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T. DE FOREST

2,340,940

METHOD OF TESTING RIGID ARTICLES FOR FLAWS

Filed Nov. 2, 1942

Fig. 1.

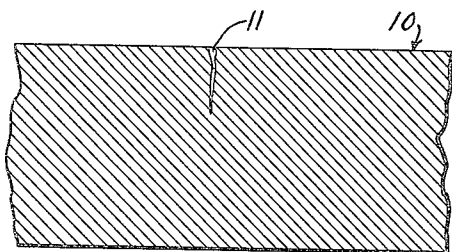


Fig. 2.

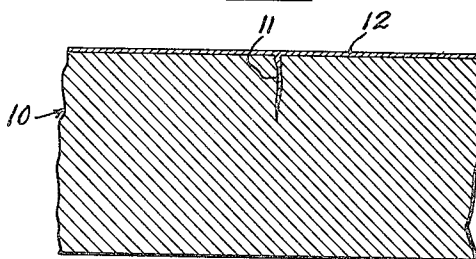


Fig. 3.

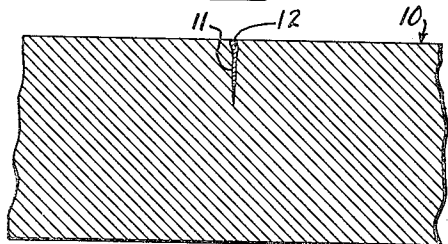


Fig. 4.

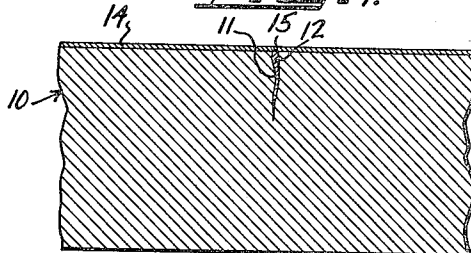


Fig. 5.

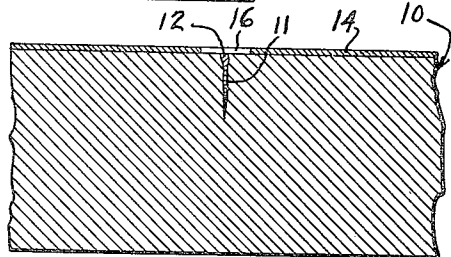
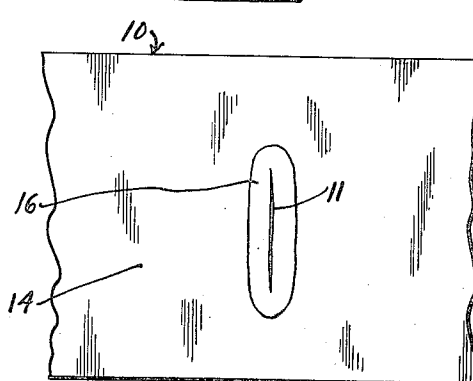


Fig. 6.



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UNITED STATES PATENT OFFICE

2,340,940

METHOD OF TESTING RIGID ARTICLES
FOR FLAWSTaber de Forest, Chicago, Ill., assignor to Magna-
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10 Claims. (Cl. 73—51)

This invention relates to improvements in methods for detecting flaws in rigid bodies, whether metallic or non-metallic. More specifically, the invention relates to rapid and non-destructive tests for the location of cracks, blow-holes, leaks, piping, seams, shrinkage cavities and other defects in rigid articles. The methods of this invention are particularly applicable to the detection of superficial defects and do not require the use of special illumination or irradiation in order to indicate the location and extent of superficial defects.

It has heretofore been proposed to detect flaws in rigid articles by coating, immersing or otherwise applying to such articles a liquid agent containing a luminescent substance and capable of penetrating into cracks or other superficial cavities so small as normally to be invisible to the human eye. After the removal of any excess of the liquid agent from the external surfaces of the articles being tested, the operator allows sufficient time for the seepage of the liquid agent from any crack or other flaw into which the agent may have penetrated. The agent can then be detected by its luminescence upon examination under special irradiation, thereby revealing the location and extent of any defect that may be present.

