

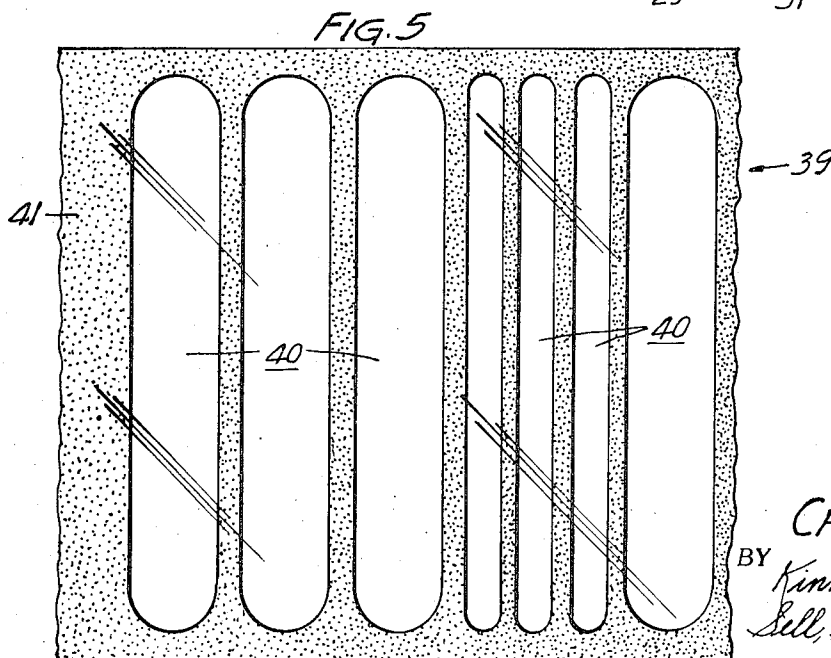
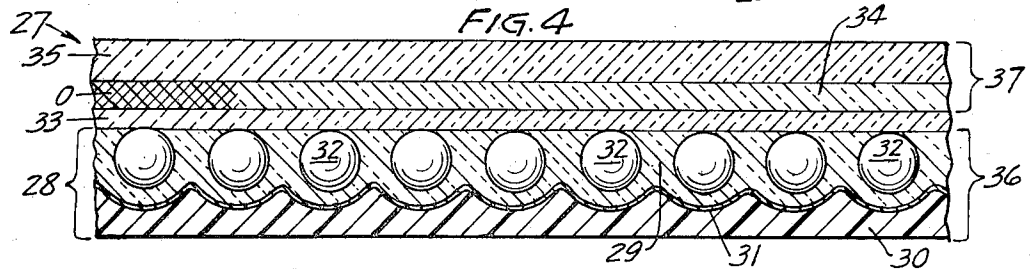
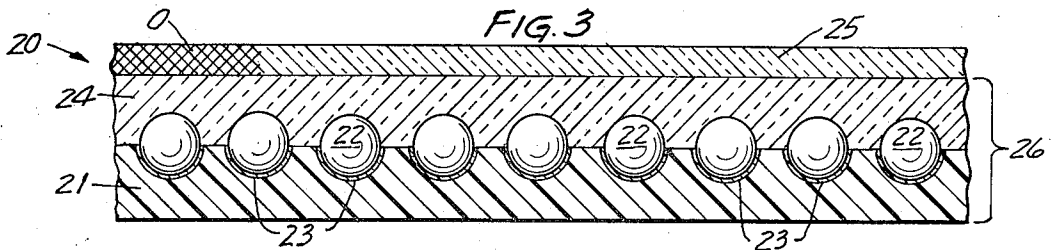
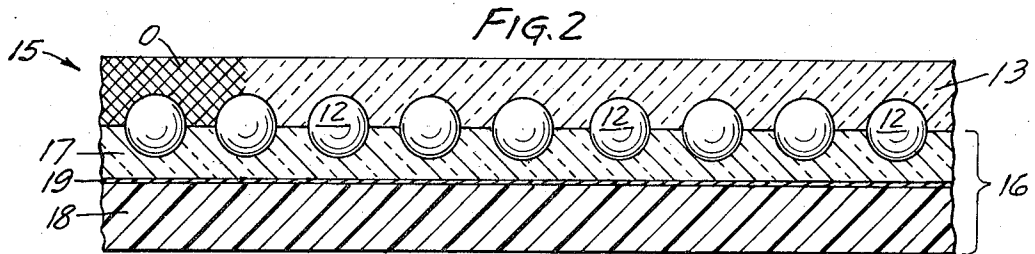
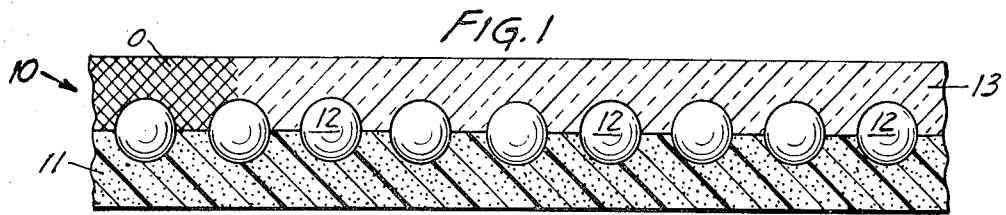
Jan. 2, 1973

