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[54] PROCESS OF PENETRANT INSPECTION

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Related U.S. Application Data

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[58] Field of Search 252/408, 312; 73/104

[56] References Cited

UNITED STATES PATENTS

2,839,918 6/1958 Switzer 73/104

Primary Examiner—John D. Welsh

[57] ABSTRACT

Compositions and processes for providing a selective increase in wash-removability of surface penetrant and entrapments of penetrant in shallow surface discontinuities, as compared with penetrant entrapments in deeper cracks. Water-washable gel-forming inspection penetrants are constructed using a balanced combination of hydrophylic surfactant and relatively volatile lipophylic synergist constituents. Thin layers of penetrant coated on test surfaces and allowed to drain and dry for a suitable period of time will tend to selectively lose part or most of the synergist constituent in surface layers, while considerably less loss will occur in penetrant contained in deep cracks. The selective loss of synergist from surface layers or shallow entrapments, will permit such penetrant layers to lose much of their gel-forming capability, and thus become more readily removable in a water wash, thereby providing an improved contrast of crack indications against an unwanted background of fine surface indications.

1 Claims, No Drawings

PROCESS OF PENETRANT INSPECTION

This application is a continuation-in-part of my copending application, Ser. No. 804,200, filed Mar. 4, 1969, for "Oil-Water Compatible Compositions Employing Non-Surface-Active Constituents." The present invention relates to gel-forming or emulsion-forming water-washable inspection penetrants and emulsifiers, and methods for using same. More particularly, the invention relates to water-washable penetrant compositions which have an improved capability for detecting surface cracks in test bodies in the presence of conditions of surface roughness or surface porosity.

RELATED PATENTS AND PATENT APPLICATIONS

U.S. Pat. No. 3,164,006	Evaluation Performance of Liquid Penetrant Tracer Materials
U.S. Pat. No. 3,282,843	Emulsifier Compositions
U.S. Pat. No. 3,300,642	Method for Changing and Restoring the Sensitivity Characteristic of Diluted Penetrants
U.S. Pat. No. 3,349,041	Gel-Forming Inspection Penetrant and Emulsifier Compositions and Processes
U.S. Pat. No. 3,429,826	Gel-Forming Inspection Penetrant and Emulsifier Compositions Employing Hydrophylic and Lipophylic Surfactants
U.S. Pat. No. 3,530,295	Tracer Processes Employing Ultraviolet Absorber Materials
application Ser. No. 787,381 now abandoned	Oil-Water Compatible Compositions and Methods of Preparing Same
application Ser. No. 804,200	Oil-Water Compatible Compositions Employing Non-Surface-Active Constituents
Re. application Ser. No. 830,903 now U.S. Pat. No. 3,386,920	Process for Fluorescence Detection of Extremely Thin Tracer Films

In the inspection penetrant method, there has been a continuing need for improvements in water-washable penetrant compositions and techniques of usage, whereby the detection of surface cracks in test parts may be facilitated, even though the test parts may exhibit surface roughness or surface porosity to the extent where, under usual processing conditions, the crack defects tend to be obscured. Previous single-step penetrant processes have been largely incapable of distinguishing extremely small surface cracks in the presence of severe surface porosity or roughness conditions, at least to a sufficient degree of flaw detection contrast.

It will be understood that actual crack defects in test parts and surface porosity and roughness conditions are quite similar in nature, in that both will act to form entrapments of an inspection penetrant material. However, these conditions differ to the extent that actual cracks in test parts usually extend more deeply into the part than do porosity or roughness conditions.

The problem of crack detection in the presence of a background porosity condition becomes increasingly severe as the flaw detection sensitivity of the penetrant composition is increased. Also, in the case of the modern gel-forming water-washable inspection penetrants, the enhanced flaw entrapment efficiencies which are characteristic of these penetrants serve to aggravate the difficulty in differentiating actual crack indications from background indications.

I have found that it is possible to design a water-washable gel-forming inspection penetrant composition in such a way that it may be employed in a usage mode which acts to selectively diminish indications of surface porosity without any material loss of actual crack indications. The result of employing such compositions, in the proper usage mode, is to greatly enhance the effective contrast of actual crack indications with respect to background indications on test surfaces.