The prior art depends for the detection of superficial flaws upon agents that emit luminescent light at the flaw or otherwise identify the location of superficial defects such as cracks. The present invention, on the other hand, provides a method for showing up any superficial flaws in a rigid article, not by relying upon any luminescence or distinctive coloring of the defective area, but by distinctively coloring the surface of the metal article more remotely surrounding the defect while leaving the area immediately adjacent the defect unaffected.

More particularly, the method of this invention comprises coating, dipping or otherwise treating an article to be tested with an oily liquid capable of penetrating into any superficial defect which would escape visual inspection. The excess of the oily liquid is then wiped or washed off from the exterior surfaces of the article, and the article is coated with a flowable colored composition, which may comprise an oil soluble or oil emulsifiable dyestuff dispersed in a low boiling liquid hydrocarbon, halogenated hydrocarbon, aliphatic ether, or the like.

I have found that the film of the colored composition which forms over the article will break above any defect into which the initially applied

liquid has penetrated and will gradually flow away from such defect to leave an uncovered area thereabout. As the coating film recedes from the defect, the suspending or dissolving medium therein evaporates off and the dyestuff either crystallizes or precipitates out at the edge of the uncovered area about the defect. Such area is thereby permanently and clearly outlined and made apparent on ordinary visual inspection.

It is therefore an important object of the present invention to provide an improved method for detecting superficial flaws in rigid articles which are normally invisible to the human eye without the use of special illumination or irradiation.

Another important object of this invention is to provide a method for detecting the extent and location of superficial cracks and the like in rigid articles by a method involving the step of distinctly coloring the continuous surface area surrounding a local discontinuity such as the crack.

A further object of the invention is to provide a method for revealing the presence and extent of surface cracks and the like in rigid articles by causing an oily liquid to penetrate into such cracks and thereafter coating the article being tested with a colored film-forming material characterized by its tendency to recede from any of the oily liquid exuding from a crack or the like whereby a permanently outlined colored area delimiting the defect is formed.

Other and further objects and features of the present invention will become apparent from the following description and appended claims.

An example of the working of the present invention will now be described with special reference to the drawing, in which:

Figure 1 is a fragmentary cross-sectional view of a metal article having a superficial crack normally invisible to the human eye;

Figure 2 is a view similar to Fig. 1 showing the treatment of the article in Fig. 1 with an oily liquid capable of penetrating the superficial crack therein;

Figure 3 is a view similar to Fig. 2 showing the oily liquid removed from the outer surface of the article but still present within the superficial crack into which it has penetrated;

Figure 4 is a view similar to Figure 3 showing the article of Fig. 3 immediately after being coated with a colored solution or suspension;

Figure 5 is a view similar to Fig. 4 showing how the colored solution recedes from the edges of the crack filled with penetrating oily material;

and

Figure 6 is a plan view of the article in the same final stage as that of Fig. 5.

In Figs. 1 to 6 the reference numeral 10 indicates generally a rigid article, which may be either metallic or non-metallic. A surface crack, which may be so small as to be invisible to the unaided eye and therefore not detectable by ordinary visual inspection, is represented by the reference numeral 11. In proceeding according to the present invention, the article 10 is initially coated with a penetrating oily material 12, as shown in Fig. 2. The penetrating liquid may suitably consist of any light oil, such as kerosene, paraffin oil, commercial ink oil, or the like. The excess of the penetrating oil is then wiped or washed off the exterior surfaces of the article being tested, but without removing the oil that has penetrated into the crack, as shown in Fig. 3.

In the next step, the article being tested is coated with a thin film of a suspension or solution of a dyestuff or pigment in a suitable volatile liquid medium such as ethylene dichloride. Fig. 4 shows the article 10 coated with a film 14 of such a colored liquid. As shown in Fig. 4, the oily medium contained in the crack 11 causes a break in the film 14 immediately above the crack 11. The resulting fissure in the film is indicated by the reference numeral 15.

Due to differences in surface tension as between the oily liquid 12 and the film 14, the latter recedes in all directions away from the fissure 15 formed above the crack 11. The fissure 15 tends to be enlarged progressively by virtue of such recession of the liquid forming the film. The initial fissuring of the film 14 as well as the recession of the film after being fissured is thought to be due to a surface tension phenomenon but may possibly be due to some other cause.

