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[54] **METHOD OF DETECTING INHOMOGENEITIES
 BY THE USE OF MIXTURES OF FLUORESCENT
 AND VISIBLE DYE-COLORED MAGNETIC
 PARTICLES**

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[56] **References Cited**

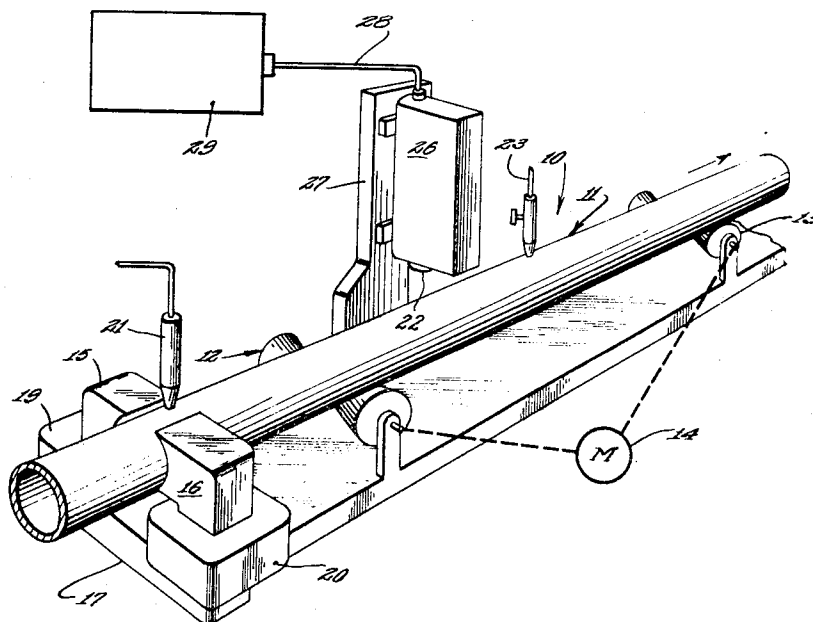
UNITED STATES PATENTS

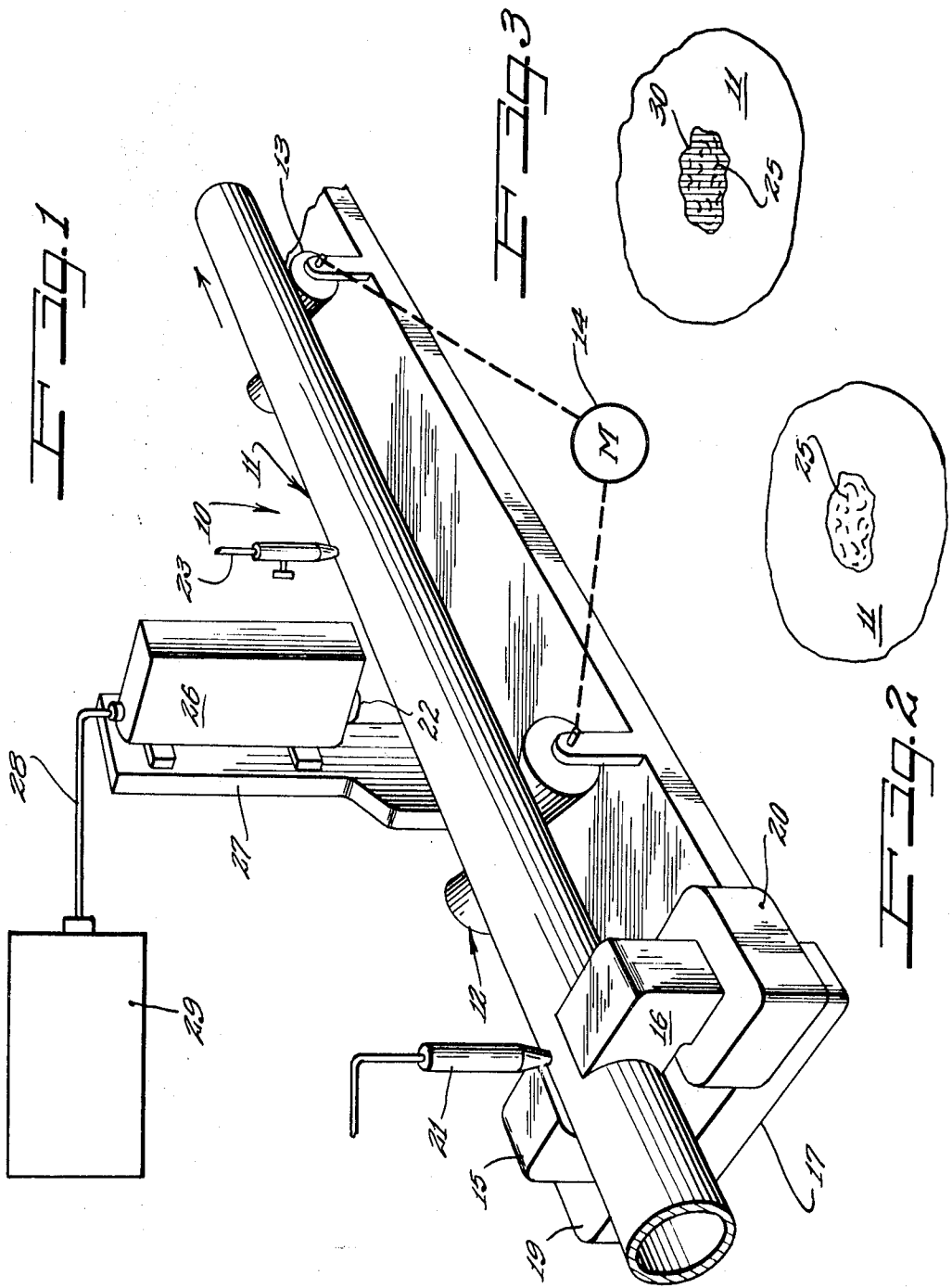
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OTHER REFERENCES