The principle object of the invention, therefore, is to provide improved gel-forming inspection penetrants which permit the selective reduction of background indications on test bodies.

Another object of the invention is to provide an improved process of penetrant inspection, in which there is provided an

improved contrast of crack indications with respect to background indications.

Other and incidental objects of the invention will in part be obvious and will in part become apparent from the following description thereof.

This invention contemplates a process of selective evaporation of a critical ingredient of a water-washable penetrant composition, such that extremely small deposits of penetrant (or emulsifier) on surfaces or in shallow surface discontinuities become diminished in their gel-forming properties with the result that they become more readily and more rapidly washable in water, as compared with penetrant entrapments in relatively deep surface cracks. In order to implement this process, it is necessary to provide suitable penetrant or emulsifier compositions which are characterized by an appropriate volatility relationship between the essential gel-forming constituents.

In my now issued U.S. Pat. Nos. 3,282,843, 3,349,041, and 3,429,826, I have described and claimed various gel-forming emulsifier compositions which are employable as water-washable inspection penetrants or as emulsifiers for oily postemulsifier-type penetrants. The compositions described in the aforesaid patents all utilize mixtures of water-soluble (hydrophylic) and oil-soluble (lipophylic) surfactant materials, these constituents being "balanced" with respect to each other so as to provide "gel-forming" compositions. When the thus-described gel-forming composition (containing an indicator dye) is applied to a test surface having cracks open to the surface, the penetrant composition enters any surface cracks by capillary attraction. When excess surface penetrant is removed by a water wash, the entrapments of penetrant in surface cracks tend to resist removal due to the feature of gel formation.

In order to properly understand the objectives and scope of the present invention, it is necessary to understand the effect of "gel-formation." In the various water-washable penetrant compositions of this invention and the oil-water compatible compositions of my above-mentioned copending applications and issued patents, a gel-forming feature is found which can be analyzed and measured as follows: As incremental amounts of water are added to a test specimen of the gel-forming composition, and as the mixture is stirred thoroughly after each addition of water, it is found that the viscosity of the mixture tends to gradually increase up to a point, usually at about 15 to 25 percent added water, where there is a sharp, steep rise in viscosity as more water is added. In many cases, this viscosity increase results in the mixture becoming practically solid, or like a stiff, immobile, pasty mass.

As still more water is added, a point is eventually reached where the mixture "inverts" and "breaks" into an emulsion. At this point, which may be anywhere from about 50 percent added water up to more than 1,000 percent added water, the viscosity of the mixture drops sharply upon the addition of more water, and the mixture then exhibits the normally expected feature of viscosity reduction with dilution by water.

In accordance with my discoveries relative to this feature of gel formation, and the definitions which I have applied thereto, it has become customary to define "gel range" as the percent added water to provide a "gel break" where the viscosity of the mixture drops from a gelled condition to below 100 centistokes. The maximum viscosity which may be achieved within the gel range may differ in different compositions, but such differences are usually of little significance so long as the maximum viscosity rises to a point well above a few hundred centistokes, such that the mixture becomes relatively immobile.

Inasmuch as wash-removal of a water-washable penetrant from a surface crack can only proceed through a process of progressive dilution and diffusion of water into the penetrant and penetrant into the wash water, it is apparent that any tendency of the penetrant to form a gel, or to become thickened or increased in viscosity on contact with water, will serve to cause the formation of "plugs" of gelled penetrant in the

openings of the surface cracks, and these plugs, although they may eventually dissolve completely in water, tend to retard the wash removal of entrapped penetrant. Accordingly, in penetrant compositions of the gel-forming type, the flaw entrapment efficiency is greatly enhanced.

Emulsifiers, as used for emulsifying postemulsifier-type penetrants, are chemically similar to water-washable penetrants, except that they contain no indicator dye. However, when an emulsifier is applied to a test surface which has previously been treated with an oily postemulsifier-type penetrant, the emulsifier and penetrant compositions become blended together so as to form a composition which is essentially equivalent to a water-washable penetrant. Accordingly, it will be understood that the compositions of the invention, with or without an indicator dye, may be used as an emulsifier for postemulsifier-type penetrants, and similar effects of selective evaporation and alteration of surface penetrant washability may be obtained as are obtained with compositions which are constructed as water-washable penetrants.