The liquid vehicle in the coating dye dispersion being quite volatile, evaporation proceeds as the film recedes from the crack 11. When the evaporation has continued to a definite stage, the dyestuff dispersed in the liquid film forming material begins to precipitate out or to crystallize out, and recession from the edges of the crack 15 ceases. As shown in Figs. 5 and 6, an uncovered and uncolored area 16 about the crack 11 is left while the more remote surrounding surface area is colored by the dyestuff precipitated from the film 14. The area 16 clearly outlines the location and extent of the crack 11. More particularly, the area 16 forms a magnified reproduction of the crack 11. The exact amount of magnification depends upon the nature and characteristics of the oily penetrant and of the specific liquid film forming material employed, as well as upon temperature conditions at the time of testing, and like factors. However, the exact amount of magnification occurring under standardized conditions can be determined, so that the present method offers a simple method not only for indicating but also for magnifying to a predeterminable extent superficial flaws in rigid articles. By the method of this invention, simple measurements and ordinary measuring devices can be employed for determining the exact magnitude of any cracks found by such inspection.

Where ethylene dichloride is used as the dispersing medium for the dyestuff, an oil soluble dye such as Glycolor Brown, Fluorol 5 G. A., Oil Yellow, Oil Orange E, Quinoline Yellow Spirit Soluble, Sudan II, Sudan C. B., Sudan G, Cya-

nosin Spirit Soluble, the fatty acid compounds of the basic triphenyl methane dyestuffs and other dyes conventionally used to color oils can be employed. Other pigments or dyestuffs can be combined with suitable dispersing media to coact with any desired penetrating media, as will be evident to those skilled in the art in the light of the foregoing disclosures.

Other vehicles for the dyestuff or pigment can be used, including halogenated hydrocarbons such as carbon tetrachloride, ketones, such as acetone and methyl ethyl ketone; and ethers, such as diethylene glycol monoethyl ether. The selection of the particular vehicle depends upon what properties are desired, particularly upon whether high or low volatility is desired to give rapid or slow evaporation of the solvent. For instance, ordinary ether may be used, but it is too volatile for best results. Acetone, on the other hand, works very satisfactorily, since it is only moderately volatile. The glycol ethers are examples of even less volatile solvents that can be used.

As previously indicated, any light or medium petroleum distillate such as kerosene, mineral spirit, or the like, may be used as the penetrant. The important thing is that the penetrant and the vehicle for the dyestuff have different surface tension values. The amount of the difference, apparently, need not be great, but some difference appears to be required. The use of identical liquids for the penetrant and the dyestuff vehicle is therefore not feasible, unless the dissolved dyestuff appreciably changes the surface tension of the vehicle, as may sometimes be the case.

The phenomenon of "wetting" is probably also involved but that is understood to be a function of the surface tension. My observations indicate that there may be still other factors involved, such as the relative degree of volatility of the penetrant and of the color vehicle, but in general I have found that whenever different liquids are used for the penetrant and color vehicle, there is a tendency for the penetrant and color vehicle to resist coalescence and for the recession previously described to take place.

In order to obtain best results, it is necessary to effectively remove the excess of the penetrant from the exterior surface of the article undergoing test. This is most easily accomplished by incorporating an emulsifying agent in the penetrant so that the excess penetrant can be readily washed off by a spray of water. Many of the known emulsifying agents for effecting an oil-in-water emulsion are suitable for use here. A preferred emulsifying agent is one known by the proprietary name, "Magnasol." After the excess of penetrant has been washed off, the article is dried, since the presence of water on the surface would introduce another variable and interfere with the obtaining of consistent results.

Many details of composition and procedure may be varied within a wide range without departing from the principles of this invention and it is therefore not my purpose to limit the patent granted on this invention otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. The method of detecting flaws in a rigid body, which comprises treating said body with a liquid agent capable of penetrating flaws therein, removing the agent from the external body surfaces, and applying to said body a relatively volatile, colored liquid of different surface tension

from said first liquid agent to form a film thereover of said colored liquid, which film will fissure about said flaws and recede therefrom to leave an uncovered and uncolored area immediately adjacent said flaws and a colored area more remotely surrounding said flaws.

