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# INSPECTION METHOD

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This invention relates to inspection and testing of specimens of various materials and surface conditions to locate and identify discontinuities, surface textures, lines of incipient failure, voids, cracks, or the like. More particularly, the invention contemplates a process and a new combination of materials resulting in improved economy and versatility for inspection or testing of specimens by dye penetrants whereby a clear, precise, permanent reproducible record of the inspection results is rapidly obtained.

Penetrants known in the prior art include various liquids mixed with dye or pigment, and are often used in combination with a so-called developer or blotting agent. Use of a liquid penetrant known to the prior art in a typical case may involve application of the penetrant to the specimen followed by a soaking period such as thirty minutes or longer to permit penetration of the liquid into the specimen material. Following the soaking period, removal of excess penetrant by appropriate cleaning is accomplished, usually involving a suitable solvent to aid such removal. Depending upon the penetrant composition, an emulsifying agent is sometimes used to transform excess penetrant as necessary for solubility of the penetrant in a cleaning solution. After cleaning, the specimen surface may be air dried for an additional period of time to dry the specimen surface but not the liquid penetrant remaining in the surface voids or cracks, after which the specimen may then be coated with the developer or blotting agent. Various powders such as ground silica, powdered chalk, or talcum are commonly used as developers, and function to provide a relatively light or otherwise contrasting background whereby the dye will more clearly appear. More importantly, the developer functions to blot residual traces of the liquid dye out of surface voids or cracks in the specimen surface, usually by a process of absorption. The pattern of blots thus produced by the liquid dye on the developer shows the general location and shape of the stated surface discrepancy.

The typical process described above, and minor variations thereof, are widely used in industry. Many dye penetrant inspection procedures currently known require considerable time to complete the inspection. In addition to their time-consuming aspects, conventional processes have the further disadvantage that the blotting action of the developer depends upon absorption of the liquid dye penetrant by the powder-like particles of the developer. Since this absorbing action continues as long as liquid dye remains in contact with the developer, the pattern initially produced quickly becomes fuzzy and is eventually obliterated so that definition is lost in a matter of minutes. Moreover, the definition obtained in the dye pattern depends partly upon grain size in the powder constituent of the developer whereby larger grain sizes produce poorer definition, and even the smallest grain size compromises the clarity of the pattern, as evidenced by the fact that the blot pattern is always of different size and shape than the void or defects indicated by the blot.

A further drawback of the conventional process is that the developer, especially where powdered materials are used for this purpose, normally wipes off immediately upon light touching so that specimens must be handled with utmost care. Also, conventional penetrants are of little or no use in detecting flaws in ceramic and porous materials, either metallic or non-metallic. One reason for their failure in this regard is that conventional penetrants produce a concentration of liquid in voids, and it is this



action upon which the usefulness of most penetrants known to the prior art depends in determining the location of surface voids. The blots produced by such concentrations are always magnified, that is, characteristically larger in size than the void or defect itself. Thus, two voids which are in close proximity will produce a single blot whereby they cannot be separately detected from close scrutiny of the dye pattern. Porous materials such as sintered metallic parts contain many voids which may be extremely close together and which are normal and acceptable features of porosity, but the mass of blots produced by conventional penetrants as a result of the normal voids entirely obscures or obliterates all indication of any deleterious voids or structural cracks which may exist in porous specimens. Moreover, known liquid dye penetrants are severely limited regarding temperatures at which they may be used. In general, known penetrants begin losing their penetrating power at temperatures below 70° F, primarily due to change of surface tension and flow characteristics, and some dye penetrants gradually thicken in consistency, becoming paste-like at temperatures of 50° F. or below.

Accordingly, it is a principal object of this invention to provide improved penetrant and developer materials capable of providing rapid inspection results having great clarity, definition, and permanency.

Another object in this case is to provide a dye penetrant having improved penetration power for use in a wide variety of metallic and non-metallic materials, both porous and non-porous.

Another object in this case is to provide a rapid drying liquid penetrant which requires no special drying procedures.

It is another object in this case to provide an improved developer for use in dye penetrant inspections.

Another object in this case is to provide a developer as stated in the preceding object capable of providing a permanent record of the inspection results.

It is a further object in this case to provide a dye penetrant and developer combination as set forth in the above objects operable over a wide range of specimen and environmental temperatures, especially sub-freezing temperatures.