In my copending applications, Ser. No. 787,381, filed Dec. 27, 1968, for "Oil-Water Compatible Compositions and Methods of Preparing Same," and Ser. No. 804,200, filed Mar. 9, 1969, for "Oil-Water Compatible Compositions Employing Non-Surface-Active Constituents," of which latter application, this present application is a continuation-in-part, I have disclosed a wide variety of emulsion-forming and gel-forming compositions which utilize not only the known and recognized hydrophylic and lipophylic surfactant substances, but also a number of substances which are not normally considered to have any "surfactant" properties whatsoever. In view of the fact that a large number of chemical compounds have been found which act in the nature of lipophylic surfactants but which are not really surface active in the accepted sense of the term, I have introduced the term "synergist" to identify the general class of oil-compatible materials which are capable of combining with water-soluble "surfactants" to form oil-water compatible mixture, emulsions, or gel-forming compositions as desired. It will be understood, of course, that the exact balance condition, or range of conditions, required for a gel-forming or emulsion-forming composition, would depend on the synergistic strength of the particular synergist substance employed, as well as the surfactant strength of the surfactant constituent which is employed. Likewise, it will be understood that the gel-forming or emulsion-forming properties of a given surfactant/synergist combination may be altered (usually reduced) by the addition of certain coupler or extender ingredients, as is described in detail in the aforesaid patents and patent applications.

The normal procedures which are employed in the water-washable inspection penetrant process involve steps as follows:

1. Test parts are dipped into the penetrant, or in the case of large parts, the penetrant is applied by spray to the test surfaces.
2. The parts are withdrawn from the penetrant and are allowed to drain. This step is in reality a dwell step which is employed to allow a period of time, usually about 5 or 10 minutes, so as to permit the penetrant liquid to enter any surface cracks and to displace air present in the cracks. A secondary effect of this dwell step is to allow as much penetrant as possible to drain back into the dip tank, so as to minimize dragout or depletion of the penetrant reservoir.
3. The parts are washed, usually with a pressure spray of water, so as to remove surface penetrant, leaving entrapments of penetrant in crack defects. This washing step is usually made as short as possible so as to minimize the effect of leaching out of entrapped penetrant.
4. The parts are finally inspected for the presence of entrapment indications. If the penetrant contains a visible-color indicator dye, inspection is carried out under white light. If the indicator dye is fluorescent in character, the inspection is carried out under black light. This inspection step may be carried out with the assistance of a developer, and/or the test parts

may be heated to assist in bringing out entrapped penetrant so that it may be observed as defect indications.

Heretofore, it has been desirable to minimize any effects of evaporation in penetrant compositions. Actually, all materials are volatile to at least some degree, and where the penetrant liquid has a low viscosity, and where the drain/dwell step allows the penetrant to run off test surfaces, leaving extremely thin residual layers of liquid, then any effects of evaporation may become relatively quite pronounced. Thus, even with low-volatility ingredients in a penetrant composition, it is possible to realize a drastic change in the chemical balance of a thin layer of surface penetrant within a few minutes of drain time. Usually, such changes occur in the direction of decreasing the solubility of the penetrant and enhancing the sensitivity for surface porosity or roughness indications. This is because the constituents which evaporate most rapidly may be a glycol-ether coupler or a mineral thinner diluent, and the removal of either or both of these ingredients, by evaporation, usually serves to augment the gel-forming feature of the penetrant composition, or to increase its viscosity, thus serving to retard the rate of solution in water or wash removal.

I have found that many gel-forming compositions suitable for inspection penetrant usage may be constructed by adding an appropriate proportional amount of a synergist constituent to a surfactant constituent. As is set forth in my above-mentioned copending applications, Ser. Nos. 787,381 and 804,200, there is usually found an optimum proportional ratio of synergist with respect to surfactant, such as a maximum gel range or gel viscosity may be obtained. Many of the known surfactant materials, such as ethoxylated alkylphenols, for example, tend to exhibit a small degree of gel formation, upon the addition of water, even when used alone. However, the addition of a synergist substance, having an appropriate synergistic strength, may act to materially enhance the effect of gel formation.