CHI FANG TUNG

3,708,378

HEAT-SENSITIVE RETRO-REFLECTIVE IMAGING SHEET

Filed Nov. 27, 1970



INVENTOR.
CHI FANG TUNG
BY *Kinney, Alexander,
Sell, Stoldt & De La Hunt*
ATTORNEYS

1

2

3,708,378

HEAT-SENSITIVE RETRO-REFLECTIVE IMAGING SHEET

Chi Fang Tung, Lincoln Township, Washington County, Minn., assignor to Minnesota Mining and Manufacturing Company, St. Paul, Minn.

Filed Nov. 27, 1970, Ser. No. 93,175

Int. Cl. B44f 1/00

U.S. Cl. 161—6

13 Claims

ABSTRACT OF THE DISCLOSURE

A heat-sensitive imaging sheet on which images that are retro-reflective may be rapidly defined. The sheet includes an imaging layer that is either normally transparent and converted to opaque in selected areas or normally opaque and converted to transparent in selected areas when heated in those areas. The imaging sheet also includes a retro-reflective layer disposed underneath the imaging layer so that light beamed against the sheet will be retro-reflected by the portions of the retro-reflective layer exposed through transparent areas of the imaging layer.

BACKGROUND OF THE INVENTION

Labels or tags carrying informative symbols that are retro-reflective are advantageously used to identify articles in the course of automated operations such as sorting, retrieving, inventory-taking and the like. The retro-reflective symbols may, for example, symbolize a number, with each digit being represented by a combination of retro-reflective bars defined against an opaque field or background. The label or tag is read by a photoelectric scanner, which comprises a light source that provides a beam of light moving across the label, a photoelectric cell mounted to receive light returned coaxially with the beam of light, and a decoder that receives electrical signals from the photoelectric cell, translates them into meaningful form, and then passes them to mechanism that performs the sorting, retrieving, recording, etc. operation.

The present invention is directed to formation of the described labels or tags. In one prior-art method, labels are made by passing an assembly of a flat-surfaced retro-reflective sheeting and a separate imaging ribbon through a type of printing apparatus. In this apparatus, a heated die formed with the pattern of the opaque field desired on the label is pressed against the assembly to selectively transfer an opaque foil from the ribbon to the sheeting in the area pressed. The pattern of the heated die may be readily changed by operation of a keyboard that substitutes or rearranges interchangeable parts in the die. Thus, potentially, a series of labels, each carrying a different symbol—for example, a different one of an ascending series of numbers—may be rapidly provided. In another prior-art technique, a reflective sheeting is printed with an opaque ink to provide a set of label sections carrying standard symbol units, and labels are formed by adhering together appropriate sections.