It is a further object of this invention to provide an improved developer as set forth in the above objects capable of rapidly producing a pattern and which achieves and maintains improved clarity and definition in such pattern over long periods of time.

Another object in this case is to provide improved penetrant inspection test results as described in the above objects capable of being removed from the specimen and filed or reproduced by normal photographic processes.

Other objects and advantages of the invention in this case will become apparent upon a close reading of the following detailed description, including an illustrative embodiment of the inventive concept.

The invention disclosed herein provides a method for non-destructive inspection of specimen surface discrepancies such as minute cracks, voids, pits or the like, comprising the steps of applying a quick-drying penetrant to the surface, removing excess penetrant from the surface, and finally applying to the specimen surface a relatively quick-drying developer in which the dye constituent of the penetrant is adapted to bleed only until the developer becomes substantially dry. Thus, the dye penetrant used in practicing the novel method in this case includes a quick-drying solvent which serves primarily as a carrier for the dye. In general, this results in more rapid and effective penetration of the dye in surface voids than that achieved by relatively slow evaporating solvents and which require prolonged soaking periods. Moreover, the dye which is deposited within minute cracks and voids in

the specimen surface, quickly becomes dry after application of the penetrant so that application of the liquid developer is not accompanied by excessive or uncontrollable bleeding. The dry dye, upon contact with the developer, migrates briefly through the developer coating until the coating becomes dry. A printed pattern is thus produced by the dye on the developer characterized by extreme clarity, detail and definition exactly reproducing each minute crack or void in the specimen surface without magnification in the size of each detail of the pattern compared with the size of the defect so indicated. Both the dye and developer materials provide the results described above even though the specimen and environmental temperature be in the sub-freezing range as much as 50° F. or more below zero.

Now considering the details of the inventive concept, the dye constituent of the penetrant used in this case is required to be of a type which is soluble in the solvent used in the developer, and which is capable of bleeding or migrating through the developer only until such solvent evaporates or such developer becomes substantially dry. It is also important that the dye be capable of such bleeding upon contact with the moist or liquid developer when said dye is in the dry or substantially dry state. It is another necessary feature of the dye that the pattern produced by its migration has no perceptible magnification, and that the amount of migration is arrested and the pattern thereby fixed rapidly after initial forming by drying of the developer. In this context, the term "fixed" is used to refer to a physical action similar but not limited to the phenomenon of adsorption. Thus, controlled bleeding of the dye is necessary to produce maximum clarity and definition of the inspection pattern.

With further regard to the dye, the inventive process disclosed herein may be adapted for use with any oil- or spirit-soluble bleeding dye having the necessary properties discussed above, especially insoluble azo type dyes; i.e., characterized by N-to-N bonds. The insoluble azo type dyes contain no water-solubilizing groups. A dye known by various names in trade such as Oil Red "O" and Sudan Red sold by the General Aniline and Film Corporation is illustrative. The stated dye has the general formula xyleneazo-beta-naphthol and the empirical composition $C_{18}H_{16}N_2O$. Mefford No. 322 dye comprising O-tolueneazoxyteneazo-beta-naphthol is further illustrative. Also, fluorescent dyes are useful such as Fluorol 7GA sold by General Aniline and Film Corporation. In addition, xanthene dyes such as Rhodamine B extra dyes have been found very satisfactory, especially in connection with specimens of glass or ceramic. Rhodamine B dye is sold by the General Aniline and Film Corporation and has the formula $C_{28}H_{31}N_2O_3Cl$. It is variously identified as a hydroxide of diethyl-monoaminophenolphthalein, and as tetraethyl diamino-ortho-carboxy-phenylxanthene chloride. Rhodamine dyes include a broad class containing some which are water soluble, and which work very successfully in the penetrant inspection method disclosed herein, especially when a wetting agent is added to the liquid dye penetrant such as an aerosol as mentioned hereinbelow.

