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METHOD AND COMPOSITION FOR FLAW DETECTION

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13 Claims. (Cl. 175—183)

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This invention relates to improvements in methods and compositions for detecting physical flaws in metallic bodies by the use of fluorescent finely divided solids employed, particularly, as suspensions in suitable liquids. More specifically, the invention pertains to the elimination of undesirable secondary fluorescent effects which occasionally or normally lessen the value and sensitivity of such methods.

At the present time, there is known a magnetic particle method utilizing fluorescent ferromagnetic particles for the purpose of rendering visible cracks, seams, and porosities in an object treated therewith when the object is viewed under filtered ultraviolet light in the substantial absence of visible light. This method is disclosed in the United States Patent No. 2,267,999. The process in question is briefly described as follows.

In proceeding according to this process for inspecting magnetizable metals, liquid suspensions of ferromagnetic particles are used to locate the flaws. These particles have a fluorescent substance adhered thereto that is insoluble in the liquid suspending medium. The object, or work piece, is first placed between the poles of a magnetizing unit to magnetize it, and while magnetized the work piece is immersed in, or flooded with, the liquid suspension of the fluorescent ferromagnetic particles. For this purpose, a dilute suspension is used of very finely divided fluorescent ferromagnetic particles in a suitable suspending medium, preferably a neutral light oil, that will not dissolve the fluorescent substance that adheres to the ferromagnetic particles. The particles are instantly drawn to the flaws, the opposite sides of which are generally of opposite magnetic polarity. The particles tend to bridge the gap between the two sides, forming ridges or piles of particles at each crack or pore. On rinsing the work piece with light oil, the ferromagnetic particles of the suspension are largely removed from the main surface, while the grouping of the fluorescent ferromagnetic particles at the flaws or defects is not disturbed. In the ideal case, the background is non-fluorescent, so that when the piece is inspected under filtered near-ultraviolet light, the particles at the flaws give brilliant indications against the non-fluorescent background.

In actual practice it has been found that light oil of the type commonly used in such a wet magnetic testing method has a slight fluorescence. Consequently, when indications of defects appear on a part being tested, the contrast between the

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solid fluorescence of the ferromagnetic particles and the oily background is reduced by liquid fluorescence of the background due to residual light oil that has not been completely removed.

Further, it is quite usual in actual practice to test parts which have a layer of heavy oil applied to them for rust inhibition purposes. Also, grease may be introduced into the bath. The heavier oils and grease are highly fluorescent so that, after a suspension of fluorescent ferromagnetic particles has been in continual use for some time, the liquid suspending medium may be so highly fluorescent as to provide a poorly contrasting background and it may be difficult to distinguish the ferromagnetic particles from this background. That is particularly true when, as is usually the case, the solid fluorescence of the ferromagnetic particles and the liquid fluorescence of the contaminated background are similar in color. It should be noted that the rinsing step following the generation of magnetic flux in the article does not ordinarily remove all liquid suspending medium from the testing field.

I have now found that the liquid fluorescence of the oily suspending medium and of matter dissolved or dispersed therein may be quenched selectively (to the exclusion of the solid fluorescence of substance intentionally adhered to the suspended ferromagnetic particles) by incorporating with the suspending medium a suitable non-fluorescent dyestuff or other organic material. Thus, the fresh testing liquid will provide a substantially non-fluorescent background for the fluorescent ferromagnetic particles, and contamination of the liquid testing medium with heavy oil, grease or other dissolved or dispersed fluorescent matter will not adversely affect the testing by lessening the contrast between the background and the fluorescent ferromagnetic particles.

It is, therefore, an important object of the present invention to provide an improved magnetic testing method involving the use of liquid suspensions of fluorescent ferromagnetic particles which are easily visible due to contrast with a substantially non-fluorescent or very feebly fluorescent background.

Another important object of the present invention is to provide a method for magnetic testing including the step of incorporating with the suspension of fluorescent ferromagnetic particles a quenching agent selectively operative on the liquid suspending medium and on fluorescent matter dissolved or dispersed therein.

A further object of the present invention is to

provide a suspension in a liquid medium of fluorescent ferromagnetic particles having incorporated therewith a quenching agent, more specifically, a non-fluorescent organic dyestuff or other organic material, that will selectively quench liquid fluorescence due to substances other than solid fluorescent substances intentionally adhered to said ferromagnetic particles.

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

In proceeding according to my present invention, I dissolve in a liquid suspending medium for ferromagnetic particles a dyestuff or other organic material that will selectively quench the liquid fluorescence of said suspending medium as well as the liquid fluorescence of substances dissolved or dispersed in said suspending medium, for instance, grease or heavy oil. When light oil or other organic suspending media immiscible with water is employed, I may use, for instance, Sudan Yellow GGA, Oil Red O, Sudan Red III, Oil Soluble Green, Glycolor Green, Glycolor Brown, or other oil soluble dyes that do not fluoresce per se and that have the property of selectively quenching all fluorescence but that due to solid substances intentionally adhered to the ferromagnetic particles. Besides the specific dyestuffs enumerated, I have found that a number of other dyes very effectively quench the liquid fluorescence of the suspending medium without quenching the solid fluorescence of the ferromagnetic particles. The preferred dyestuff is Sudan Yellow GGA. This dye is quite effective when employed in small amount and has relatively little color in normal light in contrast with the red color in visible light usually characterizing the ferromagnetic particles, if a red oxide of iron is used in the testing.

