

# United States Patent

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## [54] METHOD OF MARKING A TRANSPARENT MATERIAL

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[56]

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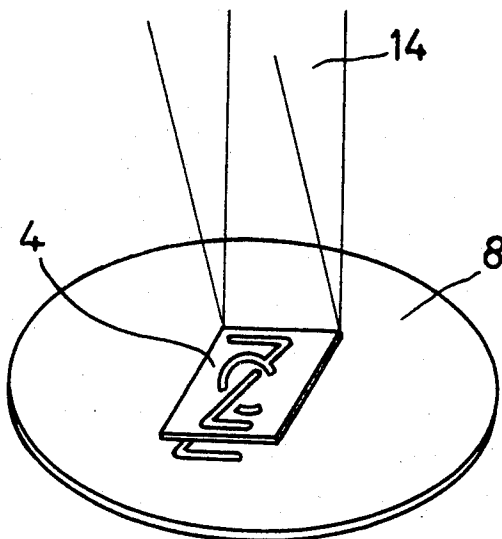
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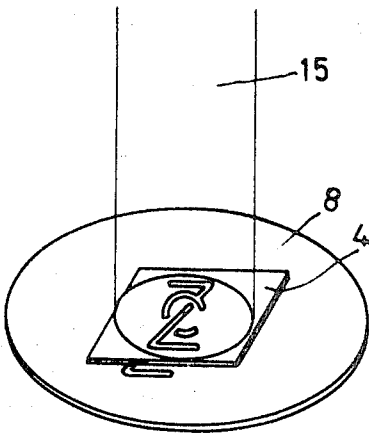
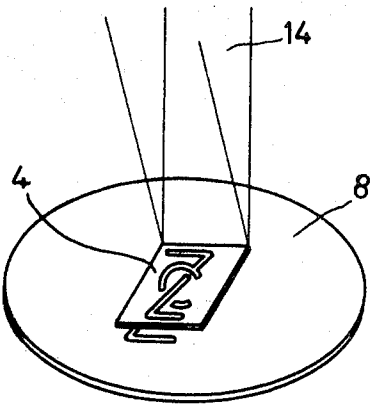
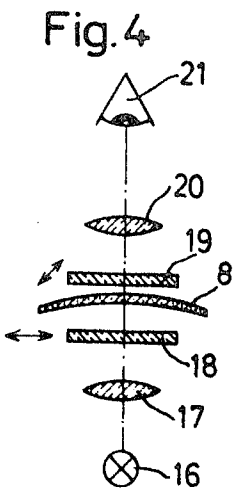
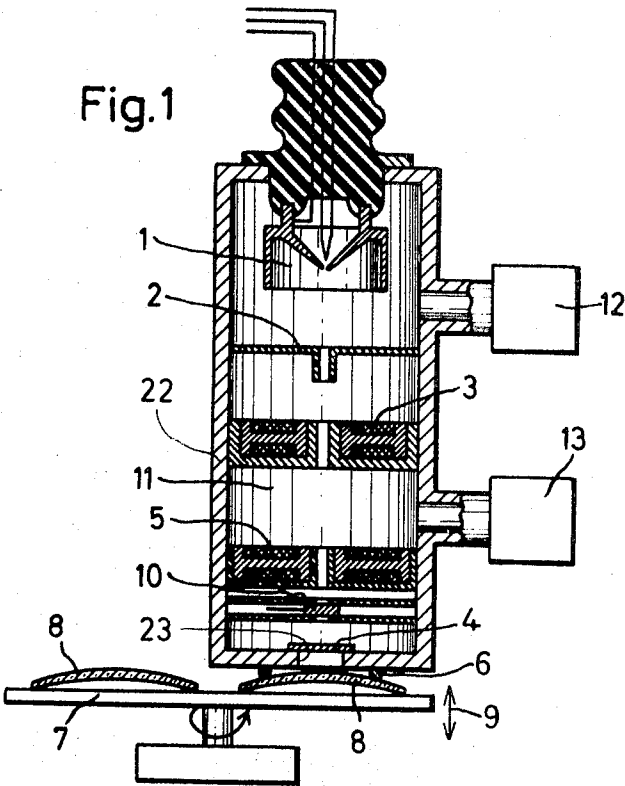
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### ABSTRACT

An identification mark is made on a transparent workpiece, such as a lens for spectacles, by irradiating the material in a pattern desired for an identification mark with radiations which produce localized permanent stresses in the material that are visible by double refraction in polarized light. Suitable irradiation may be provided by corpuscular radiation, as by an electron beam, or electromagnetic radiation, as by laser beams. The radiation is preferably applied in an amount to produce the stresses within the material, not on the surface.

**8 Claims, 4 Drawing Figures**





## METHOD OF MARKING A TRANSPARENT MATERIAL

## FIELD OF THE INVENTION

The present invention relates to a method and apparatus for placing identification markings on transparent material, such as glass. In particular, the invention is a method and apparatus for making such identification markings by applying radiation to the material to produce a predetermined pattern of localized permanent stresses therein which are rendered visible by applying polarized light.