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ABSTRACT: A method using a mixture containing both fluorescent and visible dyed magnetic particles for detecting inhomogeneities in metal workpieces. The formation of adherent accumulations of the magnetic particles at localized areas where a magnetic leakage field occurs provides indications of the existence of surface or subsurface discontinuities or the like in magnetizable workpieces. The fluorescent indications are initially detected under ultraviolet, or black light, and are rendered visible under white light by the application thereto of a solvent for the visible dye to cause bleeding thereof. Preferably, the solvent contains a light-colored pigment suspended therein to afford a contrasting background for the visible color indication, and also contains a thickening agent, resin or the like to increase the viscosity of the solvent and thereby limit the extent of bleeding of the visible dye. Compositions comprising mixtures of the respective fluorescent and visible dyed particles are applied to the surface undergoing test either in dry powdered form or in the form of suspensions of such particles in a common liquid vehicle that is a nonsolvent for the particles and also for the visible dye associated with the visible dyed particles. The visible color indications formed by the subsequent application of a solvent for the visible dye, and consequent bleeding of the visible dye enable operators to carry out under ordinary, or white light, whatever scarfing or other treatment is required to remove the surface discontinuity from the workpiece or to compensate for it.





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METHOD OF DETECTING INHOMOGENEITIES BY THE USE OF MIXTURES OF FLUORESCENT AND VISIBLE DYE-COLORED MAGNETIC PARTICLES

CROSS-REFERENCES TO RELATED PATENTS

This invention involves a novel utilization of methods and compositions similar in some respects to those disclosed in the deForest et al. U.S. Pat. No. 2,365,253, the Kazenas U.S. Pat. No. 2,936,287, dated May 10, 1960, and the Borrows U.S. Pat. No. 3,404,093. Reference is also made to the following copending applications of common ownership herewith: Borucki et al., Ser. No. 649,144, filed June 27, 1967 now U.S. Pat. No. 3,484,758; and Lorenzi Ser. No. 629,743, filed Apr. 10, 1967 now U.S. Pat. No. 3,480,855.

BACKGROUND OF THE INVENTION

The field of this invention is the art relating to the non-destructive testing of workpieces or parts for the detection therein of inhomogeneities, flaws, defects and other discontinuities.

