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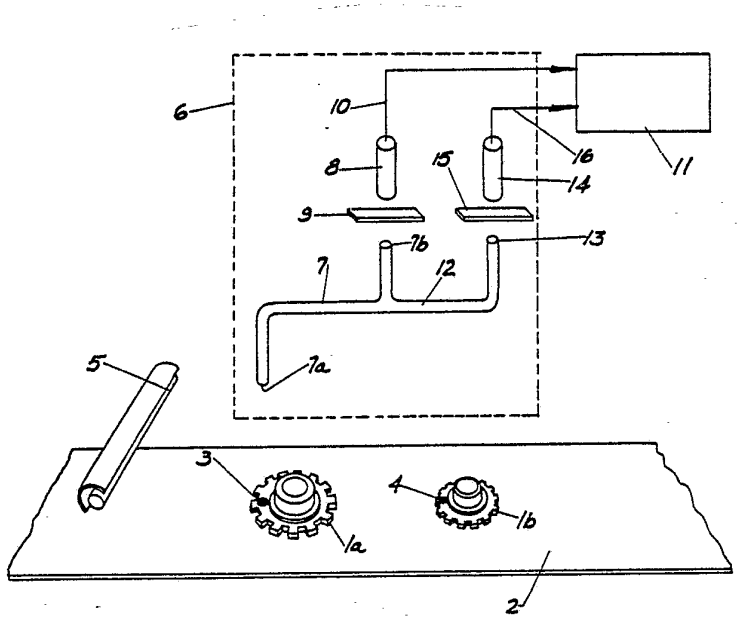

(57) Abstract

An object identification system in which objects (1a, 1b) to be identified are marked with a fluorescent material (3, 4) which emits visible light of a predetermined wavelength when illuminated with ultraviolet light (5). One or more photodetectors (8, 14) produce electrical output signals when the fluorescing marked areas are detected. The sensitivity and selectivity of the photodetectors may be improved by use of a narrow band optical filter (9, 15) matched to the specific wavelength of the fluorescent material. The visible fluorescent light may be focused onto the photodetector by means of a collimating lens (17) or an optical fiber (7). The output signals from the photodetectors may be used with any type of utilization device (11) such as a robot arm, sorter or the like. The use of fluorescent materials producing visible light of different wavelengths may be used to distinguish among various types of parts marked with the fluorescent material.

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OBJECT RECOGNITION AND IDENTIFICATION SYSTEM USING ULTRAVIOLET FLUORESCENT MATERIALS

SUMMARY OF THE INVENTION

The present invention is directed to a system for recognizing individual objects, and more particularly to a system in which identification is achieved by detecting visible light emitted from an ultraviolet fluorescent material placed on the object to be identified.

Various types of object identification or recognition systems have been proposed where the object is marked with visible indicia and optically scanned. A typical type of such system using bar codes is found in the check-out line of many supermarkets or the like.

While such systems have virtually eliminated the need for human intervention in sorting and identifying objects, there have been certain problems associated with them. For example, conventional identification systems operating under visible light conditions require a contrasting background to the indicia placed on the object to assure reliable sensing. This requires that the indicia placed on the object be visibly distinguishable from the object upon which it is placed. Consequently, the indicia must be individually selected to create the necessary contrast. Often this is accomplished by a sticker or label which is applied to the object which carries with it alternating light and dark areas to provide the necessary contrasting background. Such labels are usually permanently applied to the object, and detract from its appearance. In the case of small objects, it may be impossible to apply suitable indicia to the object itself. Furthermore, in many instances the object itself forms part of a larger assembly which requires subsequent removal of the

indicia.

Another problem which has been encountered in visible light detection systems is interference from areas or sources adjacent the scanned area. For example, erratic operation of the optical detection system may be caused by reflections from the object itself or its carrier, from movement of objects or personnel near the object being scanned, or from nearby light sources.