2. The method of detecting flaws in a rigid body, which comprises applying to the surface thereof an oily penetrant, removing the excess of said penetrant from such surface, applying to said surface a colored, relatively volatile liquid of different surface tension from said penetrant and allowing evaporation of said colored liquid to occur, whereupon a recession takes place of said colored liquid from any flaw present to leave an uncovered and uncolored area immediately adjacent said flaw and a colored area more remotely surrounding said flaw.

3. The method of detecting flaws in a rigid body, which comprises applying to the surface thereof an oily penetrant, washing off the excess of said penetrant from such surface, drying said surface, applying to said surface a colored, relatively volatile liquid of different surface tension from said penetrant and allowing evaporation of said colored liquid to occur, whereupon a recession takes place of said colored liquid from any flaw present to leave an uncovered and uncolored area immediately adjacent said flaw and a colored area more remotely surrounding said flaw.

4. The method of detecting flaws in the surface of a body, which comprises applying to said body a liquid penetrant capable of penetrating into any surface flaw, removing said penetrant from said surface while leaving said penetrant in such flaws as may be present, applying to said surface a film of a colored liquid of different surface tension from that of said penetrant and observing whether any break in said film occurs that would indicate the presence of a flaw.

5. The method of detecting flaws in the surface of a body, which comprises applying to said body a light petroleum distillate capable of penetrating into any surface flaw, removing said penetrant from said surface while leaving said penetrant in such flaws as may be present, applying to said surface a film of a colored halogenated hydrocarbon of different surface tension from that of said penetrant and observing whether any break in said film occurs that would indicate the presence of a flaw.

6. The method of detecting flaws in the surface of a body, which comprises applying to said body a light oily liquid capable of penetrating into any surface flaw, removing the excess of said liquid from said surface, applying to said surface a film of a dispersion of a dyestuff in a relatively

volatile liquid of different surface tension from that of said oily liquid, and allowing said volatile liquid to evaporate to leave a deposit of said dyestuff upon said surface, whereby from the presence or absence of uncolored areas on said surface the presence or absence of flaws may be observed.

7. The method of detecting flaws in the surface of a body, which comprises applying to said body a light oily liquid capable of penetrating into any surface flaw, removing the excess of said liquid from said surface, applying to said surface a film of a dispersion of a dyestuff in a liquid halogenated hydrocarbon of different surface tension from that of said oily liquid and allowing said halogenated hydrocarbon to evaporate to leave a deposit of said dyestuff upon said surface, whereby from the presence or absence of uncolored areas on said surface the presence or absence of flaws may be observed.

8. The method of detecting flaws in the surface of a body, which comprises applying to said body a light petroleum distillate capable of penetrating into any surface flaw, removing the excess of said liquid from said surface, applying to said surface a film of a solution of a dyestuff in ethylene dichloride, and allowing said ethylene dichloride to evaporate to leave a deposit of said dyestuff upon said surface, whereby from the presence or absence of uncolored areas on said surface the presence or absence of flaws may be observed.

9. The method of detecting flaws in the surface of an article having surface flaws or defects, which comprises effecting the introduction of a liquid penetrant into such flaws, freeing the surface surrounding such flaws from said liquid penetrant, applying to said surface a relatively volatile liquid capable of being repelled by said penetrant and containing coloring matter dispersed in said liquid, allowing sufficient time for said volatile liquid to recede from any flaws present and to evaporate, and observing the presence, extent and relative dimensions of any uncolored areas.

10. The method of detecting flaws in the surface of an article having surface flaws or defects, which comprises effecting the introduction of a petroleum distillate penetrant into such flaws, freeing the surface surrounding such flaws from said liquid penetrant, applying to said surface a solution of ethylene dichloride containing coloring matter dispersed therein, allowing sufficient time for said ethylene dichloride to recede from any flaws present and to evaporate, and observing the presence, extent and relative dimensions of any uncolored areas.

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