range of from 0–10%, a water-soluble sequestering agent between the range of from 0 to 5%, a water-soluble corrosion inhibitor within the range of 0 to 5%, and the balance, water.

The following are some of the water-soluble crystalline substances that can be used in our aqueous solution type developer:

Inorganic solubles

Sodium nitrate
Sodium bicarbonate
Sodium carbonate
Potassium nitrate
Ammonium chloride
Potassium iodide
Sodium nitrite

Inorganic solubles

Aluminum chloride
Potassium chloride
Sodium chloride

Organic compounds

Urea
Sucrose
Resorcinol
Ethylene diamine tetramine acetic acid, sodium salt

Metallo-organic salts

Sodium citrate
Potassium citrate
Ammonium acetate
Sodium gluconate
Sodium benzoate
Sodium salicylate

The following are compositions expressed in percentages by weight, of our aqueous solution type developers:

(I) Based upon the use of inorganic crystalline substances:

EXAMPLE 1

| | Percent |
|---|---|
| Ammonium chloride | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 88.9 |

EXAMPLE 2

| | Percent |
|---|---|
| Potassium nitrate | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 88.9 |

EXAMPLE 3

| | Percent |
|---|---|
| Sodium bicarbonate | 3 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 95.9 |

EXAMPLE 4

| | Percent |
|---|---|
| Sodium carbonate | 3 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 95.9 |

EXAMPLE 5

| | Percent |
|---|---|
| Potassium iodide | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 88.9 |

EXAMPLE 6

| | Percent |
|---|---|
| Sodium nitrite | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 88.9 |

EXAMPLE 7

| | Percent |
|---|---|
| Aluminum chloride | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 88.9 |

EXAMPLE 8

| | Percent |
|---|---|
| Sodium chloride | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 88.9 |



EXAMPLE 9

| | Percent |
|---|---|
| Potassium chloride | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 88.9 |

Trito X–114 is just one example of the many surfactants which could be used. Any water-soluble surfactant stable in the electrolyte medium employed is satisfactory for use. Where sulfur and chlorine content are of concern (because of presenting embrittlement problems) it is desirable to employ surfactants which are free of sulfur and chlorine.

L–77 silicone fluid is a "super wetter," and can be used alone, as the surfactant. It is a proprietary product of Union Carbide Corporation, along with other organo silicone surfactants, and is believed to be the reaction product of an organic silicone (siloxane) and a nonionic wetting agent. It is only very slightly soluble in water.

Any of the water soluble crystalline inorganic substances previously listed can be used within the ranges of percentages and in the percentages by weight shown for those in the following:

EXAMPLE 10

| | Percent |
|---|---|
| Water soluble inorganic substance (to saturation) | 1 |
| Surfactant | 0.1 to 5 |
| Water | Balance |

EXAMPLE 11, WITH CORROSION INHIBITOR

| | Percent |
|---|---|
| Potassium nitrite | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Sodium nitrite | 5 |
| Sodium dichromate | 0.4 |
| Water | 88.5 |

EXAMPLE 12, WITH SEQUESTERING AGENT

| | Percent |
|---|---|
| Potassium nitrite | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Sodium gluconate | 1 |
| Water | 87.9 |

Sodium dichromate protects aluminum from corroding, but does alter to a degree the fluorescense of the indications. In formulations where this is a problem, tetra sodium pyrophosphate can be used and in the same amount.

Other sequestering agents than sodium gluconate can be used.

Examples:

(1) EDTA
(2) Versene series
(3) Questol series

EXAMPLE 13, WITH MIXED WATER SOLUBLE CRYSTALLINE INORGANIC SUBSTANCES

| | Percent |
|---|---|
| Potassium nitrite | 10 |
| Sodium bicarbonate | 3 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 85.9 |

EXAMPLE 14, WITH "CARBOWAX" AS THE FILM FORMER

| | Percent |
|---|---|
| Ammonium chloride | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Carbowax 4000 | 5 |
| Water | 83.9 |

EXAMPLE 15

| | Percent |
|---|---|
| Sodium bicarbonate | 3 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Carbowax 4000 | 5 |
| Water | 90.9 |

EXAMPLE 16

| | Percent |
|---|---|
| Sodium borate | 1 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 97.9 |

(II) Based upon the use of water soluble metal or ammonium salts of organic acids:

EXAMPLE 17

| | Percent |
|---|---|
| Sodium benzoate | 10 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 88.9 |

In place of sodium benzoate in Example 17, sodium salicylate, sodium citrate, potassium citrate, ammonium acetate, sodium gluconate and other water soluble metal or ammonium salts of organic acids can be satisfactorily used in various proportions depending upon their solubilities within the broad limits given herein.

