METHOD AND COMPOSITION FOR FLAW DETECTION

Taber de Forest, Chicago, III., assignor, by mesne assignments, to Robert C. Switzer, South Euclid, Ohio, and Joseph L. Switzer

No Drawing. Application May 7, 1943, Serial No. 592,531

13 Claims. (Cl. 175—183)

1. 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.

2. 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. 2,267,599. 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 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.

3. 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 into 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 incorpo-
rated therewith a quenching agent, more specif-
ically a non-fluorescent organic dyestuff or other organic material, that will selectively
quench liquid fluorescence due to substances other than solid fluorescent substances inten-
tionally adhered to said ferromagnetic particles.

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

In proceeding according to my present inven-
tion, 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 in-
stance, 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, Giycolor Green, Giycolor 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 ferro-
magnetic particles. Besides the specific dyestuffs
enumerated, I have found that a number of other
dyes very effectively quench the liquid fluo-
rescence of the suspending medium without quench-
ing 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 ferromag-
netic 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% concentra-
tion) and alpha nitro naphthalene (most effec-
tively colored at 1.75% concentration).

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

For instance, various ferromagnetic materials
in finely divided powder form may have a fluores-
cent 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. 2,186,882 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 fluo-
rescence of the testing bath to be made up from
the paste by dilution with a suitable liquid.

In making such pastes, the direction in Patent
No. 2,267,999 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 quench-
ing 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 di-
luted to form the testing suspension, a quench-
ing agent of ten per cent has ordinarily been
found satisfactory. These amounts 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 con-
tent of a quenching dyestuff. More quenching
agent may then be added to keep the suspending
medium non-fluorescent.

While the mechanism by which the quench-
ing effect is accomplished has not been definitely
established, it is believed that the added quench-
ing agent may act as a filter for the ultraviolet
light, thereby to prevent fluorescence. The
quenching effect may also be due to the de-exclu-
tation of potentially fluorescent molecules. Ac-
cording 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 insuffi-
cient 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 sub-
stances 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 dis-
solved or dispersed in the oil.

Many details of composition and procedure
may be varied within a wide range without de-
parting from the principles of this invention,
which includes broadly the concept of quench-
ing selectively the fluorescence of liquid media
such as oil and of substances dissolved or dis-
persed therein, to provide a vivid contrast be-
tween such liquids and fluorescent ferromagnetic
particles suspended therein. It is, therefore, not
my intention to limit the patents 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 suspend-
ning medium and of matter dissolved or colloidal-
dispersely dispersed therein, while the term "solid fluores-
cence" has been used to designate the fluores-
cence of solid dyestuffs or other solid organic mat-
ter adhering to the ferromagnetic particles sus-
pended in the liquid medium.

I claim as my invention:
1. A composition of matter for detecting flaws
in metallic bodies comprising a liquid suspend-
ing medium, finely divided ferromagnetic par-
ticles suspended in said liquid, a fluorescent sub-
stance 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.

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 fer-
romagnetic particles, and a non-fluorescent or-
ganic 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 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 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 dyestuff insoluble in said hydrocarbon, and a non-fluorescent organic dyestuff 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 naphthoic acid dissolved in said hydrocarbon in an amount sufficient to effect selective quenching of liquid fluorescence in said hydrocarbon.

REFERENCES CITED

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

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