It, of course, becomes apparent that if we start with a gel-forming composition consisting of a balanced mixture of synergist and surfactant constituents, and if the synergist constituent could be partially or completely removed, selectively, then the effect of gel formation would be diminished. I have found that it is possible to design and construct a gel-forming emulsifier or penetrant composition such that the synergist constituent is relatively volatile. When such a penetrant composition is employed in an appropriate drain/dry step, a sufficient amount of synergist may be removed by evaporation from the thin layer of surface penetrant so that its gel-forming feature is substantially diminished.

It will be understood, of course, that in order for the compositions of this invention to be useful for practical applications, it is necessary that the degree of volatility of the synergist constituent shall fall within a range such that a change in gel-forming characteristic may take place within a reasonably short drain/dry time. On the other hand, the volatility of the synergist material should not be so great that it becomes completely removed, even from deep crack entrapments, in an excessively short drain/dry time.

Inasmuch as the usage conditions for a given water-washable inspection penetrant may vary greatly, the range of useful volatility characteristics for the synergist ingredient may vary greatly. For example, where a high-speed, automated penetrant process is employed, it might be possible to employ drain/dry times on the order of a few seconds, in which case an extremely volatile synergist substance such as trichloroethane or methylene chloride might be employed. On the other hand, where longer drain/dry times must be employed, and where large, massive, and hot parts must be penetrant inspected, the volatility of the synergist constituent must be relatively low. In any case, the selection of the volatile synergist depends on the usage mode of the penetrant composition, the duration of the drain/dry period, the temperature of the test parts, and other conditions which might affect the rate of synergist evaporation.

For most practical purposes, I have found that the vapor pressure at room temperature of the volatile synergist materials, useful in the compositions of the invention, may fall within the range of from about 0.1 mm. Hg to about 500 mm. Hg. Of course, the vapor pressure of a given synergist substance may become increased or decreased as the temperature is raised or lowered. The essential requirements, at least for the compositions of this invention, are that the synergist used must be more volatile than the surfactant constituent, and the volatility of the synergist must be sufficiently great to yield a satisfactory degree of evaporation from a thin layer of penetrant on a test surface within a practical drain/dry time interval, ranging from a few seconds to about an hour or more.

In the conventional drain/dwell step of water-washable penetrant usage, an effect of evaporation often occurs, but this is, as explained above, usually an evaporation of a coupler or extender constituent, resulting in an enhancement of any gel formation effect which may be present. In a usage of the compositions of the present invention, the drain step, if prolonged, becomes a drain/dry step in which a synergist constituent tends to evaporate more rapidly than other essential constituents. It will be understood, therefore, that for the purpose of this specification, the term "drain/dry" refers to an operation or process step in which a synergist constituent is allowed to selectively evaporate. Accordingly, although both the drain/dry method of the present invention and the drain/dwell method as used with conventional penetrant compositions may both involve effects of evaporation, the two method steps are distinctly different in that distinctly different constituents are involved in the evaporative process.

Many chemical substances can be shown to have synergistic properties and suitable volatility, that is for the purpose of this invention. I, therefore, do not limit the specification or the appended claims to the specific synergist materials which are given by way of example. Among the various synergist substances which I have found to be sufficiently volatile for the purpose of this invention are the following:

Synergistic chlorinated hydrocarbons
 Methylene chloride
 Methyl chloroform (1,1,1)
 Trichloroethane (1,1,2)
 Trichloroethylene
 Perchloroethylene
 Carbon tetrachloride
 Monochlorobenzene
 Dichlorodiethyl ether
 Orthodichlorobenzene
 1,2,3-trichloropropane
 Synergistic fluorinated hydrocarbons
 Trichloro-trifluoro ethane
 Tetrachloro-difluoro ethane
 Synergistic alcohols
 isooctanol
 2-ethyl hexanol
 1-hexanol
 Synergistic hydrocarbons
 Benzene
 Toluene
 Ethylbenzene
 Xylene
 Gasoline
 Diethyl benzene
 n-heptane
 n-hexane
 Mixed hexanes (isomers)
 Dimethyl naphthalene
 Dimethyl naphthalene (mixed isomers)
 Cyclohexane
 Refined kerosene (JP-4 fuel)
 Refined Diesel Fuel (Chevron No. 1)
 Diesel fuel (Chevron No. 2)
 Kerosene blends
 Aromatic mineral solvent blends
 Dipentene