EXAMPLE 18

| | Percent |
|---|---|
| 2,5 dimethylbenzenesulfonic acid sodium salt | 2 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 96.9 |

EXAMPLE 19

| | Percent |
|---|---|
| 4-amino naphthalenesulfonic acid sodium salt | 2 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 96.9 |

Any of the water soluble metal or ammonium salts of organic acids previously listed can be used within the ranges of and in the percentages by weight given in the following:

EXAMPLE 20

| | Percent |
|---|---|
| Water soluble metal or $NH_4$ salt of an organic acid (to saturation) | 0.5 |
| Surfactant | 0.1 to 5 |
| Film former | 0 to 10 |
| Water | Balance |

EXAMPLE 21, SPECIFIC MIXTURE

| | Percent |
|---|---|
| Sodium benzoate | 10 |
| Sodium gluconate | 1 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 87.9 |

EXAMPLE 22, SPECIFIC

| | Percent |
|---|---|
| Sodium benzoate | 10 |
| Carbowax 4000 | 2 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 86.9 |

EXAMPLE 23

| | Percent |
|---|---|
| 2,5 dimethylbenzenesulfonic acid sodium salt | 2 |
| Carbowax 4000 | 2 |
| Triton X–114 | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 94.9 |



(III) Based upon the use of water soluble organic compounds:

EXAMPLE 24

| | Percent |
|---|---|
| Urea | 10 |
| L–77 silicone fluid | 0.1 |
| Water | 89.1 |

EXAMPLE 25

| | Percent |
|---|---|
| Sucrose | 10 |
| L–77 silicone fluid | 0.1 |
| Water | 89.1 |

EXAMPLE 26

| | Percent |
|---|---|
| Resorcinol | 5 |
| L–77 silicone fluid | 0.1 |
| Water | 94.9 |

EXAMPLE 27

| | Percent |
|---|---|
| 2 butyne 1,4 diol | 5 |
| L–77 silicone fluid | 0.1 |
| Water | 94.9 |

EXAMPLE 28

| | Percent |
|---|---|
| Acetamide | 5 |
| L–77 silicone fluid | 0.1 |
| Water | 94.9 |

EXAMPLE 29

| | Percent |
|---|---|
| Hydrazine sulfate | 1 |
| L–77 silicone fluid | 0.1 |
| Water | 98.9 |

(IV) Based upon the use of a blend of water soluble organic compounds:

EXAMPLE 30

| | Percent |
|---|---|
| Urea | 5 |
| Sucrose | 5 |
| L–77 silicone fluid | 0.1 |
| Water | 89.9 |

EXAMPLE 31

| | Percent |
|---|---|
| Urea | 6 |
| Resorcinol | 4 |
| L–77 silicone fluid | 0.1 |
| Water | 89.9 |

(V) Based upon the use of a blend of water soluble organic compounds and inorganic salts:

EXAMPLE 32

| | Percent |
|---|---|
| Urea | 8 |
| Sodium bicarbonate | 2 |
| L–77 silicone fluid | 0.1 |
| Water | 89.9 |

EXAMPLE 33

| | Percent |
|---|---|
| Urea | 8 |
| Sodium nitrite | 2 |
| L–77 silicone fluid | 0.1 |
| Water | 89.9 |

EXAMPLE 34

| | Percent |
|---|---|
| Urea | 5 |
| Potassium nitrate | 5 |
| L–77 silicone fluid | 0.1 |
| Water | 89.9 |

Surfactants that have been found satisfactory for use in our aqueous solution type developer composition are the following, but in general any surfactant, whether nonionic, cationic or anionic, that is water dispersible, has good wetting properties and is compatible with the other

ingredients of the composition to form a completely water soluble film or lattice deposit, when dried, can be used alone or in combination:

(I) Non-ionic:

(A) Ethoxy fatty alcohols:
- (1) Neodol 25-9—Shell Refining Company
- (2) Neodol 23-6½—Shell Refining Company
- (3) Biosoft EA Series—Stepan Chemical Company