## PRIOR ART

Various means of placing identifying marks on transparent material, such as lenses of spectacles, are known. One means has been to engrave identification marks on portions of the articles, such as the edges of lens, where the marks will not interfere with the appearance or intended use of the article. A disadvantage of engraved marks is that they are difficult to find. Also, a particular disadvantage with marks engraved on the edge portions of spectacle lenses is that they are apt to be completely or partially obliterated when shaping the edge portions for fitting the lenses into frames.

Another means is to etch a mark on the surface of the article. The etching is suitably done with a stamp coated with an etching substance and applied lightly to the surface of the workpiece so as to make a weak etching which will be substantially invisible under normal observation and which will not interfere with the appearance or optical properties of the article. Such a mark may be placed at a preselected position on the article — at the center of a lens, for example, so that it can be found easily. Then by hazing the surface of the article the etched mark is rendered visible by the difference in the condensation on the etched and on the unetched portions. The problem with these etched marks, however, is that they must be so lightly etched that they are worn off by the polishing action of repeated cleanings of the surface.

## OBJECTS OF THE INVENTION

Objects of the present invention are to provide an article of transparent material, such as a lens, an identification mark which is normally invisible, which does not alter the appearance or optical properties of the lens, or other article, which may be applied quickly and economically, which is durable, which is difficult to alter or falsify, and which can be made visible by simple means.

## SUMMARY OF THE INVENTION

In accordance with this invention identification marks are provided by applying radiations to the transparent material for producing in the material a selected pattern of permanent stresses which are rendered visible by double refraction under polarized light. The particular design for the identification is suitably formed by applying the radiations through cut-out portions of a mask placed on the workpiece.

In accordance with a preferred form of the invention the radiation consists of accelerated electrons as provided by an electron beam, which is preferably applied so that the stresses thereby produced are in the interior of the material. The electrons impinging on the solid material are scattered by collisions with the molecules of the material so that their kinetic energy is thereby transformed into heat which produces permanent stresses in the material. The depth of penetration of an electron beam into the material depends on its velocity. The depth of penetration is defined as the depth at which the probability of there being an electron of the impact velocity  $V_0$  has declined to  $1/e$ . For example, when applying an electron beam at an accelerating voltage of 100 KV, the depth of penetration — depending substantially on the density of the material and the square of the accelerating voltage — will be approximately 10–15 microns.

The electrons initially penetrating the material heat the surface only to a small extent, this heating being insufficient to

produce permanent stresses in the surface layer. As the electrons approach their depth of penetration below the surface of the material the aforementioned scattering of the electrons generates an amount of heat which produces localized permanent stresses in the interior of the material. For producing a desired stress pattern in a selected area within the material, the beam is, therefore, applied to a given area for only a few microseconds at a time; this stress pattern may be more pronounced, still within its localized area, by reapplying the beam several times to the same area.

The stress patterns thus produced have proved to be stable and, therefore, permanent. Being below the surface, these stress patterns do not change the appearance of the article and are not destroyed or distorted by cleaning and polishing.

Marking in this manner is particularly adapted for placing identifying marks on lenses. The marks being normally invisible may be placed in a preselected position on the lenses — the center, for example — where they can readily be found when polarized light is applied to render the marks visible. It is substantially impossible to alter or falsify the marks. And the marks do not disturb the optical properties of the lenses or change their surfaces in any way; electron-microscopic and polarization-optical pictures of the surfaces of lenses so marked did not reveal any changes at all.

As mentioned above, these marks are made visible by the double refraction produced by applying polarized light to the marked article.

Radiations for producing stress pattern identification marks in transparent material, in accordance with this invention, may be corpuscular radiation provided by an electron beam, as already explained above, or by electromagnetic radiations, such as laser beams. The use of laser beams is particularly recommended for producing these marks in mass colored materials.

## DRAWINGS

The invention will now be described in greater detail with reference to the accompanying drawings in which:

FIG. 1 is a diagrammatic illustration of apparatus for producing an identification mark in a transparent workpiece by means of electron beams;

FIG. 2 is a perspective view showing a mask in line with a workpiece for defining a desired stress pattern to be produced in the workpiece by the apparatus of FIG. 1;

FIG. 3 is a perspective view of a mask in line with a workpiece illustrating the production of a stress pattern by the application of a laser beam;

FIG. 4 is a diagrammatic illustration of apparatus for applying polarized light to a masked article for making the mark visible.

## DETAILED DESCRIPTION OF APPARATUS

In the apparatus illustrated in FIG. 1 an electron beam produced by a cathode-ray source 1 passes through a tubular passage, which is through a diaphragm 2, to a cylindrical lens 3. The lenses 3 focus the beam through a deflecting system 5 onto a mask 4 which is supported in line with a workpiece 8 (such as a spectacle lens as shown) supported on a rotatable plate 7, which is also movable up and down as indicated by the arrow 9. The mask 4 is suitably a tungsten sheet from which a full scale design of the desired identification mark has been cut out.