With specific regard to characteristics of the penetrant contemplated in the instant case it is of importance that the penetrant be capable of drying substantially completely and very rapidly after being applied to a specimen surface without necessity for elaborate drying procedures. Thus, the solvent used in the dye penetrant functions only as a carrier whereby the penetrant flows freely over a specimen surface and conveys dye into cracks, voids, or the like on such surfaces, and thereafter the penetrant quickly dries by evaporation of the solvent. Due to the desirability of rapid drying, primarily by evaporation of one or more constituent elements in the dye penetrant, use of slow drying solvents, particularly oily solvents, is avoided. In addition to the solvent or carrier used in combination with the dye to provide a penetrant such as discussed above, the addition of a wetting agent such as an aerosol to the dye penetrant is optionally useful to render it alcohol soluble for later cleaning purposes as discussed in greater detail hereinbelow. The addition of the aerosol constituent is not essential in achieving advantageous results by the methods and compositions taught herein, but is useful especially where maximum penetration in porous materials or particularly minute defects is desired.

The penetrant or penetrant and developer combinations disclosed herein are adaptable for use with the common organic solvents known to the art having the above discussed properties. Thus, in the case of an oil soluble system, both the penetrant and the developer solvents may be selected from the same group within the broad class of oil type solvents which may be aromatic, aliphatic, or chlorinated. Such solvents should be of the type having relatively low molecular weight for the purpose of rapid drying or evaporating. Examples of suitable aliphatic solvents usable both in the dye penetrant and developer are ketones such as methyl ethyl ketone, methyl isobutyl ketone and acetone. Examples of suitable aromatic solvents usable in the dye penetrant and developer are xylene, toluene and benzene. Examples of suitable chlorinated solvents usable in the stated context are methylene chloride, trichlor ethylene, and carbon tetrachloride. Regarding adaptation of the novel method disclosed herein for use with a spirit soluble system, various alcohols are suitable solvents for both the dye penetrant and the developer, such as methanol, denatured ethanol and isopropyl alcohol. Regarding the proportions of mixture for the dye and solvent or vehicle in combination, acceptable results have been obtained using one part dye in 50 parts of the solvent by volume. Also, one part dye in 7 parts of vehicle is a useful ratio, but any less proportion of the solvent results in a paste-like consistency which inhibits the penetration of the dye in specimen surface defects. However, optimum results are obtained using one part dye in 14 parts of vehicle by volume. The heavier concentration of dye in a one to 14 mixture permits repetition of an inspection many times without the necessity of recoating the specimen surfaces with additional dye penetrant. Thus, after one application of dye, a developer coating may be successively applied many times and removed each time without re-dyeing the same area.

Now considering the developer used in practicing the novel method disclosed herein, it is distinctly significant that the present developer does not blot or absorb the dye penetrant as generally associated with developers previously known in the art and which usually require the dye penetrant to be in the liquid state when the developer is applied to the specimen surface. Particularly advantageous in practicing the method disclosed herein are developers which include one or more resins as a binder in combination with a solvent selected from the classes discussed above. In such developers, flexibility of the binder is achieved by a suitable plasticizer. It is the principal function of the developer to provide a precise and permanent representation of the discontinuities in the specimen surface with a resolution not obtainable by ordinary examination. The developer of the present invention controls, among other things, the amount or rate of bleeding caused by the dye upon initial contact with the developer and arrests the bleeding action completely after a brief period. While various resins are usable in the developers discussed above, namely, vinyls, acrylics, nitrocellulose, butyrates, and latex, the vinyl polymers and copolymers have been found to produce results superior to all other resins. For example, vinyl chloride resin and vinyl chloride vinyl acetate copolymers have been found particularly advantageous. The developer may be clear lacquer such as the type discussed in greater detail below or else may have a color contrasting with the dye constituent of the penetrant. The plasticizer governs the rate of evaporation of the volatile solvents out

of the developer and determines the strippable properties of the resulting coating. Among suitable plasticizers for use in combination with various of the resins discussed above are diisoctyl phthalate, dioctyl phthalate, butyl phthalate, and tri-2-ethylhexyl. Other commercially available plasticizers known to the art may be used with the above plastics.

In addition to developers having a resin constituent, other fast drying developers have been successfully used with the dyes discussed above, some being non-strippable however, and others involving less satisfactory results in various respects. The developer is preferably in liquid form, is quick-drying primarily due to rapid evaporation of the volatile solvents therefrom, and does not require special drying procedures. The pattern produced by the dye on the developer and which becomes perceptible within a few seconds after its application to the specimen thus quickly solidifies or otherwise becomes fixed and chemically stable after which no further significant change in such pattern occurs after the developer has dried. Inspection of the specimen upon which the process discussed above is practiced may be accomplished without removing the pattern from the specimen. However, if a strippable paint or lacquer is used in the developer, the inspection pattern may be stripped or peeled from the surface of the specimen in one or more continuous strips which may thereafter be stored, filed, or else used as photographic negatives to produce prints on sensitized paper by normal photographic methods, including enlargement to facilitate study of the inspection pattern. Where developers are capable of being sprayed, electrostatic spraying of the same is useful in avoiding large dip tanks, because spraying one side of a specimen provides a coating over all surfaces of the specimen.