The present invention is directed to an object recognition and identification system which overcomes these problems. In a broad sense, the present invention includes means for marking the objects to produce fluorescent radiation a plurality of spectral bands, means for illuminating the objects to cause the marking means to fluoresce, and detector means for distinguishing between each of the fluorescing marking means. More specifically, the object recognition system of the present invention includes means for marking the object to be identified with a fluorescent material emitting visible light of a predetermined wavelength when illuminated with ultraviolet light, a source of ultraviolet light, and detector means responsive to the visible light produced by the fluorescent material for producing an electrical output signal when the marking means is detected.

In a preferred embodiment of the invention, each object to be detected is marked with a small area of material which emits visible light of a predetermined wavelength only when illuminated with ultraviolet radiation. Such materials have found application, for example, in marking laundry items, and are described in more detail in U.S. Patent No. 3,066,105, U.S. Patent No. 3,162,642, and U.S. Patent No. 3,164,603. Such materials are normally colorless in ordinary light but fluoresce with a distinctive visible color in ultraviolet light.

Depending on the particular chemical composition of the material, visible light emission of a large number of spectral bands between yellow and blue may be attained. Furthermore, by proper formulation, the fluorescent materials can be caused to emit visible light at a specific desired wavelength.

In the preferred embodiment described, radiation emitted from the fluorescent material on the object is received by a photodetector which produces a suitable electrical output signal. The photodetector may be of the type responsive to visible radiation, and may be positioned adjacent to the marked object, or located some distance therefrom. In this latter case, the light emitted by the fluorescent material is focused on the photodetector by means of an optical lens system or through an optical fiber.

To increase the sensitivity and selectivity of the photodetector, a narrow band optical filter matched to the fluorescent characteristics of the marking material may be used. Consequently, only radiation of a spectral band specific to the marking material will be received by the photodetector. Furthermore, a plurality of photodetectors and filters may be used to selectively distinguish between objects marked with fluorescent materials emitting at different wavelengths.

The electrical signal output from the photodetector may be used in any way heretofore associated with object recognition and identification systems. One important application of the present invention is in the field of robotic guidance. For example, the invention finds application in the assemblage of tires to wheel rims which must be oriented with respect to each other in a specified way. By applying a small spot of the fluorescent marking material to the wheel and rim, output signals from the

photodetector can be used to guide the robot in the assembling of the tire to the rim. Another application is the selection of a particular type of component from among a collection of different components moving on a conveyor belt. By marking each type of component with a fluoresent material emitting visible light at a different wavelength when excited by ultraviolet light, an array of photodetectors can be used to distinguish and recognize each of the different types of components.

Further features of the invention will become apparent from the detailed description which follows.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a diagrammatic view of an object recognition system using the inventive principle of the present invention.

Fig. 2 is a diagrammatic view illustrating an alternate imaging arrangement for the object recognition system of the present invention.

Fig. 3 is a graphical representation of the filter response for the green fluorescent material used in connection with the present invention.

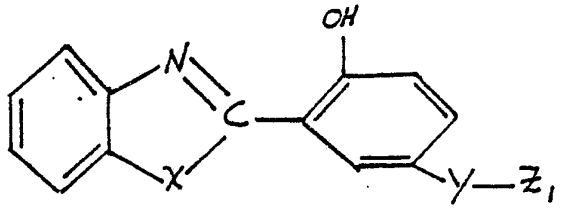
DETAILED DESCRIPTION

For purposes of an exemplary showing, a preferred embodiment of the object recognition and identification system of the present invention is illustrated in Fig. 1. It will be observed that the specific application illustrated is for distinguishing among a number of different types of objects illustrated at 1a and 1b moving on a conveyor belt 2. For example, object 1a might be a particular type of machine part, while object 1b might represent a different type of machine part.

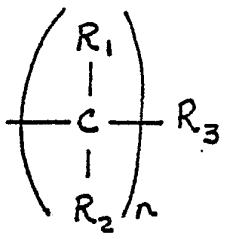
Part 1a is provided with a small spot or area 3 of a fluorescent material or coating such as that described in U.S. Patent No. 3,066,105, U.S. Patent No.