Colorless organic materials that form effective quenching agents include alpha naphthyl amine (most effectively employed at 4.25% concentration) and alpha nitro naphthalene (most effectively employed at 1.75% concentration).

Instead of incorporating the quenching agent directly with the liquid testing suspension, I may incorporate the quenching agent with the relatively heavy paste from which a testing suspension is often made up by dilution with light oil.

For instance, various ferromagnetic materials in finely divided powder form may have a fluorescent dyestuff adhered thereto as disclosed in United States Patent No. 2,267,999, and then formed into a heavy paste as disclosed in United States Patent No. 2,106,882 by grinding with an oily medium having dissolved therein a dispersing agent and a dyestuff or other organic material capable of selectively quenching any liquid fluorescence of the testing bath to be made up from the the paste by dilution with a suitable liquid. In making up such pastes, the direction in Patent No. 2,106,882 may be followed with the additional improvement of dissolving my quenching agent disclosed in the present application in any of the vehicles mentioned in the patent.

I may also incorporate the quenching agent, not with the liquid testing suspension, but with the liquid rinsing medium employed to rinse off the article being tested after the same has been subjected to a magnetic flux.

The exact amount of dyestuff or other quenching agent employed will vary according to the quenching potency of each agent and the amount of fluorescence to be quenched. In general, from one-half to two or three per cent will be found

satisfactory. In certain cases, as much as five per cent may be necessary. For the pastes of fluorescent ferromagnetic particles that are diluted to form the testing suspension, a quenching agent content of six per cent has ordinarily been found satisfactory. These amount of quenching agent will usually compensate for the fluorescence of the light oil and for that of the fairly large amount of added heavy oil.

As a testing bath gets older it may become slightly fluorescent in spite of its substantial content of a quenching dyestuff. More quenching agent may then be added to keep the suspending medium non-fluorescent.

While the mechanism by which the quenching effect is accomplished has not been definitely established, it is believed that the added quenching agent may act as a filter for the ultraviolet light, thereby to prevent fluorescence. The quenching effect may also be due to the de-excitation of potentially fluorescent molecules. According to this theory, energy is transmitted from an excited potentially fluorescent molecule to the quenching molecule on collision or close contact, with the result that both molecules have insufficient energy for fluorescence. If the energy levels for the two molecules are similar, then resonance may occur which would tend to make energy transfer less difficult. Thus the quenching dye will de-excite fluorescent molecules of oil or substances dissolved therein without de-exciting the solid fluorescent particles. The reason why some dyes are more effective than others would then be that they come closer to the energy levels of the oil molecules and of other molecules dissolved or dispersed in the oil.

Many details of composition and procedure may be varied within a wide range without departing from the principles of this invention, which includes broadly the concept of quenching selectively the fluorescence of liquid media such as oil and of substances dissolved or dispersed therein, to provide a vivid contrast between such liquids and fluorescent ferromagnetic particles suspended therein. It is, therefore, not my intention to limit the patent granted on this invention otherwise than necessitated by the scope of the appended claims.

In these claims, as well as in the specification, I have used the term "liquid fluorescence" to designate the fluorescence of the liquid suspending medium and of matter dissolved or colloidally dispersed therein, while the term "solid fluorescence" has been used to designate the fluorescence of solid dyestuffs or other solid organic matter adhering to the ferromagnetic particles suspended in the liquid medium.

I claim as my invention:

1. A composition of matter for detecting flaws in metallic bodies comprising a liquid suspending medium, finely divided ferromagnetic particles suspended in said liquid, a fluorescent substance insoluble in said liquid adhered to the surfaces of said ferromagnetic particles, and a non-fluorescent organic material dissolved in said liquid capable of selectively quenching any liquid fluorescence in said suspending medium.

2. A composition of matter for detecting flaws in metallic bodies comprising an organic liquid, finely divided ferromagnetic particles suspended in said liquid, a fluorescent substance insoluble in said liquid adhered to the surfaces of said ferromagnetic particles, and a non-fluorescent organic dyestuff dissolved in said liquid capable

of selectively quenching any liquid fluorescence in said organic suspending medium.

3. A composition of matter for detecting flaws in metallic bodies comprising a liquid hydrocarbon, finely divided ferromagnetic particles suspended in said hydrocarbon, a fluorescent substance insoluble in said liquid adhered to the surfaces of said ferromagnetic particles, and a non-fluorescent organic dyestuff dissolved in said hydrocarbon capable of selectively quenching liquid fluorescence in said hydrocarbon.