Both of these prior-art techniques are less than satisfactory. The first requires stocking of two different products, and the operation is susceptible to malfunction since it requires keeping two items of sheet material in proper registry and properly moving through the apparatus, requires selective separation of parts of the foil from the ribbon and from contiguous parts of the foil, and requires adhesion of the separated foil to the reflective sheeting. The second prior-art technique is even less desirable than the first, since it requires maintaining a stock of all needed label sections, requires a second operation of assembling the sections into labels, and requires precision

in assembling the sections to prevent misreading of the label by a scanner.

In summary, to improve the use of retro-reflective labels as machine-read identification, a better technique for forming labels has been needed. The technique should be simple, reliable, and rapid and should provide labels that are immediately ready to use. Until this invention such a technique has not been available.

SUMMARY OF THE INVENTION

The present invention provides a single integral imaging sheet that in a single rapid operation may be converted to a label carrying the desired retro-reflective informative symbols. Briefly, an imaging sheet of the invention comprises (1) a support layer, (2) a uniform continuous monolayer of retro-reflective elements—preferably glass microspheres having reflective means underlying them—carried on one side of the support sheet, and (3) an imaging layer disposed over the retro-reflective elements. The imaging layer comprises a light-stable heat-sensitive material that is rapidly chemically converted from transparent to opaque or vice versa when exposed to localized heating uniformly distributed throughout the layer. Depending on the kind of heat-sensitive material used in the imaging layer, the layer is normally transparent and converted to opaque in selected areas or normally opaque and converted to transparent in selected areas. ("Transparent," as used herein, means sufficiently light-transmitting to return light to a photoelectric scanner and actuate the scanner, while opaque means insufficiently light-transmitting to return the light needed to actuate a scanner.)

Thus, the exposure of the imaging layer to an image-defining pattern of heat reproduces the image in the layer as a transparent area in an opaque field, and light beamed against the sheet will be retro-reflected by the retro-reflective elements exposed through the transparent area. To form an image on an imaging sheet of the invention, the imaging sheet may be passed through a printing apparatus in which a heated die is applied against the sheet (such as the printing apparatus used in one of the above prior-art techniques), or the imaging sheet may be placed against a graphic original which is then briefly exposed to intense infrared radiation in a thermographic copying machine; the infrared radiation absorbed by image-defining dark portions on the graphic original is released as an image-defining pattern of heat applied to the imaging sheet. By either of these methods, the desired retro-reflective image is rapidly (1–5 seconds, for example) formed on the imaging sheet at moderate temperatures.

DETAILED DESCRIPTION

Imaging sheets of the invention can be made in a variety of forms, based in part upon principles and constructions that have been previously developed for retro-reflective sheeting. To make sheet material that incorporates transparent glass microspheres retro-reflective, it is required that there be a certain ratio between the index of refraction of the microspheres and the index of refraction of the material covering the front surface of the microspheres, as described in U.S. Pats. 2,294,930 and 2,407,680 ("front" is used to refer to that surface of the imaging sheet, glass microsphere etc. closest to the source of light during use of a label or the like made from the imaging sheet). The needed ratio varies with the spacing, if any, between the back extremity of the microspheres and the reflective means underlying the microspheres that returns light through the microspheres, and with the difference, if any, between the indexes of refraction of the microspheres and the material spacing them from the reflective means. When there is no spacing between

the back extremity of the microspheres and the underlying reflective means, the ratio should be approximately 1.9. If there is spacing between the microspheres and the underlying reflective means, the ratio can be less than 1.9.