3,162,642, or U.S. Patent No. 3,164,603. Each of these compositions represents a fluorescent pigment which is normally colorless in ordinary light, but distinctively fluorescent at a particular wavelength when excited by ultraviolet light. Normally these compounds are supplied in powder form, and are mixed with a plastic or solvent. At very low concentrations, i.e. 0.001% - 0.01%, the fluorescent material when applied to the substrate is substantially transparent and non-visible. At higher concentrations, depending upon the particular material used, or where the material is mixed with an opaque binder, the material when applied to the underlying substrate takes on a gray or off-white color. In any event, in many applications it is desirable that the material when applied to the underlying substrate be unnoticeable.

The particular chemical composition of the fuorescent material is chosen so that when it is excited by a suitable source of ultraviolet light, the emitted visible light occurs at any one of a number of specific wavelengths. For example, one class of compounds particularly useful with the present invention may be summarized by the following chemical formula:



wherein X represents either oxygen or sulfur, Y represents NHCO and $NHCONZ_2$, and Z_1 represents hydrogen, a 1-8 carbon chain aliphatic, and a radical represented by the formula:



This composition produces a colorless compound which fluoresces yellow to orange in ultraviolet light. Other substitutions of the radicals will produce various other visible output color emissions lying between yellow and blue, i.e. between about 450-620 nm.

The size of the spot area 3 applied to the substrate will depend upon the particular geometry of the underlying object and the detector installation, as will be described in more detail hereinafter. Furthermore, the spot 3 may be applied to a particular face or side of the underlying substrate such that the orientation of the object on the conveyor belt may be determined. In any event, it will be understood that one part 1a may be marked with a material 3 which fluoresces at one visible wavelength, while another part 1b may be provided with a different fluorescent compound 4 fluorescing at a different visible light wavelength. In this manner, part 1a may be distinguished from part 1b.

The fluorescent material 3 or 4 is excited by means of an ultraviolet light source 5 positioned adjacent conveyor belt 2. For purposes of an exemplary showing, light 5 produces ultraviolet light at a wavelength of 356nm. It will be understood that ultraviolet light sources having different wavelengths may be utilized in order to obtain the maximum visible light intensity from the particular fluorescent material.

The detection means used in connection with the preferred embodiment of the present invention is illustrated generally at 6 in Fig. 1. Detector means 6 includes a fiber optic bundle 7 having one end 7a positioned adjacent and directed toward part 1a so as to receive light emitted from fluorescent material 3. The opposite end 7b of the fiber optical bundle may be positioned at some distance from the part depending upon the specific conditions of the particular application.

The terminal end 7b of the fiber optic bundle is directed toward a photodetector 8 having a spectral response in the visible region matched to the fluorescent wavelength of fluorescent material 3. To further increase the sensitivty and selectivity of photocell 8, an optical filter 9 having a narrow pass band at the fluorescent wavelength of fluorescent material 3 may be provided between the terminal end 7b of the fiber optic bundle and photodetector 8. The electrical signal produced by photodetector 8 on ouitput line 10 may be provided to a suitable utilization device 11 such as a sorting mechanism, a robot arm, a diverter or the like. Such utilization means may cause the part to be reoriented, removed from the belt, or assembled in a particular orientation to another part or assembly.

It will be observed that this arrangement greatly reduces the possibility of erratic operation of detector means 6 caused by spurious light sources or reflections. Because of the unique nature of the radiation emitted by the fluorescent material 3 coupled with the relatively narrow pass band of filter 9 and the spectral response of the photodetector, the system of the present invention is sensitive only to a very narrow range of visible light wavelengths. Consequently, the system will not respond to visible light having wavelengths outside its response band. Furthermore, since the fluorescent material may be caused to fluoresce only when irradiated by a suitable ultraviolet light source, the marking means themselves are relatively insensitive to ambient conditions. Finally, the intensity of the fluorescing material provides good contrast to the background substrate of the parts 1a pr 1b.