4. A composition of matter for detecting flaws in metallic bodies comprising a liquid hydrocarbon, finely divided ferromagnetic particles suspended in said hydrocarbon, a fluorescent substance insoluble in said liquid adhered to the surfaces of said ferromagnetic particles, and the dyestuff Sudan GGA dissolved in said hydrocarbon in an amount sufficient for selectively quenching liquid fluorescence in said hydrocarbon.

5. A method for detecting flaws in a metallic article comprising creating a magnetic flux in the portion of the article comprising the test field, applying to the test field finely divided ferromagnetic particles in the form of a suspension in a liquid medium, said particles having a fluorescent substance insoluble in said liquid adhered thereto, rinsing said test field with a liquid miscible with said liquid medium, selectively quenching fluorescence of any of said liquids with a non-fluorescent organic dyestuff dissolved in said rinsing liquid, said rinsing being carried out so as to remove from said test field ferromagnetic particles not adhered thereto, and subjecting the test field to fluorescigenous radiation to render vividly apparent the location in the test field of ferromagnetic particles adhered thereto.

6. A method for detecting flaws in a metallic article comprising creating a magnetic flux in the portion of the article comprising the test field, applying to the test field finely divided ferromagnetic particles in the form of a suspension in a liquid hydrocarbon, said particles having a fluorescent substance insoluble in said liquid adhered thereto, rinsing said test field with a liquid hydrocarbon, selectively quenching fluorescence in said hydrocarbons with a non-fluorescent organic dyestuff dissolved in said rinsing hydrocarbon, said rinsing being carried out so as to remove from said test field ferromagnetic particles not adhered thereto, and subjecting the test field to fluorescigenous radiation to render vividly apparent the location in the test field of ferromagnetic particles adhered thereto.

7. A method for detecting flaws in a metallic article comprising creating a magnetic field in the portion of the article comprising the test field, applying to the test field finely divided ferromagnetic particles in the form of a suspension in a liquid hydrocarbon, said particles having a fluorescent substance insoluble in said liquid adhered thereto, rinsing said test field with a liquid hydrocarbon, selectively quenching fluorescence of said hydrocarbons with the dyestuff Sudan GGA dissolved in said rinsing hydrocarbon, said rinsing being carried out so as to remove from said test field ferromagnetic particles not adhered thereto, and subjecting the test field to fluorescigenous radiation to render vividly apparent the location in the test field of ferromagnetic particles adhered thereto.

8. A composition of matter comprising a liquid suspending medium, ferromagnetic particles dispersed therein having adhered to the surfaces of said particles a solid fluorescent dyestuff insoluble in said liquid medium, and a non-fluorescent organic material dissolved in said liquid medium capable of selectively quenching any liquid fluorescence in said medium.

9. A composition of matter comprising a liquid hydrocarbon, ferromagnetic particles dispersed therein having adhered to the surfaces of said particles a solid fluorescent dyestuff insoluble in said hydrocarbon, and a non-fluorescent organic dyestuff dissolved in said hydrocarbon capable of selectively quenching any liquid fluorescence in said hydrocarbon.

10. A composition of matter comprising a liquid hydrocarbon, ferromagnetic particles dispersed therein having adhered to the surfaces of said particles a solid fluorescent organic dyestuff insoluble in said hydrocarbon, and the dyestuff Sudan GGA dissolved in said hydrocarbon in an amount capable of selectively quenching any liquid fluorescence in said hydrocarbon.

11. A method for detecting flaws in a metallic article comprising creating a magnetic flux in the portion of the article comprising the test field, applying to the test field finely divided ferromagnetic particles in the form of a suspension in a liquid medium, selectively quenching fluorescence of said liquid medium with a non-fluorescent coloring matter dissolved in said medium, said particles having a fluorescent substance insoluble in said liquid adhered thereto, rinsing said test field with a liquid miscible with said liquid medium and subjecting the test field to fluorescigenous radiation to render vividly apparent the location in the test field of ferromagnetic particles adhered thereto.

12. A composition of matter for detecting flaws in metallic bodies comprising a liquid hydrocarbon, finely divided ferromagnetic particles suspended in said hydrocarbon, a fluorescent substance insoluble in said liquid adhered to the surface of said ferromagnetic particles, and alpha naphthyl amine dissolved in said hydrocarbon in an amount sufficient to effect selective quenching of liquid fluorescence in said hydrocarbon.

13. A composition of matter for detecting flaws in metallic bodies comprising a liquid hydrocarbon, finely divided ferromagnetic particles suspended in said hydrocarbon, a fluorescent substance insoluble in said liquid adhered to the surface of said ferromagnetic particles, and alpha nitro naphthalene dissolved in said hydrocarbon in an amount sufficient to effect selective quenching of liquid fluorescence in said hydrocarbon.

TABER DE FOREST.

REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
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