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Tuhro

[11] **3,812,374**

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[54] **SPECULAR REFLECTION SUPPRESSION APPARATUS**

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[52] **U.S. Cl.** .... **250/568,** 235/61.11 E, 250/225

[51] **Int. Cl.** **G01n 21/30,** G02f 1/18, G06k 7/00

[58] **Field of Search** .... 250/225, 219 D, 568; 235/61.11 E

[56] **References Cited**

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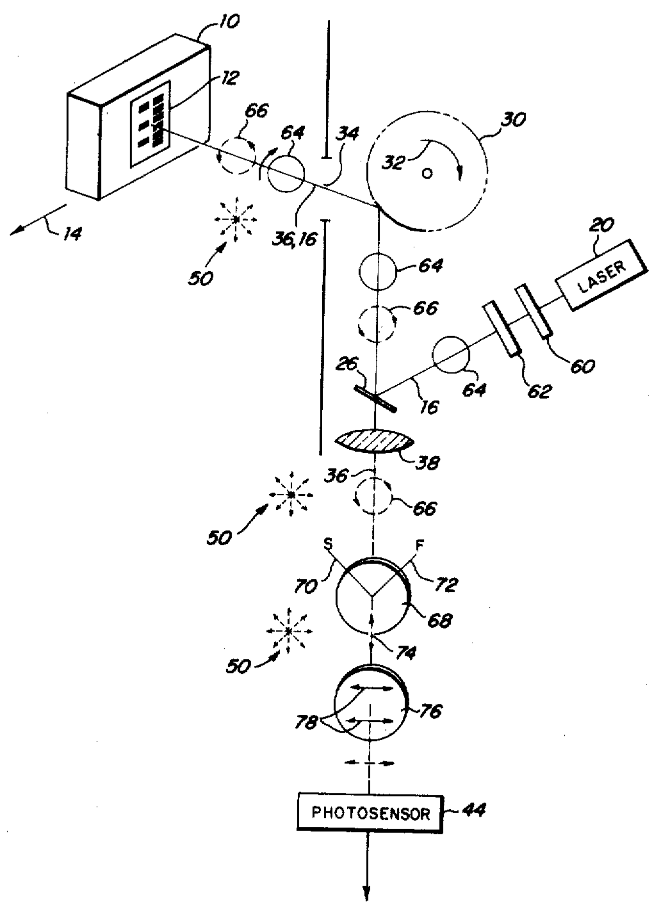
[57] **ABSTRACT**

In a system for reading a diffuse reflective label, apparatus for suppressing specular reflections comprising a source of polarized radiation having a first polarization; means for providing relative motion between the label and polarized radiation for scanning a diffuse reflective label with the polarized radiation of the first polarization; and means for receiving diffusely reflected radiation having random polarization and specularly reflected radiation having the first polarization including polarizing means for selectively blocking specular reflections having the first polarization and passing radiation having other polarization for increasing the signal to noise ratio of the diffusely reflected radiation to the specularly reflected radiation.