In further connection with the novel method disclosed herein, it has been found that some plastic vinyl tapes, such as those in common surgical use, may be applied to a treated specimen surface in dry form and will act as a developer coating when activated by moistening with a solvent of the type discussed above, such as methyl isobutyl ketone. However, while such tapes provides some advantages over the prior art, they are not as rapid or effective generally as the rapid drying liquid developers discussed above.

The examples given below are illustrative of the benefits and advantages obtained from use of the novel teachings contained herein and are representative only.

*Example I*

The inventive method disclosed herein was practiced with great success in disclosing extremely minute surface discrepancies on metallic specimens of advanced alloy stainless steel and fusion welded joints on such specimens. A penetrant solution comprising 14 parts methyl isobutyl ketone, 1 part of xyleneazo-beta-naphthol and 2 parts aerosol by volume was prepared. The dye penetrant was applied to weld seams and workpiece surface portions by brushing, and required no soaking period to achieve effective coverage or penetration. The methyl isobutyl ketone evaporated very quickly after carrying the dye into surface cracks and then was not a significant factor in the remaining steps of the process. The dyed portion was then superficially cleaned by a solution of equal parts methyl alcohol and methyl isobutyl ketone which also quickly evaporated with no significant residual effects on the inspection process. Thereafter, the specimen surface was spray coated with a developer which included a vinyl base paint comprising about 19% vinyl chloride vinyl acetate copolymer resin, 1% white mineral oil, about 61% toluene, 14% methyl ethyl ketone, 6% diisoctyl phthalate, and a nominal amount of non-chalking titanium dioxide (rutile) sufficient to give the necessary amount of whiteness for contrast with the red dye. A thinner of methyl isobutyl ketone was added to the foregoing paint to reduce the same to spraying consistency. The sprayed coating immediately picked up dye traces, some of which were barely visible without microscopic aid, after which the developer coating quickly dried and the dye pattern formed thereon became permanently fixed and unchangeable. The pattern was characterized by a virtually complete absence of magnification in respect to the actual size of the surface void or crack compared with the trace produced in the final pattern on the developer coating.

The resulting dried developer was then peeled from the specimen surface in one continuous layer by manually pulling on one end and later was used as a photographic negative for printing on sensitized paper.

*Example II*

The novel method disclosed herein was successfully practiced in a water soluble system using a Rhodamine dye (sold under the trade name Rhodamine B extra S by General Aniline and Film Corporation) mixed with methyl isobutyl ketone. The dye penetrant was applied to a stainless steel specimen by brushing, followed by surface cleaning as discussed in Example I above. Thereafter, a developer using a water soluble system and comprising a mixture of ethyl cellulose and titanium dioxide in a commercial product known as Logo, sold by the Bee Chemical Company to which a vehicle of denatured alcohol was added, was applied to the inspection area by spraying. The resultant dye pattern formed quickly and became permanently fixed upon drying of the developer. The pattern was of superior clarity and permanency in comparison with conventional dye inspection results; however, the degree of definition was slightly less than that associated with the results from Example I. The dye pattern and developer coating were subsequently removed from the specimen by water washing.

*Example III*

A fluorescent type penetrant was used in combination with a developer of transparent lacquer to inspect weld seams in advanced alloy stainless steel specimens. Fluorescent dye in the form of Fluorol 7GA was combined with methyl ethyl ketone which constituted the vehicle or carrier for the stated dye. After superficial cleaning of the specimen surfaces in the manner described for Example I above, a coating of liquid developer having a composition identical to that specified in Example I above except omitting the titanum dioxide coloring agent, was sprayed upon the specimen surface. Omission of the pigment from the stated developer results in a clear vinyl lacquer upon which a fluorescent pattern was formed by the stated dye. After the developer coating had dried, which occurred very quickly, the developer coating with the pattern printed thereon was peeled from the specimen surface in one continuous strip, and used for printing on photographic paper. Also, a very clear and well defined pattern was visible from the stripped coating when viewed under ultraviolet light.