(B) Alkylphenol polyglycol ethers:
- (1) Triton X Series—isooctyl phenyl polyethoxyethanols—X-100, X-102, X-114—Rohm & Haas
- (2) Triton N Series—nonyl phenyl polyoxyethanols—N-101—Rohm & Haas
- (3) Surfonic N Series—alkylaryl polyethylene glycol ethers—N-60, N-95, N-200, N-300—Jefferson Chemical Company
- (4) Igepal CO Series—nonylphenoxy poly (ethyleneoxy) ethanol—General Aniline & Film Company
- (5) Stepanol B-129—sodium salt of an alkylphenoxy poly oxyethylene—Stepan Chemical Company

(C) Fatty acid esters of polyglycol ethers:
- (1) Stepanol TBK—an alkoxypolyoxyethylene ethanol—Stepan Chemical Company

(D) Alkanolamides:
- (1) Sole Terge 325—lauric alkanolamines—Hodag Chemical
- (2) Sole Terge 59-K—mixed fatty alkanolamines—Hodag Chemical Company
- (3) Ninol 1281—mixed fatty alkanolamines—Stepan Chemical Company
- (4) Ninol 1285—fatty acid alkanolamines—Stepan Chemical Company

(E) Acetylenic glycols and their ethoxylated derivatives:
- (1) Surfynol 104—acetylenic glycol 2, 4, 7, 9 tetramethyl—Airco Chemical
- (2) Surfynol T.G.—a mixture of 5-decyne-4.7 diol, 100% concentration of 104, and an alkylphenyl ether of polyethylene glycol in ethylene glycol surfynol, 83% concentration

(F) Ethoxylated fatty acid esters of sorbitan

(G) L-77 silicone fluid non-ionic wetting agent—Union Carbide

(II) Cationic:

(A) Alkyl aryl quatenary ammonium salts:
- (1) Katapone VV328—an alkyl polyethoxyethanol benzylammonium chloride, 85% concentration—General Aniline & Film Corporation
- (2) Hyamine 3500—N-alkyl ($C_{12}$, $C_{14}$, $C_{16}$) dimethylbenzyl ammonium chloride—Rohm & Haas
- (3) Hyamine 2389—methyl dodecylbenzyl trimethyl dodecyl xylene bis (trimethyl ammonium chloride) 50% concentration—Rohm & Haas
- (4) Ethoquad 0/25—polyoxyethylene oleylmethyl ammonium chloride, 95% concentration—Armour Industrial Chemical Company

(B) Pyridinium salts:
- (1) Emcol E-607—N-lauroyl colamino formyl methyl (pyridium chloride), 90% concentration—Witco Chemical Company, Inc.

(III) Anionic:

(A) Alkyl aryl sulfonates:
- (1) Suframin 85—linear alkyl aryl sodium sulfate—Ultra Division of Watco Chemical Company
- (2) Stepan DS-60—desalted sodium dodecyl benzene sulfonate—Stepan Chemical
- (3) Stepan AAAS—ammonium salt of dodecyl benzene sulfonate—Stepan Chemical

(B) Alkyl sulfonates:
- (1) Petroleum sulfonates

(C) Alkyl sulfates:
- (1) Stepanol—sodium lauryl sulfate series WA-C, WA, WAQ



(D) Sulfated and sulfonated esters and ethers:
- (1) Aerosol OT—dioctyl ester of sodium sulfosuccinic acid—American Cyanamid
- (2) Aerosol AY—diamyl ester of sodium sulfosuccinate—American Cyanamid

(E) Sulfated and sulfonated amides and amines:
- (1) Sulfocolaurate A.D.R.—lauric acid ester of the potassium salt of sulfoacetic acid amidified with betaamine ethyl alcohol

(F) Phosphate esters:
- (1) Victawet 58B—a phosphorated higher alcohol $(Capryl)_5$—$Na_5(P_3O_{10})_2$, of 70% concentration, anionic—Stauffer Chemical

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The preferred water soluble developer composition of our invention, in its dry form, has the following formula, expressed in percentages by weight:

EXAMPLE 35

| | Percent |
|---|---|
| Sodium benzoate | 55.80 |
| Urea | 27.90 |
| EDTA | 1.12 |
| Carbowax 4000 | 13.95 |
| L-77 silicone fluid | 0.28 |
| Surfonic LF-17 | 0.95 |
| Total | 100.00 |

Carbowax 4000 is a proprietary synthetic, water-soluble wax having a water solubility of 100 grams per 100 cc. at 20° C. Other members of the Carbowax series of waxes can be used so long as they are water-soluble, non-volatile and preferably solid at room temperature.