1 Claim, 3 Drawing Figures



PATENTED MAY 21 1974 3,812,374

SHEET 1 OF 2

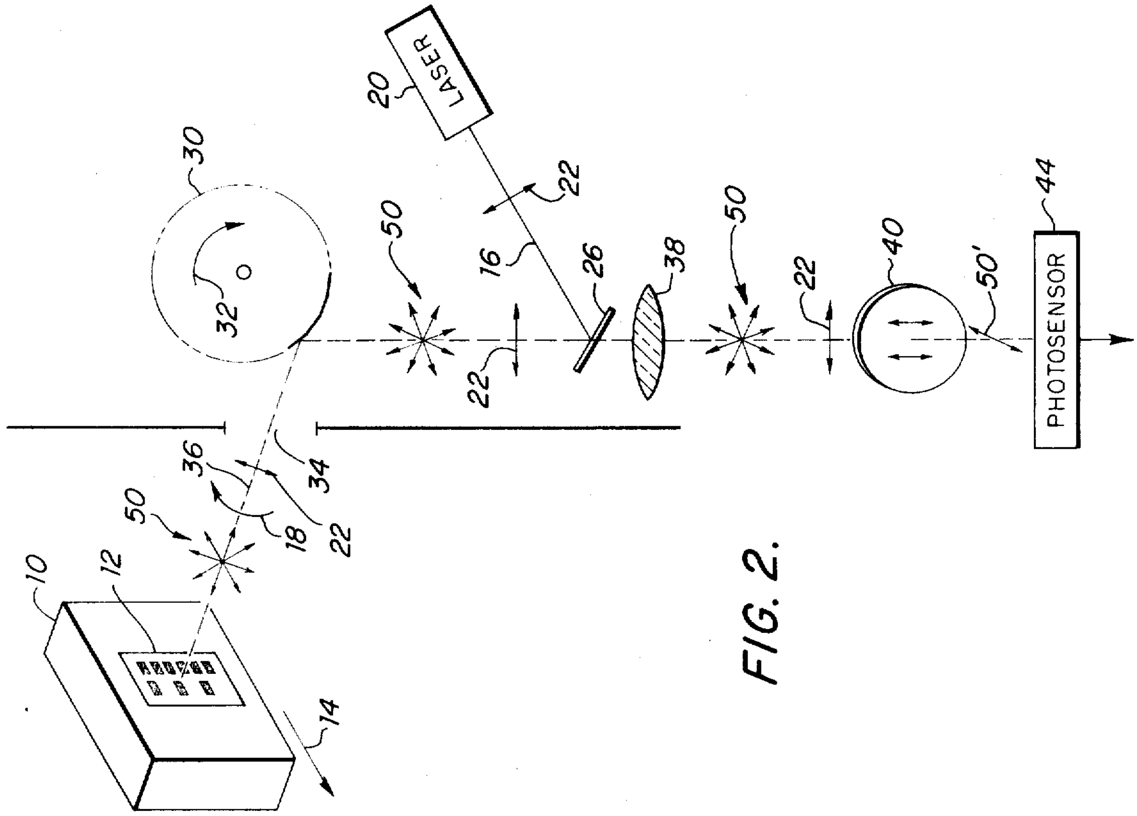


FIG. 2.