In some instances, it may be desirable to provide electrical outputs responsive to a plurality of

wavelengths. In this situation, a branch 12 may be added to fiber optic 7, with the output end 13 of branch 12 located adjacent a second photodetector 14. A second optical filter, having a pass band different from optical filter 9, may be interposed between the output end 13 of the fiber optic bundle and the second photodetector 14. The electrical output on line 16 from the second photodetector is applied to utilization means 11.

In one application of the system just described, optical filter 9 may have a pass band matched to the visible light output from fluorescent material 3, while optical filter 15 may have a pass band matched to the visible light output from fluorescent material 4. In this manner, detection means 6 may be caused to distinguish between objects marked with different fluorescent materials.

Alternately, the optical pass bands of the filters may be set to recognize the same visible color from a particular fluorescent marking. For example, as illustrated in Fig. 3, a fluorescent material having a green color may be separated through the use of separate filters into separate optical bands of blue and yellow. The electrical outputs from each of photodetectors 8 and 14 may then be used independently or in combination as recognition signals for this particular color. In any event, in this embodiment the detection means includes a plurality of filters passing to an associated one of the photodetectors the different spectral bands emitted by the marking means.

An alternate arrangement for the focusing optics is illustrated in Fig. 2. In this arrangement, the emitted light from the fluorescent material 3 is focused through a collimating lens 17 and an optical filter 18 having a narrow pass band, and applied to a photocell 19. The electrical output 20 from the

photocell may then be applied to utilization means 11 as previously described. This arrangement permits the lens or lenses to be placed further away from the area being scanned in order to give a greater depth of field. Such an arrangement finds particular application where the detection means must be located some distance from the objects being scanned, for example on a packaging line.

It will be understood that various changes in the steps, materials, and arrangements of parts, may be made without departing from the spirit of the invention as expressed in the appended claims. For example, in some applications the focusing optics, fiber optics or collimating lens, may be dispensed with and the photodetector placed directly adjacent to the objects to be scanned.

Furthermore, each object may be provided with a plurality of fluorescent markings. In this situation, a corresponding number of photodetectors and filters may be used to individually recognize and distinguish between the markings on the objects.

The embodiments of the invention in which an exclusive property or privilege is claimed are as follows:

1. An optical recognition system comprising means for marking the objects to produce fluorescent radiation in a plurality of spectral bands, means for illuminating the objects to cause said marking means to fluoresce, and detector means for distinguishing between each of said fluorescing marking means.

2. The optical recognition system according to claim 1 wherein said marking means comprises materials producing visible light when irradiated by ultraviolet light, and said illuminating means comprises a source of ultraviolet light.

3. The optical recognition system according to claim 2 wherein said materials fluoresce with blue, green or yellow light.

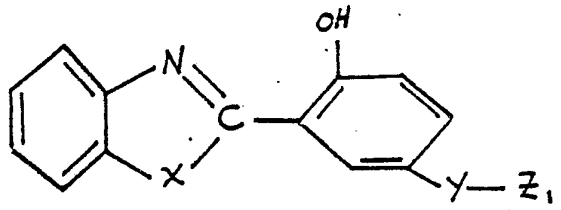
4. An optical object recognition system comprising means for producing fluorescent radiation in a first spectral band, means for detecting the fluorescent radiation in said first spectral band, and means responsive to said detecting means for producing an electrical output signal upon detection of said fluorescent radiation.

5. The object recognition system according to claim 4 including means for producing fluorescent radiation in a second spectral band, means for detecting fluorescent radiation in said second spectral band, and wherein said electrical signal producing means includes means for producing an electrical signal in response to detection of fluorescent radiation in either or both of said spectral bands.

6. An object recognition system comprising means for marking the object to be identified with a fluorescent material emitting visible light of a

predetermined wavelength when illuminated with ultraviolet light, a source of ultraviolet light, and detector means responsive to said visible light for producing an electrical output signal when said marking means is detected.