In place of Carbowax 4000 as the film-former, other water-soluble film-formers can be used in the same percentage as that given above and within the ranges given in the broader range formulations, such as: hydroxymethyl cellulose (Methocel H6); sodium carboxymethyl-cellulose (CMC); acacia, or gum arabic; bassorin or tragacanthin (the soluble portion of gum tragacanth); Jagar, a product of Stein-Hall & Co., Inc., said to be a natural vegetable colloid from guar seed; and the like. These film-formers act to produce more uniform small size crystals of the crystalline substance used in the resulting film and to cause such film to adhere well to the test piece surface.

EDTA is the abbreviation for ethylene diamine tetraacetic acid. Other sequestering agents, such as those previously named herein can be employed, especially sodium D-gluconate.

L-77 silicone fluid has outstanding wetting and spreading characteristics and can be used by itself at extremely low concentrations (0.05 to 0.10%) by weight of the aqueous solution of the selected crystalline substance or mixture of crystalline substances. Other surfactants, such as those already listed herein, can be used in the same percentage as given in Example 35 or within the broad range of percentages herein given. Where required in order to prevent embrittlement of the metal of the test piece, the surfactant, as well as the other components of our developer composition, should be substantially or wholly free of sulfur and chlorine.

Algaecides and biocides can be added in low concentrations where desirable or required, for example Hyamin 2389, which is water soluble, non-toxic and functions as a cationic wetting agent. It functions particularly well with L-77 silicon fluid. Hyamin 2389 is a mixture of 40% methyl-dodecylbenzyl-trimethyl ammonium chloride, 10% methyldodecylxylene bis-trimethyl ammonium chloride as a 50% aqueous solution, and can be used in concentrations of from 10 to 400 p.p.m.

The dry composition, e.g. that of Example 35, can be diluted with or dissolved in water to any extent within the broad ranges of percent by weight given in the following example:

EXAMPLE 36

| | |
|---|---|
| Soluble crystalline substance | 0.5% to saturation or above. |
| Water dispersible surfactant | 0.1% to 10%. |
| Water soluble film former | 0% to 10%. |
| Water soluble sequestering agent | 0% to 5%. |
| Water soluble corrosion inhibitor | 0% to 5%. |
| Biocide or algaecide | 0 up to 400 p.p.m |
| Water | Balance. |

The higher the bath concentration, especially of the soluble crystalline substance, the brighter are the fluorescent penetrant indications. A workable concentration of the crystalline substance is obtained by using from ¼ lb. of the dry composition per gallon up to as high as saturation, 3 lbs./gal. of water or even higher. An average solution concentration is 1 lb. of the dry composition per gal. of water.

The water soluble developer of our invention has the following advantages over previously known pigmented developers:

(1) It is completely removable by the use of water alone, since the residual developer layer or film after drying is completely soluble in water.

(2) Since there are no particles to keep in suspension, there is no need to agitate the developer bath or container.

(3) There is no problem of geilling or thickening of the developer solution in whatever tank or container it is used in.

(4) Since there are no pigment particles, particle size is not a factor with respect to the sensitivity of the color indication and no masking of indications due to agglomeration of particles.

(5) There are no settling or sludging problems.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

We claim:

1. In a method of detecting surface discontinuities in which a liquid penetrant is applied to the surface of a test piece to become entrapped in any discontinuities therein, the excess of penetrant is removed without removal of penetrant residue entrapped in discontinuities and a developer is thereafter applied to said surface to enhance the visibility of flaw indications including said entrapped penetrant residue, the improvement which comprises:

applying as said developer an aqueous solution consisting essentially of a water-soluble crystalline substance present in an amount of at least 0.5% by weight up to saturation, and

a water dispersible surfactant compatible with said water-soluble crystalline substance and present in an amount from 0.1% to 10% by weight of said solution; said water dispersible surfactant being compatible with said water-soluble crystalline substance upon crystallization of the latter by evaporation of water from said solution to deposit on said test piece surface a water soluble crystalline film permeable by said penetrant residue to give a flaw indication of enhanced visibility upon inspection thereof.