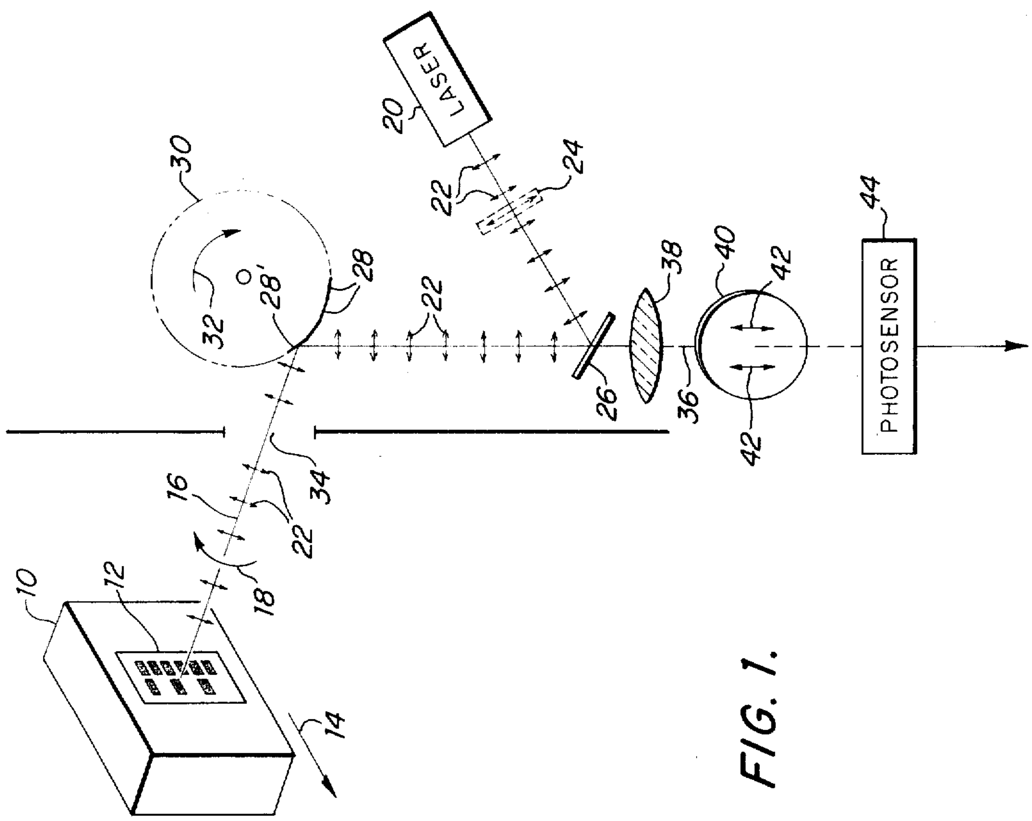
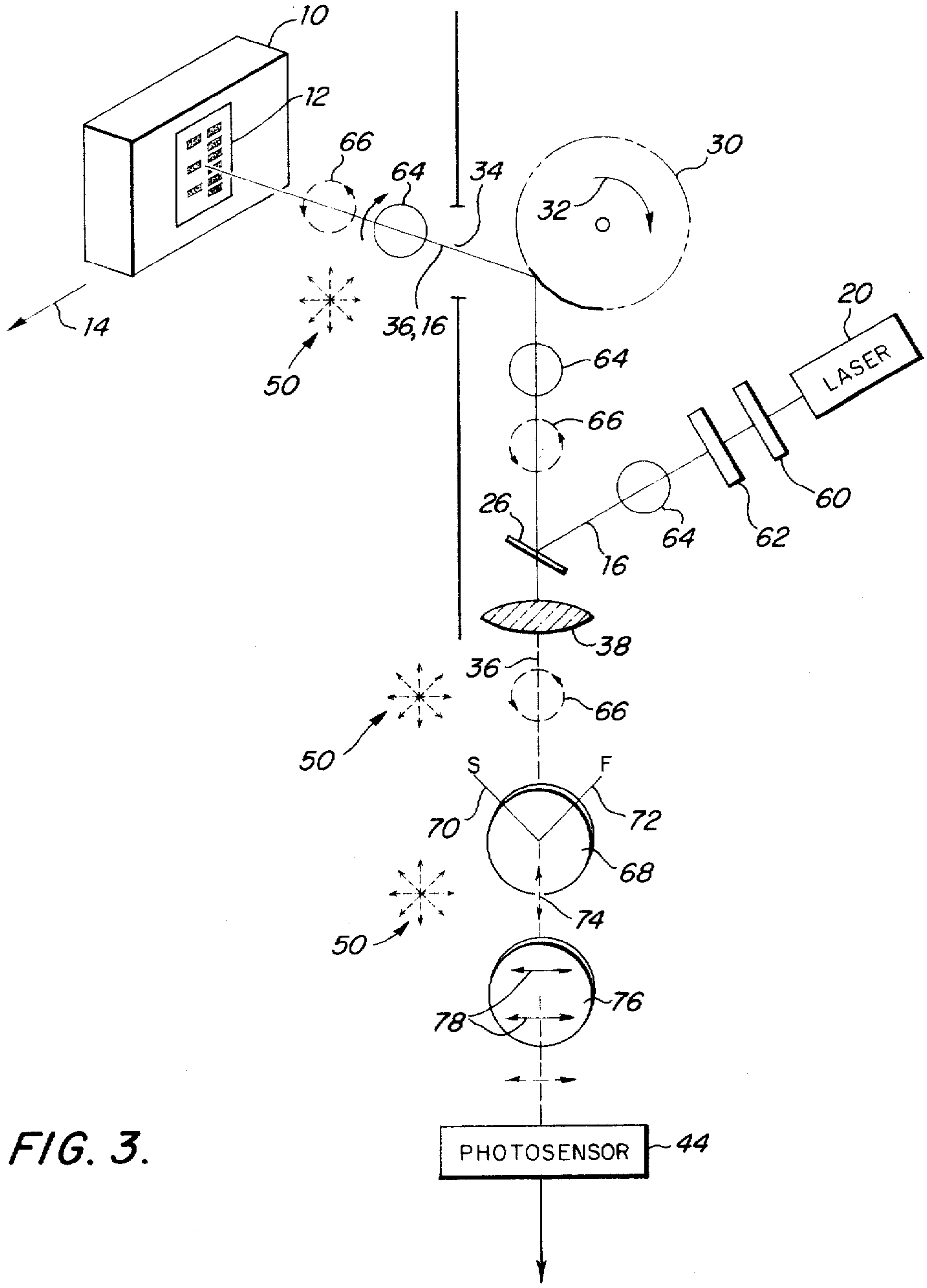