7. The apparatus according to claim 6 wherein said fluorescent material is chosen from the class consisting of compounds having the following chemical structure:



8. The apparatus according to claim 6 wherein said fluorescent material is substantially colorless when illuminated by ordinary light.

9. The apparatus according to claim 6 wherein said fluorescent material is capable of emitting visible radiation in a relatively narrow band in the range of about 450-620nm.

10. The apparatus according to claim 6 wherein said marking means comprises a plurality of fluorescent materials, each of said fluorescent materials emitting visible light over a different relatively narrow spectral band when illuminated by ultraviolet light.

11. The apparatus according to claim 10 wherein said detector means includes means for distinguishing between each of said different spectral bands.

12. The apparatus according to claim 6 wherein said detector means comprises a photodetector responsive to visible light and optical transmission means for focusing light emitted from said marking means onto said photodetector.

13. The apparatus according to claim 12

wherein said optical transmission means comprises a collimating lens.

14. The apparatus according to claim 12 wherein said optical transmission means includes an optical fiber, one end of said fiber being positioned adjacent the object bearing the marking means, the other end of said fiber being positioned adjacent said photodetector.

15. The apparatus according to claim 12 wherein said optical transmission means includes an optical filter having a relatively narrow pass band for selectively passing to said photodetector only those wavelengths emitted by said fluorescing marking means.

16. The apparatus according to claim 12 including a plurality of said photodetectors, said optical transmission means comprising a plurality of optical filters, each of said filters passing to an associated one of said photodetectors a different spectral band emitted by said fluorescing marking means.

17. The apparatus according to claim 16 including a plurality of marking means, each such means emitting visible light over a different spectral band.

18. An object recognition system comprising a fluorescent material for marking the object to be identified, said material emitting visible light in a relatively narrow spectral band when illuminated with ultraviolet light, a source of ultraviolet light for illuminating the object to be identified, and at least one photodetector positioned to receive visible light emitted by the fluorescent material, said photodetector producing an electrical output signal when the fluorescent material is detected.

19. The apparatus according to claim 18 including an optical filter having a relatively narrow pass band for passing only visible light emitted by said

fluorescent material, said filter being interposed between the photodetector and the object to be identified.

20. The apparatus according to claim 19 including means for focusing light emitted by the fluorescent material onto said photodetector.

21. The apparatus according to claim 20 including a plurality of said photodetectors and optical filters, each of said filters passing to an associated one of said photodetectors visible light of a different spectral band.

22. The apparatus according to claim 21 including a plurality of fluorescent materials each emitting visible light over a different spectral band corresponding to the spectral band of one of said filters.