The novel methods disclosed herein using the materials illustratively mentioned or otherwise discussed above have been found to provide extremely rapid and most effective inspection techniques. Thus, quenching cracks which are normally very minute, and other surface conditions appear clearly and quickly within a period of one minute and often within five or ten seconds after application of the developer on a treated specimen. Due to the characteristics of the developer and the dye penetrant, especially with respect to the quick-drying characteristics of both, the pattern initially produced by the dye is arrested before any significant magnification occurs, and is permanently fixed whereby no change in the pattern occurs although the inspection results be stored or otherwise remain unattended for hours, weeks or months, whether removed from the specimen surface or not.

The present inspection method and combination of materials may be practiced with diverse workpiece or specimen materials, and has been found to provide extremely accurate, detailed and rapid inspection results

in connection with porous materials, wood, plasma sprayed metals, glass, ceramic, and many others, including ice.

Other examples and results from actual tests illustrating the inventive concept discussed above are set forth below. In all examples, the dye penetrant solution contained the same ratio of one part dye, 14 parts vehicle, and 2 parts of an aerosol by volume. The aerosol was 75% pure, and was included mainly as a wetting agent and to facilitate cleaning with alcohol following the test. Also, in each of the following examples, the developer and vehicle were mixed in a ratio of 2 parts vehicle to 1 part of developer, with slight variations as necessary to reduce the developer to spraying consistency. All the tests involved application of the dye by brushing upon the specimen surface and spraying of the developer and vehicle combination, and included specimen materials of steel, wood, glass and various plastics as well as those specified below.

*Example* IV

A dye penetrant mixture of Oil Red O and a vehicle of methyl isobutyl ketone was applied to metallic specimens comprising fusion welded joints in steel and specimen layers of plasma sprayed aluminum oxide over steel. The excess dye was cleaned from the specimen in each case in the manner described for Example I above. A coating of strippable developer comprising a mixture of methyl isobutyl ketone and vinyl base paint sold commercially as Brolite by the Andrew Brown Paint Company was then sprayed on specimen surfaces. Brolite has a composition generally similar to that described for the vinyl base paint in Example I above. A dye pattern showing surface defects developed immediately after the developer coating was applied and defects were extremely well defined by dye traces in the pattern. The same combination of dye, developer and vehicle was used with similarly successful results on specimens of ice and of precipitation hardenable stainless steel while both the dye and the steel were at a temperature of 50° F. below zero.

*Example* V

A dye of Rhodamine B extra S combined with a vehicle of ethyl methyl isobutyl ketone was applied to metallic specimens, the excess dye removed, and a developer similar to Example IV above thereafter applied. Excellent delineation of surface defects was achieved in the resulting dye pattern, and the developer coating was peeled from the specimen in one continuous strip. This combination of materials was also found to provide consistently excellent results at specimen and environmental temperatures 50° below zero. The Rhodamine dye used in this test is daylight visible as well as under black light, i.e., ultraviolet light or near the ultraviolet range.

*Example* VI

A dye penertant comprising Fluorol 7GA and methyl isobutyl ketone was applied to metallic specimens and the excess dye thereafter removed. A developer identical to that used for Example IV and V described above except omitting the titanium dioxide pigment, was thereafter applied by spraying. Since the dye used in this test was visible in ultraviolet light or light near the ultraviolet range, use of a clear developer permits greater visibility of the dye trace. Excellent delineation of the inspection pattern was obtained, and the strippable developer coating was peeled from the specimen in one continuous strip for detail study under black light and for making photographic prints therefrom. The dye and developer combinations in this example were also found to produce consistently superior results with specimen and environmental temperatures in the sub-zero range, such as 50° F. below zero.

*Example* VII

A dye similar to that used for Example IV above was applied to metallic specimens and the excess removed therefrom. Thereafter, a developer coating comprising nitrocellulose lacquer complying with Military Specification MIL–L–7178 and a vehicle of methyl isobutyl ketone was applied by spraying. The dye trace developed immediately upon application of the coating and delineation of the dye trace was excellent. The developer dried rapidly and was non-strippable from the specimen surface.