The above-identified patents disclose the separate use in nondestructive testing of (1) magnetic particles colored with a dye which becomes visible upon the action of certain solvents and (2) magnetic particles colored with a fluorescent dye.

The present invention, however, utilizes a mixture of (1) and (2) in combination and in such manner that an initially formed magnetic particle indication of a flaw can be readily detected under black light and a subsequently formed visible color indication can be readily seen under normal, or "white light." The application of a suitable solvent serves to form the visible color indication at the locus of the magnetic particle indication.

SUMMARY OF THE INVENTION

In accordance with the present invention, two types of colored magnetic particles are prepared: one in which the particles are colored by a potentially visible dye; and a second, in which the magnetic particles are colored by a fluorescent dye. These two types of colored magnetic particles can be prepared in accordance with the disclosures in the aforementioned patents, or the magnetic particles colored by a fluorescent dye can be prepared by the method of the Borrows et al. application Ser. No. 649,144, mentioned above.

The present invention involves a method of detecting inhomogeneities, defects, flaws or other discontinuities in workpieces, parts thereof, and, in general, solid articles or objects that are magnetizable, such as ferrous metal objects. To the magnetized workpiece is applied as by sprinkling, pouring, or spraying thereover, a flowable mixture, such as described above, of fluorescent dye-colored magnetic particles and visible dye-colored magnetic particles. The particles can be applied in dry form in the same way as is sometimes practiced in the magnetic particle inspection method or they can be applied in a liquid suspending medium. Both types of application are described in the previously mentioned U.S. Pat. No. 2,365,253. Preferably, relative movement is effected between the flowable mixture during its application to the workpiece and the surface to which the mixture of particles is applied so that an accumulation of magnetic particles occurs only where there is a magnetic leakage field caused by a surface discontinuity. Wherever there is an accumulation of adherent magnetic particles a liquid solvent that is a solvent for the visible dye of the visible dye-colored particles is applied to the accumulation, thereby causing a dissolution of the visible dye in the solvent, or a bleeding of the dye.

The method of our invention makes use of the fluorescent dye-colored pigment to give an early and easily observed indication of surface discontinuities in the workpiece, while the subsequent color indication provided by the bleeding of the dye of the visible dye-colored pigment affords a contrasting color indication under white light to facilitate location and removal under ambient lighting of any surface discontinuity that needs to be removed, as by scarfing, or other procedure.

The application to the surface-adhering particles of a solvent for the visible dye enhances the visibility of the color indication under white light. By incorporating a light-colored pigment in the solvent for the visible dye a desirable color contrast is obtained, and by incorporating in the solvent a thickening agent, resin or other solute having a viscosity-increasing function, the spreading of the visible dye indication can be restricted to the locus of the surface discontinuity.

BRIEF DESCRIPTION OF THE DRAWING

Other objects, features and advantages of the invention will be readily apparent from the following description of preferred embodiments of the invention, taken in conjunction with the accompanying drawings, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure. In the drawings:

FIG. 1 is a perspective view of apparatus, shown somewhat schematically, suitable for use in the practice of the invention herein described;

FIG. 2 is a fragmentary plan view of a portion of the surface of the workpiece showing the accumulation thereon of colored magnetic particles; and

FIG. 3 is a similar fragmentary plan view after the application of a solvent for the visible dye of the visible dye-colored magnetic particles.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Many different forms of magnetic materials, both natural and synthetic, can be used in making the colored magnetic particles that have been found suitable in carrying out the method of our invention. Preferred magnetic materials are the magnetic iron oxides, such as magnetite, Fe_3O_4 ; gamma ferric oxide, Fe_2O_3 ; and magnetic ferrites. Metallic iron powder and carbonyl iron particles can also be used. These magnetic materials, often referred to as paramagnetic particles, are employed in finely divided form, the particle sizes varying widely between as fine particles as those having maximum dimensions of about 0.2 and preferably about 3 microns, to larger sized particles of as much as 75 microns' maximum dimensions. In general, the smaller size ranges of particles are used where it is desired to detect relatively fine surface discontinuities, while the larger size ranges of particles are used for grosser surface defects.