FIG. 1.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PHOTOSENSOR
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FIG. 3.

SPECULAR REFLECTION SUPPRESSION APPARATUS

FIELD OF INVENTION

This invention relates to an apparatus for enhancing the signal to noise ratio in the reading of diffuse reflective media, and more particularly to such apparatus for blocking specular reflections.

BACKGROUND OF INVENTION

In the early development of automatic reading machines the media, such as labels, read by the machines typically had to conform to very definite requirements such as size, registration marks, and contrast properties in order to insure that these relatively unsophisticated machines could recognize and distinguish the labels. As these machines have grown more sophisticated in system design as well as in the design of optical and electronic components they have become capable of recognizing and reading a wider range of labels. For example, presently there are labels in use which consist of essentially gum backed white paper labels on which a code is printed in black ink by conventional printing techniques or even by computer print-out devices. Such labels are extremely desirable for they not only begin with an inexpensive paper label which is easily available and not a special item but they are printed inexpensively and can even be printed by a computer. This latter feature is significant in many applications such as inventory control where the inventory, orders, purchases, shipments, billing, etc. are all "computerized" on the same computer system which can print labels as an integral part of its overall control of the flow of goods.

Such paper labels are typically regarded as diffuse reflecting surfaces. However, it has been determined that while usually 90 percent or more of incident radiation is reflected diffusely, a significant amount, anywhere from a few tenths of a per cent or less to ten per cent or more, of the incident radiation is specularly reflected. This small but significant amount of specular reflection has introduced a major source of error into the system causing a number of labels to be missed or misread. This is so because under certain conditions when the label, scanning beam and receiver are in a particular orientation the specular reflection may be reflected directly back to the receiver. Since the specular reflection is only a small part of the reflection this may not seem such a serious problem. But it is. For the specular reflection is highly efficient; most of it will be reflected to the reader. The diffuse reflection, by its nature, is not efficient and less than half, typically, only 0.1 to 0.01 percent, of the diffuse reflection may actually reach the reader. Thus, in many cases the specular reflection reaching the reader can overwhelm the desired diffuse reflection and distort the label reading. The problem is even greater when strong ambient light such as sunlight is present in which case the specular reflection received by the receiver can actually be greater than the diffuse reflection. The problem is also apparent when the background of the label, i.e., the surface of the object, produces specular reflection such as is the case with metal objects. This problem exists regardless of the color of the labels or contrasted coding. In a typical black on white label the inked black surface has been found to give greater specular reflection than the uninked white surface presumably because the ink fills the paper pores and makes the surface smoother. The initial reaction after the source of the problem is discovered is to rearrange the reader so that the specular reflection cannot be received by it. This is not a workable solution because typically: the size and working requirements of the reader will not permit it; existing equipment and structures at the site will not permit it; the ambient light is so strong that specular reflection is high in all arrangements; the process of precisely aligning the equipment to avoid the specular reflections is tedious and time consuming as is the continuing monitoring required to maintain the alignment and the objects are apt to be in any number of different orientations as they pass the reader.