FIGS. 1-4 illustrates some of the different constructions that may be used in imaging sheets of the invention. The imaging sheet 10 shown in FIG. 1 comprises a support layer 11; a monolayer of transparent glass microspheres 12 partially embedded in the support layer; and a flat-surfaced imaging layer 13 covering the portions of the glass microspheres not embedded in the support layer. The support layer 11 is pigmented with a material that makes the layer reflective, so light transmitted through the glass microspheres is reflected by the support layer. The imaging layer 13 comprises a light-stable, heat-sensitive material distributed uniformly throughout the layer, and the sheet is shown after it has been exposed to heat, causing the formation of an opaque area O that partially defines a transparent image in the imaging layer. An advantage of the imaging sheet 10 of FIG. 1 is that it contains a minimum number of interfaces within the sheeting which reduce the brightness of a retro-reflective image.

The imaging sheet 15 shown in FIG. 2 is similar to the imaging sheet shown in FIG. 1 except that the support layer 16 is formed in two parts 17 and 18 and a reflective layer 19 is coated between the two parts. The reflective layer 19 takes the place of the pigment dispersed in the support layer 11 of the imaging sheet shown in FIG. 1 and reflects light transmitted through the glass microspheres and the part 17 of the support layer 16.

In an alternative construction based on the construction shown in FIG. 2, the layer 17 is an imaging layer and the layer 13 is a transparent heat-stable layer. When the imaging sheet is exposed to an image-defining pattern of heat the imaging layer 17 becomes opaque (or transparent) in the heated areas and masks out (or exposes) portions of the reflective layer 19. In the areas where the reflective layer is masked out, light will not be returned to a photoscanner "reading" the label in sufficient amount to actuate the scanner.

The imaging sheet 20 shown in FIG. 3 comprises a support layer 21; a monolayer of transparent glass microspheres 22 partially embedded within the support layer, each microsphere carrying a layer 23 of reflective material over its embedded surface; a flat-surfaced transparent cover layer 24 over the portions of the glass microspheres not embedded in the support layer; and an imaging layer 25 carried on the flat front surface of the cover layer.

The imaging sheet 27 shown in FIG. 4 comprises a support layer 28 that is formed in two parts 29 and 30; a layer 31 of reflective material that lies between the two parts; a monolayer of transparent glass microspheres 32 embedded in the support layer, with their front extremity at the front edge of the support layer; a flat-surfaced transparent cover layer 33; an imaging layer 34; and a transparent protective layer 35 covering the imaging layer. The support layer does not sufficiently cover the microspheres to make the retro-reflectivity of the microspheres wholly depend on the index of refraction of the material of the part 29 of the support layer; instead the index of refraction of the cover layer 33 is also critical. Although the imaging layer 34 is covered by the protective layer 35, it has been found that the imaging layer still receives sufficient heat from an image-defining pattern of heat applied to the imaging sheet to cause the heat-sensitive material to be rapidly converted from transparent to opaque or vice versa. Inclusion of such a protective layer is preferred to protect images formed in the imaging layer from being partially or wholly removed or blurred as a result of abrasion, exposure to solvents, etc.

FIG. 5 shows a portion 39 of a typical label made with an imaging sheet of the present invention having transparent bars 40 defined against an opaque background 41.

Techniques and materials for preparing retro-reflective sheeting are well developed, as illustrated by such patents as U.S. Pats. 2,294,930, 2,407,680, 3,005,382, and 3,449,201. The procedures used are generally a series of coating operations and for this invention include an operation to coat the material of the imaging layer at an appropriate point in the process. The imaging layer typically comprises a film-forming binder and a light-stable heat-sensitive material dispersed in the binder. The materials used in the different layers of the sheeting are chosen so that they will be compatible with one another in the sheeting.

A variety of light-stable, heat-sensitive materials that upon exposure to heat are rapidly chemically converted—that is, undergo an alteration that may be described in chemical terms, such as reduction or oxidation—from transparent to opaque or vice versa are available for inclusion in an imaging layer of an imaging sheet of the invention. An especially useful type of material includes metal salts or metal soaps, especially silver salts such as silver behenate, that are reduced to free metal by the action of a reducing agent present in the imaging layer. Such materials are described and illustrated in U.S. Pats. 2,910,377, 3,031,329, and 3,080,254, where they are disclosed for use in imaging layers of heat-sensitive copy sheets. When imaging layers described in these patents are exposed to an image-defining pattern of heat in conventional heat-providing copy machines, the heat-sensitive material is rapidly converted to develop a well-defined reproduction of the image.