As already indicated, the fluorescent dye-colored magnetic particles can be prepared in accordance with the disclosures of the various patents and applications for patent identified hereinbefore. The Kazenas U.S. Pat. No. 2,936,287 discloses the making of fluorescent dye-colored magnetic pigments in which the fluorescent dye is bonded by means of a resin, such as an epoxy resin, to the magnetic iron that constitutes the paramagnetic core of the ultimate fluorescent dye-colored magnetic particle. Alternatively, the fluorescent dye-colored magnetic particles can be prepared in accordance with the disclosure in the Borucki et al. application Ser. No. 649,144, by admixing a magnetic powder with a fluorescent resinous pigment powder under such conditions as to provide core-forming particles of the fluorescent-magnetic powder and an adherent coating of a film-forming resin encapsulating the core-forming particles.

The visible dye-colored magnetic particles can be made in the manner described in the deForest U.S. Pat. No. 2,365,253, using any of the paramagnetic particles therein referred to and any of the visible dyes disclosed therein that are not soluble in the liquid suspending medium for the pigments. If a liquid hydrocarbon solvent, such as petroleum hydrocarbon liquid is used in suspending the mixture of fluorescent and visible dye-colored pigment particles, it would not, of course, be feasible to use visible dyes that are soluble in liquid hydrocarbon solvents, since then the whole liquid suspension of the dyed pigments would be colored with the color of the visible dye and the color of the fluorescent dye would be completely masked.

By the same token, where water, or an aqueous-type liquid is used as the liquid medium for dispersing both the fluorescent dye-colored and the visible dye-colored particles, visible dyes should be selected that are not soluble in water but are soluble in the solvent later used to cause bleeding of the visible dye. Examples of visible dyes that are relatively insoluble in water but are relatively soluble in liquid hydrocarbons are Oil Red O, Mefford 322, and Aviation Blue.

The following examples will serve to illustrate different embodiments of our invention but without limiting the scope thereof to the specific details of the examples:

EXAMPLE I—Dry powder form of colored magnetic particles.

There is first prepared a batch of visible dye-colored magnetic particles using the following ingredients within the designated parts by weight:

Ingredient	Parts by Weight	
	Preferred Formula	Operative Range
Iron powder	100	100
Visible dye		
Oil Red BNC	10	1-15
Solvent for dye		
Dimethyl formamide (DMF)	20	2-25

The Oil Red BNC is first dissolved in the DMF and the resulting solution, together with the iron powder, placed in a muller. The muller is operated until all of the solvent (DMF) is driven off and a powder consisting of dry dye-coated iron particles results.

Such dry iron particles coated with a visible dye are then mixed in suitable proportions with any suitable dry fluorescent magnetic powder. The proportions may vary between 2 to 1 and 1 to 2 of the visible and fluorescent magnetic particles but neither the fluorescent magnetic particles nor the visible dye magnetic particles should be in such large excess as to mask the effect of the other in the practice of our method.

Any bleeding type of visible dye can be used with any type of solvent capable of causing the visible dye to be readily seen under normal lighting conditions. Light-colored pigments, such as talc, titanium dioxide and the like can be incorporated for dispersion in the solvent to enhance color contrast and any suitable agent can be incorporated in the solvent for increasing the viscosity thereof and thereby limiting the development of the visible color indication to a restricted area that includes the locus of the flaw or other surface discontinuity.

Some of the dry mixture of visible dye-colored and fluorescent dye-colored particles, when applied to a magnetized surface undergoing test, will accumulate at the sites of magnetic leakage fields, if any exist, and exhibit a fluorescent indication under black light. Upon application to any such accumulation of a solvent for the visible dye, bleeding thereof occurs and gives a visual indication of the existence and location of the flaw or other surface inhomogeneity.

In making up a liquid dispersion of the two types of dye-colored magnetic particles, it is preferable to use approximately equal parts by weight of the respective particles, although the weight proportions may vary between one-to-two and two-to-one of the fluorescent dye-colored particles and the visible dye-colored magnetic particles. As can be readily appreciated, if the percentage of the visible dye-colored particles is more than about 66% percent of the total mixture by weight, then the visible dye magnetic particles will mask the fluorescent magnetic particles and the latter will not impart to the original flaw indication the desirable brilliant fluorescence for quickly showing up existing surface discontinuities.