SUMMARY OF INVENTION

It is therefore an object of this invention to provide a simple, inexpensive, extremely reliable apparatus for blocking specular reflections which is easy to install and maintain.

It is a further object of this invention to provide such apparatus which blocks the specular reflections.

It is a further object of this invention to provide, in a system for reading diffuse reflective media, apparatus for increasing the signal to noise ratio relative to diffuse and specular reflections.

The invention results from the discovery that there is a sufficient amount of specular reflection from diffuse reflective media and environs to cause, under certain conditions, erroneous readings and the realization that specularly reflected radiation maintains the same polarization in the reflected ray as it had in the incident ray so that by using polarized light of a first polarization to scan the label a polarizing element can be set to block light of that polarization while passing light of other polarization thereby blocking the specular reflections derived from the scanning beam but passing a substantial portion of the diffuse reflections.

The invention features apparatus for suppressing specular reflection adapted for use in a system for reading a diffuse reflective label. The apparatus includes a source of polarized radiation having a first polarization and means for providing relative motion between the label and polarized radiation for scanning a diffuse reflective label with the polarized radiation of the first polarization. There are means for receiving diffusely reflected radiation having random polarization and specularly reflected radiation having the first polarization. Polarizing means are provided for selectively blocking specular reflections having the first polarization and passing radiation having other polarization for increasing the signal to noise ratio of the diffusely reflected radiation to the specularly reflected radiation.

DISCLOSURE OF PREFERRED EMBODIMENT

Other objects, features and advantages will occur from the following description of a preferred embodiment and the accompanying drawings, in which:

FIG. 1 is a diagrammatic representation of a system for reading a diffuse reflective label including apparatus according to this invention for blocking specular reflections from the label or the background surrounding the label;

FIG. 2 is a diagrammatic representation similar to that shown in FIG. 1 showing more specifically the reflected radiation returning from the label; and

FIG. 3 is a diagrammatic representation of a system similar to that shown in FIGS. 1 and 2 using circularly polarized radiation.

The apparatus for blocking specular reflections according to this invention may be used in a system for reading a diffuse reflected label which is either located on a background or in an environment from which there are significant specular reflections or in which the label itself produces significant specular reflections or both. A beam of linearly polarized light is provided either by a polarized laser or an unpolarized laser or any other unpolarized light source with a polarizing element provided at its output. The linearly polarized beam is directed to strike the diffuse reflective label that is to be read. The return beam reflected from the label contains randomly polarized diffuse radiation reflected from the label plus it may also contain significant amounts of specular reflection from the label or from the background surrounding the label. The specular reflection is not randomly polarized but rather is polarized in the same way as was the scanning beam from the laser. The return beam and other radiation coming from the area of the label is received by the reader through some receiving means which may include a linear polarizing unit and may also include a lens and aperture or slot. The linear polarizing unit is oriented with its polarization axis transverse to the polarization axis of the linearly polarized light constituting the scanning beam. Typically, for optimum results the polarization axis of the polarizing element will be orthogonal to that of the polarization axis of the scanning beam. Thus, the polarizing element will block any radiation having a polarization axis which is the same as that of the scanning beam. Specular reflection causes the return beam to have the same polarization as the incident beam. Therefore, since the specular reflection will return polarized in the same way as the incident scanning beam the polarizing element oriented with its polarization axis orthogonal to that of the polarization axis of the scanning beam will effectively block all of the specular reflections returning from the label and the surrounding area. Diffuse reflections having random polarizations will be attenuated by approximately 50 percent by the polarization element, but the remaining portion of the diffuse reflection, which is passed by the polarizing element, will be essentially free of the specular reflection due to the blocking action of the polarizing element.