Turpentine

As I have explained in detail in my above-mentioned copending application, Ser. No. 787,381, synergist materials may vary considerably in their so-called synergistic strengths. Also, certain synergists may exhibit gel-forming or emulsion-forming action in the presence of some surfactants and not in the presence of other "weaker" surfactants. Still further, certain synergist substances, when employed with "weak" surfactant systems, or with other balanced surfactant/synergist mixtures, may act in the nature of extenders or diluents. For example, in the case of a refined kerosene having low aromatic content, such material may provide a pronounced synergistic action, to yield good gels (upon the addition of water), when in combination with a 10-mol ethoxylated nonylphenol surfactant. As the surfactant strength of the ethoxylated nonylphenol is weakened by the addition of a glycol-ether coupler, the synergistic action of the kerosene diminishes to a point where gels are no longer formed upon the addition of water, and the kerosene then behaves as though it is merely a diluent. On the other hand, a kerosene blend, containing a relatively large amount of aromatic fractions, such as xylene, will exhibit a pronounced synergistic effect even in the presence of a greatly "weakened" surfactant.

It is pointed out and emphasized that certain of the relatively volatile synergist substances which may be employed in the compositions of this invention have been utilized in the past in inspection penetrant compositions. However, they have been employed in different modes of usage and for different purposes. For example, mineral thinner fractions have been utilized in the past as extender diluents in penetrant compositions employing mixtures of relatively high-strength synergist and surfactant substances, as is set forth in my copending application, Ser. No. 787,381. Under these previously described conditions of usage, the mineral thinner fraction normally does not exhibit any discernible synergistic characteristics, since it does not contribute to the gel-forming or emulsion-forming feature of the composition.

Accordingly, it will be understood that ordinary prior usages of certain of the volatile materials described herein, or any similar materials, would not provide the desired volatile-synergist feature of the invention as a natural consequence of such usage. It is only when the substances are employed in a manner which is adapted to provide a gel-forming effect when in combination with an appropriate relatively nonvolatile and active surfactant, that the objectives of the invention are satisfied.

Thus, for the design of a gel-forming water-washable penetrant formulation, the selection and use of a given synergist substance must be carried out with due consideration of the particular surfactant constituent and the degree of alteration in its surfactant feature due to the presence of other coupler or diluent constituents. Procedures for making such selections are set forth in the above-identified application, Ser. No. 787,381.

The various synergist substances which are useful in the compositions of this invention may be employed in combination with virtually any surfactant substance of the types which are set forth in the above-mentioned application, Ser. No. 787,381. This is because most of the known surfactant materials are relatively nonvolatile.

Although any one or a combination of many surfactant substances may be employed in compositions of this invention, I have found it convenient to employ an ethoxylated nonylphenol surfactant for the purpose of providing examples of the compositions and processes of the invention. The surfactant substance thus employed is nonylphenol which has been reacted with about 9 to 10 mols of ethylene oxide per mol of nonylphenol. This material is readily available commercially. It is liquid in form at normal room temperatures, and it provides a suitable gel formation feature which is reasonably typical of the various useful and available surfactants.

In the examples to be given below, fluorescent indicator dyes are employed. Although the two dyes C.I. Fluorescent Brightening Agent No. 68 (sensitizer) and C.I. Solvent Yellow

43 (color former) are used in the formulations of the examples, it will be understood that any compatible dye, visible color or fluorescent, may be substituted in the formulations. Such indicator dyes might include certain of the oil-soluble visible color dyes, or any one or a combination of oil-soluble dyes which are set forth in my now issued U.S. Pat. No. 3,386,920. Such indicator dyes might also include any of the oil-soluble ultraviolet absorber dyes such as are set forth in my copending application, Ser. No. 731,225, filed May 22, 1968, for "Tracer Processes Employing Ultraviolet Absorber Materials."