In making up a liquid dispersion of the mixture of fluorescent and visible dye-colored magnetic particles approx-

imately the same proportions of the solids to the common liquid vehicle used as the dispersing medium are used as was heretofore customary in magnetic pigment dispersions. For example, between about 0.1 and 0.25 ounce of the solid mixture of magnetic particles are dispersed in each gallon of the liquid ultimately used as the suspending medium. The preparation of the liquid suspension is preferably accomplished in a succession of steps, such as described in the following example.

EXAMPLE II—with water as the common liquid vehicle for suspending the colored magnetic pigment particles.

1. Using Oil Red BNC as the visible red dye, and dimethyl formamide (DMF) as the solvent, make up a solution in the following proportions:

40 parts by weight of DMF

20 parts by weight of Oil Red BNC;

The resulting solution, together with magnetic particles, is placed in a muller, as in example I and a powder consisting of dry, visible dye-coated magnetic particles obtained.

2. Fluorescent magnetic particles are prepared in accordance with method generally described in the Borucki et al. pending application Ser. No. 649,144, and more particularly pages 3 to 6 thereof. Briefly stated, the fluorescent magnetic particles are suitably formed as follows:

To a solution of film-forming (encapsulating) resin in an organic solvent (isopropanol) add suitable amounts of magnetic particles and finely divided fluorescent pigments while agitating vigorously in a Waring Blender or other high shear mixer. This causes the fluorescent pigment to adhere to the magnetic particles resulting in a slurry of magnetic-fluorescent particles suspended in the resin solution.

With continued agitation add sufficient water to cause the resin to be thrown out of solution and deposited as an encapsulating film on the composite particles.

The particles are then separated from the liquid and dried by any suitable means.

3. The dry visible dye-colored magnetic particles (1) and the fluorescent magnetic particles (2) are then mixed in suitable proportions and dispersed in water for use as described hereinafter.

EXAMPLE III—with oil as the common liquid vehicle for suspending the colored magnetic particles.

1. Using Rhodamine B-Extra as a suitable water and alcohol soluble visible dye, and isopropanol as the solvent, make up a solution of:

40 parts by weight of isopropanol

20 parts by weight of Rhodamine B-Extra;

2. In making up the magnetic particle dispersion, disperse 80 parts by weight of a natural magnetite in an excess of kerosene; and

3. Mix solution (1) with the magnetic particles (2) with vigorous agitation, then filter off the solid particles and air-dry them to provide the visible dye-colored magnetic pigments for admixture in approximately equal proportions by weight with a batch of fluorescent dye-colored pigment particles prepared as described in example II or in U.S. Pat. No. 2,936,287. The mixing can be accomplished in a dry state or in the form of a paste or slurry in which kerosene, or other light petroleum oil is the common liquid vehicle.

A mixture of the visible dye-colored and of the fluorescent dye-colored magnetic particles is suspended in kerosene, or other light petroleum oil as the common liquid vehicle, in the proportions previously indicated and with a total solids content, also as indicated, of between about 0.1 and 0.25 ounce per gallon. The dispersion or suspension is sprayed or otherwise applied to the surface undergoing test.

As shown on the drawings, particularly FIG. 1 thereof, the reference numeral 10 indicates generally a type of equipment suitable for use in the practice of the method of our invention, more particularly where liquid suspensions of the magnetic particles are employed. The device 10 serves for the positioning thereon of a workpiece 11, which is here illustrated as an

elongated length of pipe, but may be a solid billet of elongated cylindrical or other form. The workpiece 11 is supported upon rollers 12 and 13, which may be driven by a motor M as diagrammatically illustrated at 14. The workpiece 11 passes between pole pieces 15 and 16 of a magnetic yoke structure 17, on which coils 19 and 20 are provided. The coils 19 and 20 are connected to a source of direct current (not shown) so as to develop magnetic flux passing transversely through the workpiece 11.