*Example* VIII

The dye used in Example IV above was applied to metallic specimens, the excess dye removed, and a developer comprising cellulose nitrate dope and a vehicle of methyl isobutyl ketone was applied by spraying. The resulting dye trace appeared less rapidly than occurred in Examples IV through VII discussed above, and the color of the dye changed from brilliant red to a purple hue less sharply visible than that characterizing the test results discussed above. The final test pattern was not strippable from the specimen.

*Example IX*

A dye penetrant identical with that used in Example IV above was used in combination with a developer comprising butyrate cellulose acetate dope and a suitable thinner. The pattern was less visible and less clearly defined than that obtained from the materials described in Examples IV through VII above.

*Example X*

A dye coinciding with that described above in connection with Example IV was used in combination with a developer comprising chlorinated rubber enamel paint with a vehicle comprising xylene. Following application of the developer and vehicle, a dye trace indication appeared very slowly and of less visible color than that characterizing the dye itself before the developer coating was applied. However, the dye pattern had very good definition. The inspection results were not strippable from the specimen due to inherent characteristics of the enamel.

*Example XI*

A dye corresponding with that described in connection with Example IV was used in combination with a developer and vehicle comprising alkyd resin sold commercially as Kem Lustral Enamel by the Sherwin Williams Paint Company, in combination with a vehicle of naphtha. The resulting dye pattern was superior to that obtained in connection with Example X above but inferior with respect to clarity and contrast of the patterns obtained from Examples IV, V, and VI above. The inspection pattern was non-strippable.

*Example XII*

A dye corresponding to that described for Example IV above was used in combination with the developer described in connection with Example II above on metal surfaces. The resulting inspection pattern, although characterized by definition superior to that obtainable from conventional dye penetrants, was poorer than that obtained in connection with Examples IV through XI above. The developer coating was non-strippable.

*Example XIII*

A dye penetrant comprising one part of Oil Red "O," 10 parts of methyl isobutyl ketone, and 5 parts of polyvinyl chloride base paint corresponding to that described for the developer in connection with Example I above except omitting titanium dioxide pigment, was prepared. The foregoing dye penetrant was applied with brush to various porous materials including plasma sprayed aluminum oxide, sintered metals, and the like, and allowed to dry. A rinse solution of three parts of isopropyl alcohol and one part methyl isobutyl ketone was quickly brushed on the dried area, after which the coating formed by the dye on the specimen surface was peeled off in one continuous

strip. Thereafter, a developer and vehicle combination identical to that described in connection with Example I above was spray coated over the area previously covered by the dye, whereby a pattern of dye traces rapidly appeared in the developer coating and became fixed. The dried developer coating was peeled off in one continuous strip.

*Exmple XIV*

The test materials and procedures described in connection with Example XIII above were repeated except for the substitution of the fluorescent dyes used for Examples V and VI above in place of Oil Red "O." The inspection results were in each case equally as satisfactory as those obtained from Example XIII above. As in the case of materials described in connection with Example XIII above, the materials tested in this example were found to produce consistently excellent dye patterns when specimen and environmental temperatures were as low as —50° F. below zero throughout the temperature range to a maximum of 110° F. above zero.

While the particular details set forth above are fully capable of attaining the objects and providing the advantages herein stated, the specific materials and method thus disclosed are merely illustrative and could be varied to produce the same results without departing from the scope of the inventive concept as defined in the appended claims.

I claim:

1. A method of obtaining a pattern of surfacing discontinuities in a specimen, said method comprising:
applying to said specimen surface a relatively quick-drying liquid penetrant comprising a rapidly evaporating solvent containing a bleeding dye,
removing excess penetrant from said surface while some of said dye in a substantially dry state remains in said surface discontinuities, and thereafter
applying to said surface at least one coating of a relatively quick-drying developer comprising a wetting agent and a plastic medium, said dry dye being adapted to be wetted by said wetting agent and bleed into said plastic medium to the surface of said coating while said developer remains substantially in the moist state,
said dye being further adapted to terminate said bleeding when said developer becomes substantially dry, whereby a stain pattern produced in said developer precisely recording said surface discontinuities is permanently fixed in size and location upon drying of said developer.