EXAMPLE I

A water-washable gel-forming inspection penetrant composition was prepared as follows:

Ethoxylated nonylphenol (10 mols ethylene oxide)	500 ml.
Dimethyl naphthalene	200 ml.
Diethylene glycol monobutyl ether	50 ml.
Fluorescent sensitizer (C.I. B/A No. 68)	5 grams
Fluorescent color-former (C.I. Solvent Yellow No. 43)	1 gram

In the foregoing formulation, the diethylene glycol monobutyl ether was included for the purpose of adjusting the viscosity feature of the composition. The formulation was tested using a Ceramic Test Block of the type described and claimed in my U.S. Pat. No. 3,164,006. The Ceramic Test Blocks used have unglazed surfaces which contain many thousands of very small cracks and fissures of various sizes in which entrapments of penetrant can form. The ceramic material, itself, is glassy and transparent in character, so that the presence of any entrapments of penetrant can be readily seen; that is, of course, provided that the effective film thickness of an entrapment is greater than the critical value for the particular penetrant used, below which color or fluorescence response tends to diminish.

To one-half of the surface of a clean Ceramic Block, a smear of the above penetrant composition was applied by means of a small spoonula. The surface of the block was then blotted gently with paper toweling, and wiped so as to remove most of the penetrant coating, leaving a very thin layer of penetrant on the surface of the block. The test block was then allowed to stand on its edge in a drain/dry step, for a period of 1 hour. This drain/dry exposure was conducted under ambient conditions of normal room temperature and air circulation.

After completion of the above drain/dry period, the other half of the test block surface was coated with the penetrant composition. Again, the excess penetrant was wiped from the surface, to prevent migration of the penetrant smears into each other, and the test block was allowed to stand for a few minutes so as to permit penetration of the fresh penetrant into any surface discontinuities which were present. The entire surface of the Ceramic Block was then washed with a spray of water at room temperature. During and following the various penetration, drying, and washing operations, the Ceramic Block was observed continuously under black light.

During and after washing with water, the "evaporated" half of the test block showed a much cleaner wash-removal of fine surface porosity indications than did the other half of the block surface. On the other hand, the brighter indications on the test block, which resulted from larger and deeper cracks or fissures in the block surface, appeared to have about the same degree of brightness on both halves of the block. It was, therefore, concluded that the penetrant composition of this example provided an effect of selective evaporation such that surface penetrant and entrapments of penetrant in shallow surface discontinuities are rendered more readily washable, as compared with entrapments in deep cracks in the test surface.

The above test was repeated using a jet engine turbine bucket having a heat-resistant coating on its surface. Half of the porous surface of this test part was treated with the

penetrant in its drain/dry mode, while the other half of the surface was treated with the penetrant in its freshly applied mode. After washing with a spray of water, it was noted that a considerably cleaner background, or porosity indications, was obtained on the portion of the part which had been treated in the drain/dry mode. At the same time, the penetrant retained its ability to reveal the presence of actual cracks and deep pinholes in the turbine bucket.

EXAMPLE II

A penetrant composition was prepared similar to that of example I, except that 1,1,1-trichloroethane was substituted for the dimethyl naphthalene, and the diethylene glycol monobutyl ether was omitted. Similar steps of penetrant application were carried out on the Ceramic Test Block, and on the turbine bucket test part, except that in this case, the drain/dry time was limited to about 2 minutes, and the freshly applied mode of application was limited to a few seconds dwell time.

As before, washing in a spray of water resulted in a considerably cleaner and more rapid removal of surface penetrant from the "evaporated" portions of the test surfaces, as compared with the areas of freshly applied penetrant. Again, there appeared to be little or no differences in the indications for deep cracks.

It was concluded from this experiment that a satisfactory selective evaporation of a volatile synergist could be achieved, even with an extremely volatile synergist substance, such that a selective removal of background porosity indications could be provided without loss of indications of deep cracks.