In inspecting the workpiece 11 for surface inhomogeneities, flaws, defects or surface discontinuities, magnetic particles may be applied to the surface of the workpiece 11 either during or after magnetization thereof. Magnetization of the workpiece is, of course, possible only where the workpiece is of a magnetizable material, such as a ferrous metal or alloy. The workpiece can be premagnetized provided there is sufficient residual magnetism to attract the magnetic particles and cause an accumulation thereof to occur at the locus of any surface discontinuity.

During the carrying out of the method for detecting surface discontinuities in the workpiece 11, the workpiece may be moved in the direction of the arrow continuously or intermittently along its axis upon the rollers 12 and 13, or may be rotated about its axis by any suitable means (not shown) or may be subjected both to axial and rotational movement during the application to the surface of the workpiece of a mixture of the fluorescent dye-colored magnetic particles and the visible dye-colored magnetic particles.

The reference numeral 21 indicates a spray head through which a liquid dispersion of the mixture of colored magnetic particles is applied against the surface of the workpiece 11. A source of black light 22 is positioned in a sensing unit 26 beyond the spray head 21 (in the direction of the arrow in FIG. 1) for irradiating the surface of the workpiece immediately following the spraying thereon of the dispersion of dye-colored particles. A valve-controlled liquid dispensing nozzle 23 serves to apply a suitable visible dye solvent and/or developer to any accumulation of the magnetic fluorescent particles sensed by the sensing unit 26 as a result of the black light irradiation of the surface undergoing inspection.

In FIG. 2 the reference numeral 25 indicates an adherent accumulation of fluorescent and visible dye magnetic particles such as would be detected in the first instance as a fluorescent color indication by the unit 26.

The formation of the fluorescent color indication 25 can be detected automatically by an image dissector system such as illustrated and described in the Lorenzi application above referred to. Such a system, as shown in FIG. 1, includes the sensing unit 26 mounted by a suitable support 27 above the workpiece 11 and connected through a cable 28 to an indicating unit 29, like that shown and described in said Lorenzi application; or any other suitable means can be used. In such an arrangement the application of the solvent through the nozzle 23 is synchronized with the sensing of an accumulation of magnetized particles on the workpiece so as to direct a spray of the solvent against such an accumulation.

Where a dry powder mixture, as described in example I is used, apparatus similar to that disclosed in the Dunsheath U.S. Pat. No. 2,678,421 can be employed for applying the mixture to the workpiece.

Alternatively, a wholly manually operated system can be substituted for the image dissector system, and the solvent and/or solvent developer for the visible dye can be applied to the accumulation of magnetic pigment particles as soon as collections thereof, similar to the collection 25, are built up on the surface of the workpiece.

As already explained, the solvent or solvent-developer to be applied through the valve-controlled nozzle 23, or to be applied manually, includes a solvent for the visible dye and preferably includes dispersed in said solvent a light-colored pigment capable of forming a contrasting background for the particular visible dye employed in the system. Also as previously explained, the nature of the solvent used for the visible

dye to cause bleeding thereof will depend upon which particular system of liquid-suspended magnetic pigment particles is used, (1) the one in which water is the liquid vehicle used as the suspending medium in which, of course, the visible dye is insoluble; or (2) the system in which the liquid suspending medium is nonaqueous, e.g. a liquid hydrocarbon oil, in which the visible dye is insoluble, and the solvent used for causing bleeding of the visible dye is a liquid such as alcohol or the like that is nonmiscible with the liquid hydrocarbon oil used as the pigment-suspending medium.

Suitable liquid developers having dispersed therein a light-colored pigment include those in which the solvent is an alcohol, a nonaqueous solvent, such as a volatile liquid hydrocarbon like trichlorethane, methylene chloride, or trichloroethylene; or a liquid ketone, like acetone, MIBK, or the like, that in addition to serving as a suspending medium also is good as a solvent for resins and synthetic plastics. The latter category includes solutions of polyvinyl chloride, or other synthetic plastic, in a relatively volatile hydrocarbon solvent, or a lacquer-type solvent developer, such as nitrocellulose in amyl or butyl acetate. The thickening agent, which may be a resin or synthetic plastic, as indicated, serves to render the solvent more viscous and thereby restrict the free flow and spreading of the color indication formed by the dissolution of the visible dye into the particular solvent used as a common solvent for the visible dye and for the thickening agent.