2. A method of obtaining a pattern of surface discontinuities in a specimen, said method comprising:
applying to said specimen surface a relatively quick-drying liquid penetrant comprising a relatively low molecular weight organic solvent containing an azo type dye,
cleaning said surface to remove excess penetrant therefrom while some of said dye in a substantially dry state remains in said surface discontinuities, and thereafter
applying to said surface a coating of relatively quick-drying developer comprising a solvent and a resin medium in which said dye wetted by said solvent is adapted to bleed to the surface of said coating while said developer remains substantially in the moist state,
said dye being further adapted to terminate said bleeding when said resin becomes substantially dry, whereby a stain pattern produced in said resin conforming exactly to said specimen discontinuities is permanently fixed in size and location upon drying of said developer.

3. A method of obtaining a pattern of surface discontinuities in a specimen, said method comprising:
applying to said specimen surface a relatively quick-drying liquid penetrant comprising a relatively volatile solvent having a dye added thereto selected from the class consisting of azo, fluorescent and xanthene dyes,
cleaning said surface to remove excess penetrant therefrom while some of said dye in a substantially dry state remains in said surface discontinuities, and thereafter
applying to said surface a relatively quick-drying developer solution of a resin selected from the group consisting of vinyls, butyrates, acrylics, latex and nitrocellulose,
said dry dye being adapted to be wetted by and bleed into said developer while said developer remains substantially in the moist state, and to terminate said bleeding when said resin becomes substantially dry, whereby a pattern produced in said resin is permanently fixed in size and location upon drying of said developer.

4. A method of obtaining a patterns of surface discontinuities in a specimen, said method comprising:
applying to said specimen surface a relatively quick-drying liquid penetrant comprising an azo type dye in a highly evaporative solvent,
cleaning said surface to remove excess penetrant therefrom while some of said dye in a substantially dry state remains in said surface discontinuities, and thereafter
applying to said surface a developer comprising a relatively quick-drying solution of a polyvinyl resin, said solution including an agent adapted to wet said dye sufficiently for said dye to bleed into said resin.

5. A method of inspection for surface discontinuities in a specimen, said method comprising:
applying to said specimen surface a relatively quick-drying liquid penetrant comprising a low molecular weight solvent containing a bleeding type dye,
removing excess penetrant therefrom while some of said dye in a substantially dry state remains in said surface discontinuities, and thereafter
applying to said surface a relatively quick-drying developer comprising a polyvinyl chloride resin and a volatile solvent in which said dye is soluble.

6. A method of inspection for surface discontinuities in a specimen, said method consisting of the steps of:
applying to said specimen surface a relatively quick-drying liquid penetrant comprising a highly evaporative solvent having a bleeding type dye added thereto,
cleaning said surface to remove excess penetrant therefrom while some of said dye in a substantially dry state remains in said surface discontinuities, and thereafter
applying to said surface a relatively quick-drying developer comprising a resin selected from the group consisting of vinyls, butyrates, acrylics, latex and nitrocellulose in a relatively low molecular weight organic solvent.

7. A method of obtaining a pattern of surface discontinuities in a specimen, said method comprising:
applying to said specimen surface a relatively quick-drying liquid penetrant comprising a relatively low molecular weight solvent having an azo type dye added thereto,
cleaning said surface to remove excess penetrant therefrom while some of said dye in a substantially dry state remains in said surface discontinuities, and thereafter
applying to said surface a relatively quick-drying developer comprising a resin, a plasticizer, and at least one organic solvent adapted to wet said dye and having a relatively low molecular weight.

8. The method set forth in claim 7 above, wherein:
said developer comprises from about 15–25% resin, from about 55–65% aromatic solvent, from about 10–16% ketone, and from about 4–10% plasticizer.

9. The method set forth in claim 7 above, wherein:

said developer comprises about 19% polyvinyl chloride resin, about 61% toluene, about 14% methyl ethyl ketone, about 6% diisoctyl phthalate, and about 1% white mineral oil.

**10.** A method of obtaining a pattern of surface discontinuities in a specimen, comprising:

applying to said surface a liquid penetrant comprising a volatile spirit solvent having a spirit soluble bleeding dye added thereto,

removing excess penetrant from said surface,

drying said surface by evaporation of said solvent to leave said dye in a substantially dry state, and thereafter

applying to said surface a quick-drying developer comprising a resin binder in which said dye is bleedable when said developer is moist, and a volatile spirit solvent to render said developer moist until evaporation of said last mentioned spirit solvent.