Alternatively, a quarter wave plate and a linear polarizing element or a source of linearly polarized radiation may be used to produce circularly polarized radiation for the scanning beam. The return beam will then contain specular reflections which are circularly polarized and diffuse reflections which are randomly polarized. Submission of the return beam to a quarter wave plate having the opposite rotation to that of the circular polarization of the return beam produces an output from the quarter wave plate which is linearly polarized and oriented so as to bisect the slow and fast axes of the quarter wave plate. Following this, in the return beam, a linear polarizing element, having its polarization axis transverse to, or optimally, orthogonal to, the axis of polarization of the linearly polarized light produced at the output of the quarter wave plate, will effectively block all of the circularly polarized light in the return beam. Since any specular reflection will contain the same polarization as the incident beam, in this case circular, specular reflection would be essentially blocked. However, diffuse reflection having random polarization passes through the quarter wave plate maintaining its random polarization and then encounters the polarizing element which attenuates approximately half of the randomly polarized diffuse reflections and passes the remaining portion.

In one embodiment, FIG. 1, an object **10** bearing a label **12** moving in the direction of arrow **14** is scanned by scanning beam **16** moving upwardly in the figure as shown by arrow **18.** Beam **16** may be generated by a light source, such as laser **20,** which produces light polarized as indicated by the arrows **22.** If an unpolarized source is used, a polarizing element **24** may be placed at the output of the source to produce the proper linear polarization. Scanning beam **16** from laser **20** strikes mirror **26** from which it is reflected to one of a number of mirrors **28** on the periphery of a rotating wheel **30** which rotates in the clockwise direction as shown by arrow **32.** After striking any particular mirror **28'**, beam **16** is reflected out through an aperture **34** to label **12.** Return beam **36** is essentially coincident with scanning beam **16** from the label to mirror **26** via a mirror **28.** In FIG. **1** the scanning beam **16** has been emphasized over the return beam **36** while in FIG. **2** the converse is true. Beyond mirror **26** return beam **36** passes through lens **38** and then through linear polarizing element **40** having its axis of polarization transverse, and optimally orthogonal, to that of the polarization axis of scanning beam **16** as indicated by arrows **42.** The output from polarizing element **40** is delivered to a photosensor **44** which is connected to pulse shaping and amplifying circuits and finally to decoding circuits for decoding the information coded on label **12.**

Typically, laser **20** may have a beam diameter of 0.040 inch so that mirror **26** may be very small, on the order of a tenth of an inch in diameter. Since lens **38** may be approximately **2** inches in diameter, mirror **26** affords a very small loss of the light collected from the returning beam. Alternatively, mirror **26** may be replaced by a partially reflecting mirror or prism or by a larger mirror having a small hole in the center through which the scanning beam can pass. Although polarizing element **40** is shown between lens **38** and photosensor **44** this is not a limitation of the invention as the polarizing element **40** may be placed anywhere in the system where it will affect the return beam but not the scanning beam such as between lens **38** and mirror **26,** for example.

The operation of the system with respect to the return beam may be more clearly understood with reference to FIG. **2** where the return beam **36** has been emphasized over the scanning beam **16** except in the area between mirror **26** and laser **20.** There are two types of radiation associated with return beam **36**: the specular reflection linearly polarized in the same way as the scanning beam **16,** as shown by arrows **22,** and the diffuse reflection which is randomly polarized, as indicated by the bundle of arrows **50.** When the specular reflection, polarized as indicated by arrows **22,** strikes crossed polarizing element **40** whose polarization axis is orthogonal to the polarization axis, indicated by arrows **22,** that specular reflection, having the linear polarization axis as indicated by arrows **22**, is blocked and does not pass through polarizing element **40**. However, the randomly polarized radiation striking crossed polarizing element **40** is discriminated: the portion of the randomly polarized radiation which is orthogonal to the axis of polarization element **40**, i.e., parallel to the axis of polarization of the scanning beam, as indicated by arrows **22**, is blocked. The remaining portion of the randomly polarized radiation, which is aligned with the axis of polarization of polarizing element **40**, is passed, as indicated by arrow **50'**, and is subsequently detected by photosensor **44**.