It will be understood that the selection of a particular "volatile" synergist for use in a composition and process of the invention may depend on various conditions of usage. In addition, it will be understood that various constituents may be added to the formulations of the invention for purposes which are not germane to the actual gel-forming feature of the compositions. As indicated in the examples given above, a low-volatility glycol-ether might be found useful for adjusting certain viscosity features of the composition, or, if preferred, this constituent might be deleted. Also, any one or a combination of extender or diluent liquids might be included in the composition. Such liquids might include glycols, nonsynergistic mineral thinners, esters, nonsynergistic alcohols, and the like. Such liquids might also include certain volatile extender liquids to provide a mode of usage in accordance with my U.S. Pat. No. 3,300,642.

EXAMPLE III

A water-washable inspection penetrant similar to that of example I was prepared as follows:

Ethoxylated nonylphenol (10 mols ethylene oxide)	5 gallons
Dimethyl naphthalene	2 gallons
Diethylene glycol monobutyl ether	0.5 gallon
Fluorescent sensitizer (C.I. B/A No. 68)	7 oz.
Fluorescent color-former (C.I. Solvent Yellow 43)	1.5 oz.

The above formulation was diluted with 75 gallons of perchloroethylene to form a low-viscosity penetrant fluid. This dilution was carried out in accordance with the disclosures of my U.S. Pat. No. 3,300,642. A deep dip tank was arranged so that the level of the liquid in the tank was about a foot or so below the lip of the tank. In this manner, the rate of evaporation of the perchloroethylene diluent from the liquid in the dip tank was minimized.

A basketful of turbine bucket parts having rough surfaces was dipped in the diluted penetrant and allowed to dwell in the penetrant bath for about 2 minutes. The parts were then withdrawn and were suspended over the dip tank for a drain/dry time of 60 minutes. About 7 minutes before completion of the 60-minute drain/dry period, a second lot of parts

was dipped in the penetrant for 2 minutes, and were suspended above the dip tank for about 5 minutes. Both lots of parts were washed simultaneously in a spray of water at room temperature. They were then dried in an oven and a dry powder developer was applied.

Upon inspection of the parts under black light, it was found that the initial design sensitivity of the undiluted penetrant had been restored by evaporation of the perchloroethylene from the coating of penetrant on the test parts. Thus, in this example, the perchloroethylene constituent was employed primarily as a volatile diluent to permit the changing and restoring of the sensitivity characteristic of the penetrant in accordance with the method of the aforesaid U.S. Pat. No. 3,300,642.

It was further observed that the parts which had been suspended for a drain/dry time of 60 minutes showed considerably less background porosity indications than did the lot of parts which had not been allowed to drain/dry. Thus, actual crack indications showed on "evaporated" parts with an improved contrast against a clean background.

Although the invention has been described with reference to particular embodiments thereof, it will be understood that various changes and modifications may be made therein without departing from the spirit of the invention nor the scope of the appended claim.

I claim:

1. In a process of penetrant inspection of test parts for surface discontinuities, comprising the steps of applying a water-washable dye penetrant to test surfaces, treating said test surfaces by washing with water to effect removal of excess surface penetrant, and inspecting said surfaces for the presence of penetrant entrapment indications, the improvement con-

sisting of the steps of adding a volatile synergist constituent to said penetrant prior to application of said penetrant to said test surfaces, and draining and drying said test parts, prior to washing with water, for a time sufficient to evaporate said volatile synergist from surface penetrant without substantial evaporation from penetrant entrapments in crack defects, said volatile synergist constituent being at least one member selected from the group consisting of

- 10 Methylene chloride,
- 1,1,1-methyl chloroform,
- 1,1,2-trichloroethane,
- Trichloroethylene,
- Perchloroethylene,
- Carbon tetrachloride,
- 15 Monochlorobenzene,
- Dichlorodiethyl ether,
- Orthodichlorobenzene,
- 1,2,3-trichloropropane,
- Trichloro-trifluor ethane,
- 20 Isooctanol,
- 2-ethylhexanol,
- 1-hexanol,
- Benzene,
- Xylene,
- 25 Gasoline,
- Diethyl benzene,
- Ethylbenzene,
- Dimethyl naphthalene,
- Cyclohexane,
- 30 Turpentine.

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