**11.** A method of obtaining a pattern of surface discontinuities in a specimen, comprising:

applying to said specimen surface a liquid penetrant comprising xylene azo beta naphthol dye dissolved in a relatively low molecular weight organic solvent in an amount sufficient to give a brilliant red hue to said penetrant,

removing excess penetrant from said surface,

drying said surface to leave said dye in a substantially dry state in said surface discontinuities, and thereafter

applying to said surface a quick-drying developer comprising a copolymer consisting of polyvinyl acetate and polyvinyl chloride, a plasticizer selected from the class consisting of diisoctyl phthalate, dioctyl phthalate, butyl phthalate, and tri-2-ethylhexyl phthalate, and a volatile solvent adapted to wet said dye and to render said developer moist until evaporation of said volatile solvent.

**12.** The method recited in claim **11** above, wherein:

said dye consists of xylene azo beta naphthol, and

said plasticizer consists of diisoctyl phthalate.

**13.** A method of obtaining a pattern of surface discontinuities in a specimen, said method comprising:

applying to said specimen surface a relatively quick-drying liquid penetrant comprising a low molecular weight solvent containing a bleeding type dye,

removing excess penetrant from said surface while some of said dye in a substantially dry state remains in said surface discontinuities, and thereafter

applying to said surface a relatively quick-drying strippable paint containing a volatile solvent in which said dye is soluble, said dye being adapted to bleed into said paint until said paint dries, and

removing said dried paint from said specimen surface by stripping therefrom in a substantially continuous strip.

**14.** The method of obtaining a pattern for surface discontinuities in a specimen set forth in claim **13** above, said method further including:

printing a photographic enlargement on sensitized paper by using said strip as a photographic negative in a photographic enlarger.

**15.** A method of obtaining a pattern of surface discontinuities in a specimen, said method comprising:

applying to said specimen surface a layer comprising a dyeing agent in a liquid resin vehicle,

allowing said layer to dry,

removing said layer from said surface while some of said agent remains in said surface discontinuities and thereafter,

applying to said surface a relatively quick-drying developer comprising a resin selected from the group consisting of vinyls, butyrates, acrylics, latex, and nitrocellulose in a relatively low molecular weight organic solvent.



**16.** The method set forth in claim **15** above, wherein:

said dyeing agent in said layer consists of an azo type bleeding dye, and

said resin vehicle comprises a polyvinyl chloride resin.

**17.** A method of obtaining a pattern of surface discontinuities in a specimen, said method comprising:

applying to said specimen surface a resinous coating comprising a fluorescent dye in a liquid resin vehicle,

allowing said coating to dry,

stripping said coating from said surface while some of said dye remains in said discontinuities, and thereafter

applying to said surface a relatively quick-drying developer comprising a resin selected from the group consisting of vinyls, butyrates, acrylics, latex, and nitrocellulose in a relatively low molecular weight organic solvent.

**18.** A method of obtaining a pattern of surface discontinuities in a specimen, said method consisting of the steps of:

applying to said specimen surface a bleeding type dye,

removing excess dye from said surface while some of said dye remains in said surface discontinuities, and thereafter

applying to said surface a relatively quick-drying developer comprising a resin selected from the group consisting of vinyls, butyrates, acrylics, latex and nitrocellulose in a relatively low molecular weight organic solvent.

**19.** A method of obtaining a pattern of surface discontinuities in a specimen, said method comprising:

applying to said specimen surface a liquid dye penetrant including a coloring agent,

removing excess dye penetrant from said surface while some of said coloring agent remains in said surface discontinuities, and thereafter,

applying to said surface a relatively quick-drying developer comprising a resin selected from the group consisting of vinyls, butyrates, acrylics, latex and nitrocellulose,

said coloring agent being adapted to be wetted by and bleed into said developer while said developer remains substantially in the moist state.

**20.** A method of obtaining a pattern of surface discontinuities in a specimen, said method comprising:

applying to said specimen a liquid dye penetrant including a bleeding dye in an amount sufficient for some of said dye penetrant to enter said discontinuities, and thereafter

applying to said surface a relatively quick-drying developer comprising a resin, a plasticizer, and at least one organic solvent having a relatively low molecular weight,

said dye being adapted to bleed into said developer while said developer is in a substantially moist state and to terminate said bleeding when said developer dries.


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