2. The method as defined by claim 1, in which,

said liquid penetrant is an oil, and

said surfactant is miscible with said oil to effect migration of said penetrant residue into said water soluble film.

3. A method as defined by claim 1, in which said water soluble crystalline substance is an organic compound soluble in water to the extent of 10% by weight of the resulting solution.

4. A method as defined by claim 1, in which said water soluble crystalline substance is an inorganic salt.



5. A method as defined by claim 1, in which said water soluble crystalline substance is a metal salt of an organic acid.

6. A method as defined by claim 1, in which after inspection of said flaw indication said film is removed by water washing to leave a clean surface.

7. A method as defined by claim 1, in which said water soluble crystalline substance is present in an amount of at least 1% by weight, and said surfactant is present in the range of from about 0.1% to 10% by weight of said aqueous solution.

8. A method as defined by claim 1, in which said aqueous solution has a composition within the following proportions by weight of the solution:

water-soluble crystalline substance from 0.5% to saturation,

water-soluble surfactant from 0.1% to 5%, water-soluble film-forming substance from 0 to 10%,

water-soluble sequestering agent from 0 to 5%,

water-soluble corrosion inhibitor from 0 to 5%, and the balance water,

said solution upon evaporation leaving a penetrant permeable crystalline film removable by water washing alone.

9. A method as defined by claim 8 wherein,

said water-soluble crystalline substance is sodium benzoate, and

said water-soluble film-forming substance is a normally solid, non-volatile water-soluble wax having a water solubility of 100 grams per 100 cc. at 20° C.

10. An aqueous solution for use as a water-soluble developer in the liquid penetrant method of detecting surface discontinuities in a test piece, consisting essentially of the following:

at least 1% of a mixture of sodium benzoate and urea,

from 0.1% to 5% of a surfactant,

from 0 to 10% of a water-soluble film-former that is non-volatile and solid at room temperature, and

the balance water, said solution upon evaporation of the water leaving a water-soluble crystalline film permeable by the liquid penetrant to form a flaw indication of enhanced visibility upon inspection thereof.

11. A water-soluble developer for use in the liquid penetrant method of detecting surface discontinuities in a test piece, comprising an aqueous solution consisting essentially of the following:

from 0.5% to saturation and above of sodium benzoate,

from 0.1% to 10% of a water dispersible surfactant,

a water-soluble film-forming, normally water-soluble wax in an amount up to 10% and sufficient to produce uniformly sized small crystals of said sodium benzoate, from 0 to 5% of a corrosion inhibitor, and the balance being largely water,

said solution upon evaporation of the water leaving a water-soluble crystalline film permeable by the liquid penetrant to form a flaw indication of enhanced visibility upon inspection.

12. An aqueous solution for use as a water-soluble developer in the liquid penetrant method of detecting surface discontinuities in the test piece, consisting essentially of the following:

from 0.5% to saturation of a crystalline water-soluble metal or $NH_4$ salt of an organic acid,

from 0.1% to 5% of a surfactant, and

up to 10% of a water-soluble film-forming, normally solid, non-volatile wax having a water solubility of 100 grams per 100 cc. of water at 20° C. in an amount sufficient to produce uniform small sized crystals of said crystalline salt,

the balance being largely water and said solution upon evaporation of said water leaving a water-soluble crystalline film permeable by said liquid penetrant to form a flaw indication of enhanced visibility upon inspection thereof.

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U.S. Cl. X.R.

250—71; 252—152, 301.2, 301.3, 351, 408

# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,561,262 Dated February 9, 1971

Inventor(s) James S. Borucki & Bruce C. Graham

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, line 14, cancel "prent" and substitute --present--.

Col. 4, lines 28 & 29, cancel "(to saturation)", and in the column headed by "Percent", after "1" insert --to saturation--.

Col. 4, in Examples 11, 12 and 13, first line under each example, cancel "nitrite" and substitute --nitrate--.

Col. 5, under Example 20, line 49, cancel "(to saturation)" and, same line, after "0.5" add --to saturation--.

Col. 8, line 71, cancel "silicon", and substitute --silicone--.

Col. 9, line 31, correct the spelling of --gelling--.

Signed and sealed this 12th day of October 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Pate