As shown, the beam-producing end of the cathode-ray source 1, the diaphragm 2 and the deflecting system 5 are within a housing 22 which has an opening 23 in optical alignment with the lens 3 and deflecting system 5, and the mask 4 is adapted to be supported over the opening 23. A high-vacuum valve 10 is in the housing 22 in line between the deflecting system 5 and the opening 23 and defines a chamber 11 in the portion of the housing above it. Pumps 12 and 13 are connected into a chamber 11 for evacuating it when the valve 10 is closed, the pump 12 being connected into the upper, or

beam generating, portion of the chamber 11 which is above the diaphragm 2.

The bottom end of the housing 22 is provided with a seal ring 6 around the opening 23 to engage the surface of a workpiece 8 for sealing off the area of the workpiece against which the electron beam impinges for producing the identification mark.

In operation, the valve 10 is closed to seal off the chamber 11 which is then evacuated by the pumps 12 and 13; the closing of valve 10 also blocks the path of the electron beam to the mask 4. The electric power to the cathode-ray source is turned on, while the beam is blocked by a bias voltage. The plate 7 carrying one or more workpieces 8 is rotated to center one of the workpieces with the seal ring 6 and opening 23, after which the plate 7 is moved upward until the latter workpiece firmly abuts the ring 6 to seal the portion of the chamber 11 below the valve 10, and the area of the workpiece within the ring 6, against outside pressure.

Then the valve 10 is opened, so that a partial vacuum is created through the chamber 11 (including the cathode-ray source and the area of a workpiece 8 within the ring 6). Together with the opening of the valve the beam from the cathode-ray source is released so that the beam is focused by the cylindrical lens 3 in a line on the mask 4, as indicated in FIG. 2. The beam 14 is thereafter moved across the mask 4 by operation of the deflecting system 5 so that the beam impinges on the workpiece 8 in a pattern defined by the design cut out of the mask.

The deflecting system 5 is suitably operated to scan the mask so that a surface area of approximately 100 microns in diameter is impinged upon for only a few microseconds for providing an energy density of the electron beam 14 from  $1 \times 10^{-3}$  to  $5 \times 10^{-3}$  Ws/cm<sup>2</sup>. The beam 14 may be moved over the mask 4 one or more times; multiple passes increase the visibility of the stress pattern under polarized light.

After the beam 14 has thus been moved over the entire pattern of the mask to produce a corresponding stress pattern in the workpiece thereunder the valve 10 is closed thereby sealing the upper portion of the chamber 11 from the lower portion. At the same time the beam 14 is blocked by a suitable bias voltage. The plate 7 is moved down to disengage one workpiece 8 from the ring 6, and is rotated to move a different workpiece 8 in position under the ring. Then, when the plate is moved up again to fix the new workpiece in sealing engagement with the ring, the valve 10 is opened and the above-described marking operation is applied to the new workpiece.

FIG. 3 illustrates the manner in which a laser beam 15 is ap-

plied to produce a stress pattern identification mark in accordance with this invention. As shown, the laser beam 15 covers the entire area of the design cut out of the mask 4. Therefore, only a short laser pulse is generated at one time to produce the entire mark.

FIG. 4 illustrates the use of apparatus for rendering visible the stress pattern which has been produced in a workpiece 8 in the manner described above. The apparatus comprises a light source 16, a condenser 17, two crossed polarizers 18 and 19 and a magnifier lens 20 in optical alignment for light from the light source 16, to pass through a workpiece 8 placed between the polarizers 18 and 19 for an observer indicated at 21. The identification mark, magnified by the magnifier lens 20, appears bright against a dark background. By moving the workpiece 8 the identification mark is seen to have a brilliantly shining character which lightens and darkens so as to be particularly easy to recognize.

What is claimed is:

1. A method of marking a transparent material for identification comprising irradiating said material by means of radiation applied thereto in a pattern desired for an identification mark, said radiation being applied at an energy density which generates sufficient internal heat to produce localized permanent stresses within the interior only of the material without producing such stresses in its surface layer, the stress pattern so produced being normally invisible but capable of being rendered visible by double refraction in polarized light.

2. The method of claim 1 which said irradiating is accomplished by applying accelerated electrons to said material in the form of a focused electron beam.

3. The method of claim 2 in which said electron beam is moved over the material in said pattern more than once.

4. The method of claim 2 in which said electron beam is moved over the material in said pattern.

5. The method of claim 4 in which said electron beam is moved with such a speed, that each element of said material is impinged with an energy density of from about  $1 \times 10^{-3}$  to about  $5 \times 10^{-3}$  Ws/cm<sup>2</sup>.

6. The method of claim 1 which includes masking portions of said material as means for defining a predetermined pattern of localized stresses to be produced.

7. The method of claim 2 in which said electron beam is focused in a line on said mask and is moved across it thereby impinging along said predetermined pattern.

8. The method of claim 1 in which said irradiating is accomplished by applying a laser beam to said material.

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