Some products of the invention can be formed using pre-existing and readily available components. For example, with respect to FIG. 4, a retro-reflective sheeting comprising the combination of the microspheres 32, the support layer 28, and the reflective layer 31 (the combination designated 36 in FIG. 4) is a standard item of commerce. Heat-sensitive transparency film, which comprises an imaging layer 34 carried on a transparent sheet 35 (the combination designated 37 in FIG. 4), is also a standard item of commerce. Thus, the imaging sheet 27 of FIG. 4 may be conveniently made by laminating the two available sheet materials using a transparent binder material having an appropriate index of refraction to form the cover layer 33. Or the imaging sheet 20 shown in FIG. 3 is formed by coating the imaging layer 25 on standard, commercially available, flat-surfaced reflective sheeting, designated 26 in FIG. 3 and which comprises in combination a support layer 21, glass microspheres 22, reflective layers 23, and cover layer 24.

The materials in the other layers of an imaging sheet of the invention are chosen from a variety of film-forming materials available. Those materials that are to transmit light are preferably highly clear. An especially useful material for a protective layer or film such as the layer 35 in the imaging sheet shown in FIG. 4 is polyethylene terephthalate because of its clarity, toughness, mark-resistance, and resistance to solvent-attack.

The invention can be further illustrated by the following examples.

EXAMPLE 1

A flat-surfaced reflective sheeting comprising the combination 26 shown in FIG. 3 was coated on its flat front surface with a liquid mixture comprising 20 parts of silver behenate dispersed in a solution of 3 parts methyl gallate, 33 parts polyvinyl acetate, 3 parts phthalazinone, 0.6 part tetrachlorophthalic anhydride, 0.2 part of benzotriazol and 440 parts of a solvent mixture of ethanol and methyl ethyl ketone. The liquid mixture was coated at a wet thickness of about 6 mils and then placed in an oven set at 160° F. for 3 minutes to provide an imaging layer. A solution of cellulose acetate butyrate was then coated over the imaging layer and dried, giving the imaging sheet a clearer appearance.

The resulting imaging sheet was pressed against a graphic original in a thermographic copying machine

5

where the graphic original was briefly exposed to intense infra-red radiation. The graphic original served as a label master and carried black image-defining areas, which were reproduced as opaque areas in the imaging layer of the imaging sheet of this example. These opaque areas defined retro-reflective image areas on the imaging sheet.

EXAMPLE 2

An imaging sheet such as shown in FIG. 4 was prepared using as a first component a 3-mil-thick polyethylene terephthalate film coated with a silver behenate-based imaging layer such as taught in Example 1 and as a second component retro-reflective sheeting that comprised the combination 36 in FIG. 4. A solution of 20 parts of a film-forming drying-type soya alkyd and one part of a modified melamine-formaldehyde hardener was knife-coated over the surface of the sheeting and the solvent evaporated to leave a 2-mil-thick coating. Then, while the coating was still tacky, the polyethylene terephthalate film was laminated to it—with the imaging layer against the coating—by passing the assembly through pressure rollers. Upon exposure of the resultant imaging sheet to an image-defining pattern of heat, either by pressing the surface of the imaging sheet with a heated platen (such as in a Franklin printer) or passing it through a thermographic copying machine with a label master as described above, an image was formed on the imaging sheet as a retro-reflective area defined by an opaque background.