With a dry mixture of the fluorescent and visible dye-colored magnetic particles there is no problem as to the type of solvent and/or liquid solvent developer that can be used, since any of those that are suitable for use with the visible dye can be employed.

In connection with the use of a liquid dispersion of the mixture of visible dye-colored and fluorescent dye-colored magnetic pigments, it is sometimes impracticable to depend upon a single liquid developer to accomplish the desired result of causing a limited bleeding of the visible dye from the mixture of pigments. This is because the mixture of pigments is filmed over with the dispersing liquid of the pigment suspension either the water of example II or the oil of example III, and the liquid developer cannot act directly upon the visible dye to dissolve it and cause it to bleed. Materials that would penetrate the film of the dispersing liquid were generally found to have poor solvent action toward the visible dye of the magnetic pigment mixture.

We discovered, however, that the desired bleeding of the visible dye from the flaw indication accumulations, as at 25 (FIG. 2), could be easily accomplished by the use of two separate developer compositions sprayed or otherwise applied in proper sequence to the accumulations 25.

Where, as in example II, the common liquid used to suspend the mixed pigment particles is water, the preferred developer composition to be first applied can be that described in the Borucki application Ser. No. 576,837, filed Sept. 2, 1966, and particularly one of the specific formulas set forth on pages 7 and 8 of the specification of said application. When this composition is sprayed against an accumulation of magnetic particles, such as indicated at 25 (FIG. 2), the sprayed composition wets the surface and drives off the aqueous film from the surfaces of the mixed magnetic particles.

Then, a second developer composition can be applied to effect satisfactory bleeding of the visible dye. Such a composition is suitably a nonaqueous developer comprising a dispersion of a fine light-colored pigment such as titanium dioxide, calcium carbonate, talc, or mixtures thereof in a liquid vehicle comprising a relatively volatile liquid hydrocarbon and a non-volatile wetting agent.

A specific composition of a suitable nonaqueous developer is the following:

Trichlorethylene	110 gal.
TiO ₂ , CaCO ₃ , silica	110 lbs.
Isocetyl phenoxy polyethoxy ethanol (OPE 9-10)	3 gals.
Zinc Stearate	6 lbs.

Any pigmented nonaqueous developer having a highly volatile hydrocarbon can be employed, but where nonflammability is desired chlorinated hydrocarbons should be used.

Where, as in example III, the common liquid vehicle serving to disperse the mixture of magnetic pigment particles is an oil, such as kerosene, and the visible dye is water and/or alcohol soluble, such as Rhodamine B-Extra, the oil film over the mixed magnetic pigments in any accumulation, such as that at 25, is broken by the application thereto of a suitable latex, such as a vinyl-maleate copolymer latex. An alcohol-based developer is then applied to develop the visible dye indication. A suitable alcohol-based developer is the following:

50/50 mixture ethanol and ethyl acetate	110 gals.
Mixture of TiO_2 and SiO_2 pigments	110 lbs.
Wetting Agent (nonyl phenyl polyethylene glycol ether)	3 gals.

Other alcohol-based dispersions of light-colored pigments can be used to cause bleeding of the alcohol-soluble visible dye used in the visible dye-colored pigment of example III.

After the development of the visible color indication, as indicated at 30 in FIG. 3, the workpiece is processed by operators working under normal lighting conditions, viz white light, to compensate for the surface defects revealed by visible color indications, as at 30. If the defect or flaw can be removed by a scarfing or like operation, the operation is performed and the workpiece passed, if acceptable, for use in accordance with its intended purpose.

The advantages of our method as described herein are numerous:

1. The visibility of ordinary magnetic particle indications is enhanced. Magnetic particles heretofore used in nondestructive testing are available in very few colors, most of which are drab and contrast little if at all with the ferrous metal surfaces undergoing test. While certain fluorescent magnetic particles are highly fluorescent under black light, they are hardly distinguishable in visible light from the magnetic pigment itself, e.g. gamma Fe_2O_3 . Under such circumstances it is not practical to attempt to rely on the visibility of fluorescent color indications when operating in visible light to remove the surface defect. Our method makes such operation practical by providing a visible color indication that is intensely visible under ordinary lighting conditions.