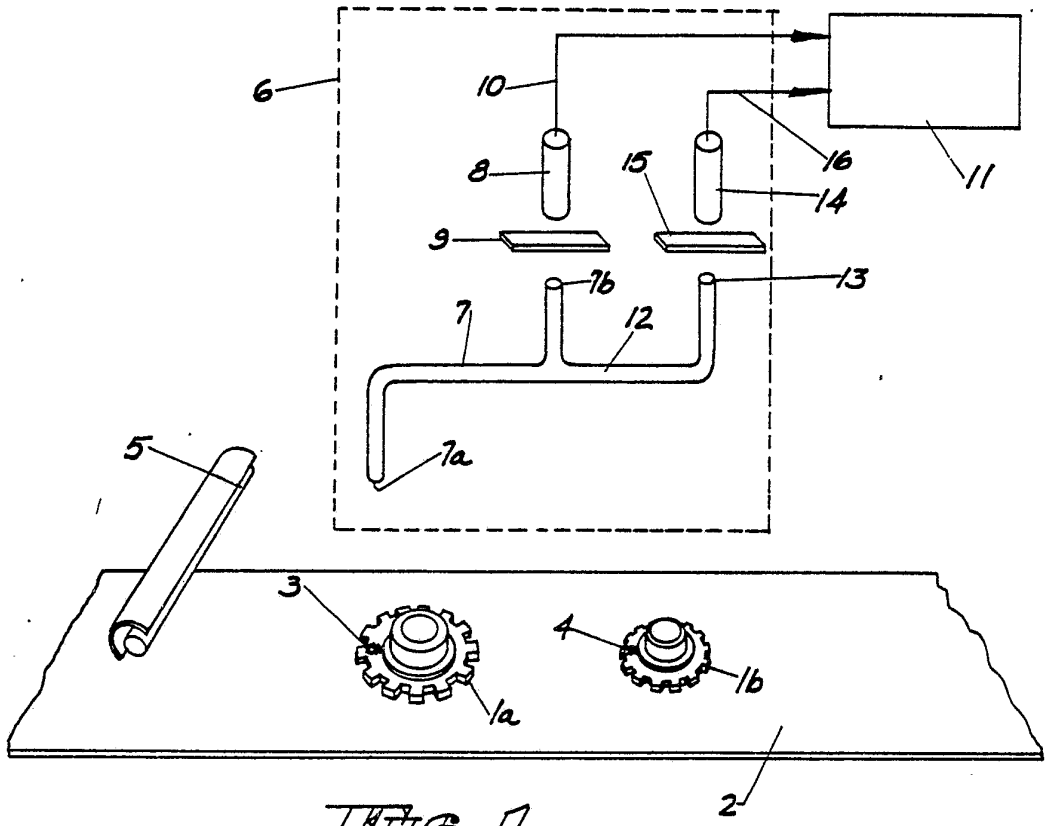


FIG 1

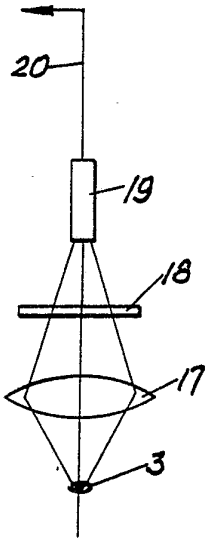


FIG 2

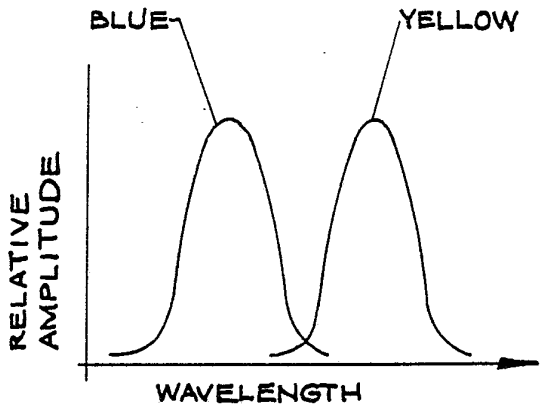


FIG 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 84/00417

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[3]: B 07 C 5/34; G 06 K 7/12

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC[3]	B 07 C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X Y	US, A, 3662181 (HERCHER et al.) 9 May 1972 see figures 1-3; column 1, lines 25-30; column 2, line 17 - column 3, line 57	1-6,9-13,15-22 8,14,7
Y	US, A, 3891324 (DAVIES) 24 June 1975 see figures 16-18; column 17, line 40 - column 18, line 4	8,14
Y	US, A, 3162642 (Mc CAFFERTY) 22 December 1964 see column 1, lines 7-15; column 1, line 68 - column 2, line 52 (cited in the application)	7

* Special categories of cited documents: [15]

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [1]	Date of Mailing of this International Search Report [1]
3rd July 1984	20 JUIL. 1984
International Searching Authority [1]	**Signature of Authorized Officer [20]**
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/US 84/00417 (SA 6894)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 13/07/84

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 3662181	09/05/72	None	
US-A- 3891324	24/06/75	US-A- 3843440	22/10/74
US-A- 3162642		None	