What is claimed is:

1. A light-stable heat-sensitive imaging sheet on which retro-reflective images may be rapidly defined comprising (1) a support layer, (2) a uniform continuous monolayer of retro-reflective elements disposed on one side of the support layer, and (3) an imaging layer disposed over the retro-reflective elements comprising, in uniform distribution throughout the layer, a light-stable heat-sensitive material that is rapidly chemically modified as to its light-transmitting properties by exposure to heat, the imaging layer being selected from the group consisting of (1) normally transparent light-stable layers that are adapted to be converted to opaque when exposed to heat and (2) normally opaque light-stable layers that are adapted to be converted to transparent when exposed to heat, whereby light beamed against the sheet will be retro-reflected only by retro-reflective elements exposed through the transparent areas.

2. An imaging sheet of claim 1 in which the imaging layer is disposed on a flat-surfaced transparent cover layer that is disposed over the retro-reflective elements.

3. An imaging sheet of claim 1 in which a transparent protective film is disposed over the imaging layer.

4. An imaging sheet of claim 1 in which the retro-reflective elements are transparent glass microspheres disposed on the support layer and having a reflective layer underlying their back extremities.

5. An imaging sheet of claim 4 in which the imaging layer is disposed on a transparent film, the retro-reflective elements are glass microspheres embedded in the support layer to the level of the front extremities of the microspheres, with a reflective layer underlying the back extremities of the microspheres, and the film carrying the imaging layer is adhered to the support layer by a continuous transparent layer of material that has a refractive index that makes the microspheres retro-reflective.

6. An imaging sheet of claim 5 in which the imaging

6

layer is disposed between the film and the glass microspheres.

7. An imaging sheet of claim 6 in which the film comprises polyethylene terephthalate.

8. An imaging sheet of claim 1 in which the heat-sensitive material comprises a metal soap.

9. An imaging sheet of claim 8 in which the metal soap comprises silver behenate.

10. An imaging sheet of claim 1 in which the imaging layer is normally transparent and converted to opaque.

11. A heat-sensitive imaging sheet on which retro-reflective images may be rapidly defined comprising (1) a support layer, (2) a uniform continuous monolayer of transparent microspheres disposed on one side of the support layer, (3) a reflective layer disposed beneath the layer of transparent microspheres, and (4) an imaging layer disposed between the transparent microspheres and reflective layer and comprising a light-stable heat-sensitive material uniformly distributed throughout the layer that is rapidly chemically modified as to light-transmitting properties by exposure to heat, the imaging layer being selected from the group consisting of (1) normally transparent light-stable layers that are adapted to be converted to opaque when exposed to heat and (2) normally opaque light-stable layers that are adapted to be converted to transparent when exposed to heat, whereby light beamed against the sheet will be retro-reflected only by retro-reflective elements exposed through the transparent areas.

12. A heat-sensitive imaging sheet on which retro-reflective images may be rapidly defined comprising (1) a support layer; (2) a uniform continuous monolayer of transparent microspheres disposed on one side of the support layer and having a reflective layer underlying their back extremities; (3) an imaging layer disposed over the microspheres comprising, in uniform distribution throughout the layer, a light-stable heat-sensitive material that is rapidly chemically converted from transparent to opaque by exposure to heat, whereby light beamed against the sheet will be retro-reflected by microspheres exposed through transparent areas; and (4) a transparent protective film disposed over the imaging layer and forming an exterior surface of the sheet.

13. An imaging sheet of claim 12 in which the heat-sensitive material comprises a silver salt.

References Cited

UNITED STATES PATENTS

3,190,178	6/1965	McKenzie	350—105
3,218,166	11/1965	Reitter	117—36.8 X
2,555,715	6/1951	Tatum	350—105
3,493,286	2/1970	Bacon, Jr.	350—105
3,005,382	10/1961	Weber	350—105
3,388,027	6/1968	Altman	161—6 X
3,413,058	11/1968	Tung et al.	350—105
3,222,986	12/1965	Altman	350—105 X
3,430,375	3/1969	Altman	350—105 X

FOREIGN PATENTS

1,149,730	6/1963	Germany	161—6
-----------	--------	---------	-------

PHILIP DIER, Primary Examiner

U.S. Cl. X.R.

40—2, 135; 117—36.8; 161—162, 194, 410; 350—105