2. By virtue of the solvent action of the visible dye solvent or of the pigmented solvent-type developer applied to the visible dye of the mixed pigment particles, the resulting visible dye solution spreads out over the magnetic pigment particles like a paint to give a brightly colored enlargement of the indication against a strongly contrasting background created by the white or light colored pigment of the solvent or solvent-developer.

3. The highly visible colored enlargement of the flaw indication enables operators working under visible light not only to recognize the indication readily but also to eliminate the crack or other defect that gave rise to the indication. This can usually be accomplished by a chipping, grinding or scarfing operation, whereby the workpiece is made acceptable for its intended use.

4. Where the system is made substantially automatic, as by the use of the image dissector system illustrated in FIG. 1, the initial inspection for flaws by an inspector is rendered unnecessary, thereby effecting some economy in the operation. Also, there is a saving in the amount of coating materials required, since where an inspector is relied upon to observe flaw indications, it is necessary to cover substantially the en-

tire surface of the workpiece (which may be a very large billet) so that the inspector can judge which defects the operator (repairman) should remove and which can be safely ignored.

5. Also, where the scanning is accomplished by an automatic black light scanner, the fact that about one-half of the magnetic particles in the indication buildup are non-fluorescent does not prevent the scanner from "seeing" the fluorescent color of the buildup and thereupon activate the value of the spray head 23 to spray solvent and/or solvent-type developer over the buildup. This type of automatic system eliminates the necessity of the operator examining the entire surface of the billet for a few color indications since he need examine only the developed visible color flaw indications.

We claim:

1. In a method of detecting inhomogeneities in a magnetizable workpiece, the steps which comprise applying to a surface of such workpiece while magnetized a mixture of discrete finely divided magnetic particles, some of said magnetic particles in said mixture having adhering thereto a fluorescent pigment and others of said magnetic particles in said mixture having a potentially visible dye adhering thereto that bleeds in contact with a solvent therefor, subjecting said surface to fluorescigenous radiation to give fluorescent indications wherever accumulations of said pigment-adhering particles occur, and subsequently applying to such accumulations said solvent that causes said potentially visible dye of said other particles to bleed and thereby give under white light a visible color indication of any surface discontinuities present.
2. The method as defined by claim 1, wherein said mixture is applied as a flowable dispersion of said finely divided magnetic particles.
3. The method as defined by claim 2, wherein said dispersion is a suspension of said particles in a liquid vehicle in which said visible dye is insoluble.
4. The method as defined by claim 3, wherein said solvent for said visible dye has dispersed therein a light-colored pigment to afford a contrasting background for said visible dye.
5. The method as defined by claim 4, wherein said solvent also includes a thickening agent dissolved therein to increase the viscosity and restrict the extent of such bleeding of said visible dye.
6. The method as defined by claim 1, wherein said mixture of magnetic particles is applied in a dry state by flowing onto said workpiece surface.
7. The method as defined by claim 6, wherein said solvent for said visible dye has a light-colored pigment suspended therein and has dissolved therein a thickening agent to enhance the color contrast and the visibility of said color indication.
8. The method as defined by claim 3, wherein said liquid vehicle is a liquid hydrocarbon in which said visible dye is insoluble, said visible dye is soluble in alcohol, and an alcohol is used as the solvent to cause bleeding of said visible dye.
9. The method as defined by claim 3, wherein said liquid vehicle is water, said visible dye is soluble in a liquid hydrocarbon, and a liquid hydrocarbon is used as a solvent for said visible dye.
10. The method as defined by claim 3, wherein said liquid vehicle is water, said visible dye is insoluble in water, and said solvent causing said visible dye to bleed is a nonaqueous solvent developer for said visible dye.
11. The method as defined by claim 1, wherein said mixture contains approximately equal parts by weight of said fluorescent colored magnetic particles and of said potentially visible dye-colored magnetic particles.