Thus, specular reflection produced by the label or surrounding area, derived from the return beam **36** and directed back to the reader system, will be blocked insofar as that specular reflection maintains the same polarization axis as imposed on the scanning beam and which the polarizing element **40** has been oriented to block. The randomly polarized radiation in the return beam derived from the diffuse reflections will pass through the polarizing element with only approximately a 50 percent loss. Therefore, while only approximately half of the useful information in the randomly polarized diffuse reflections is lost or is atentuated, effectively all of the specular reflections, derived from the incidence of the scanning beam on the label and the surrounding area, is blocked. Typically, commercially available linear polarizing elements having an attenuation rate of 1,000 to 1 are not uncommon.

Although thus far the illustrative embodiments of FIGS. **1** and **2** have described a system using a linearly polarized scanning beam, this is not a necessary limitation of the invention, for as shown in FIG. **3**, a form of elliptically polarized radiation such as circularly polarized radiation may be used for the same purpose. Circularly polarized radiation is regarded as a form of elliptically polarized radiation in which the major and minor axis are equal and linearly polarized light may be considered as a form of elliptically polarized radiation in which one of the axes is zero. Circularly polarized light may be produced using a laser or other light source **20** and first subjecting the beam to a linear polarizing element **60** and then submitting the linearly polarized beam to a quarter wave plate **62** such that the axis of linear polarization of the beam bisects the slow and the fast axes of the quarter wave plate. The circularly polarized beam **16** is then reflected as before off of mirror **26**, scanner wheel **30** and out aperture **34** to label **12**. The return beam **36** contains two types of radiation associated with it: diffuse reflections having random polarization as indicated by the bundle of arrows **50** and specular reflection having circularly polarized radiation as indicated by circles **66**. For purposes of this example, the circular polarization of the return beam **36** is, arbitrarily, shown as a left-handed or counter-clockwise polarization. When the return beam containing the randomly polarized, arrows **50**, and circularly polarized, circles **66**, radiation passes through lens **38** it first strikes a quarter wave plate **68** or other circular polarizing element. The circularly polarized radiation derived from the specular reflection is converted by the quarter wave plate **68** to linearly polarized radiation with its polarization axis oriented to bisect the angle between the slow **70** and fast **72** axes of quarter wave plate **68**. This linearly polarized radiation is indicated by arrow **74**; when the randomly polarized radiation, indicated by the group of arrows **50**, derived from the diffuse reflections encounters quarter wave plate **68** it passes through and emerges as still randomly polarized radiation, as indicated by the group of arrows **50**. However, both the linearly polarized radiation **70**, indicated by arrow **74**, and the randomly polarized radiation, indicated by bundle of arrows **50**, is next submitted to a linear polarizing element **76** having its polarization axis, as indicated by arrows **78**, transverse or, optimally, orthogonal to the direction of the polarization axis of the radiation emerging from quarter wave plate **68** derived from the circularly polarized radiation in the return beam. Thus, the linear polarization radiation indicated by arrow **74** derived from the circular polarization in the return beam **36** is totally blocked by polarizing element **76** and does not reach photosensor **44**. However, the randomly polarized radiation, indicated by group of arrows **50**, when submitted to polarizing element **76** is only partially attenuated so that the radiation, having an axis of polarization parallel to that of polarizing element **76**, is passed while the remainder is not. Thus, this arrangement too decreases the radiation associated with the specular reflections effectively to zero while it attenuates the radiation associated with the diffuse reflections by a factor of approximately two.

Other embodiments will occur to those skilled in the art and are within the following claims:

What is claimed is:

1. In a system for reading a diffuse reflective label, apparatus for suppressing specular reflections comprising:

a source of polarized radiation having a first circular polarization;

means for providing relative motion between the label and the polarized radiation for scanning a diffuse reflective label with said polarized radiation of said first circular polarization, and;

means for receiving diffusely reflected radiation having random polarization and specularly reflected radiation having said first circular polarization including polarizing means for selectively blocking specular reflections having said first circular polarization and passing radiation having other polarization for increasing the signal to noise ratio of the diffusely reflected radiation to the specularly reflected radiation.

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