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- (54) SUB-SURFACE MARKING
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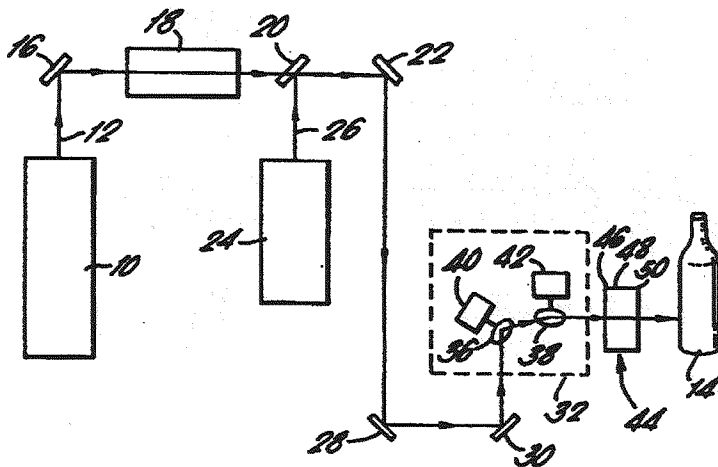
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(57) ABSTRACT

A method and apparatus for providing a body of material (14) with sub-surface marking in the form of an area of increased opacity to electromagnetic radiation. The method includes directing at a surface of the body (14) a high energy density beam (12, 26) to which the material (14) is transparent, and bringing the beam (12,26) to a focus at a location spaced from the surface and within the body (14) so as to cause localized ionization of the material (14). In a preferred embodiment the apparatus includes a laser (10) as a high energy density beam source and provides means (36, 38) to move the focus of the beam (12,26) relative to the body (14) so as to enable the mark to be of a predetermined shape.



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**REEXAMINATION CERTIFICATE
ISSUED UNDER 35 U.S.C. 307**

THE PATENT IS HEREBY AMENDED AS
INDICATED BELOW.

Matter enclosed in heavy brackets [] appeared in the patent, but has been deleted and is no longer a part of the patent; matter printed in italics indicates additions made to the patent.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

Claims 1, 7 and 19 are determined to be patentable as amended.

Claims 2-6, 8-18 and 20-25 dependent on an amended claim, are determined to be patentable.

New claims 26-52 are added and determined to be patentable.

1. A method of forming a sub-surface mark within a body, at least a portion of said body being of a material to be marked, said method comprising the steps of:

- (a) directing at said portion a high energy density beam to which the material is transparent; [and]
- (b) focusing the beam at a location in the material, within said portion, and spaced from the surfaces of said portion [so as to cause]; and
- (c) *creating a plasma* by localised ionisation of the material at said location [and the creation] to create at said location [of] a mark in the form of an area of increased opacity to electromagnetic radiation, substantially without any detectable change at said surfaces or at the surfaces of said body.

7. An apparatus for forming a sub-surface mark within a body, at least a portion of said body being of a material to be marked, said apparatus comprising:

- means for creating a high energy density beam to which the material is transparent; and
- means for focusing the beam at a location in the material, within said portion, and spaced from the surfaces of said portion so as to cause a *plasma* by localised ionisation of the material at said location and the creation at said location of a mark in the form of an area of increased opacity to electromagnetic radiation, substantially without any detectable change at said surfaces or at the surfaces of said body.

19. An article of manufacture comprising a body, at least a portion of said body being of a material having an internal zone of damage resulting from *creation of a plasma* by localized ionization and spaced from the surfaces of said portion and the surfaces of said body to form a mark within said portion.

26. A method of forming a sub-surface mark within a body, at least a portion of said body being of a material to be marked, said method comprising the steps of:

- (a) directing at said portion a high energy density beam to which the material is transparent;
- (b) focusing the beam at a location in the material, within said portion, and spaced from the surfaces of said portion;
- (c) *creating a plasma* by localised ionisation of the material at said location to create at said location a

mark in the form of an area of increased opacity to electromagnetic radiation, substantially without any detectable change at said surfaces or at the surfaces of said body, the mark including at least one from the group of numerals, letters, and symbols that is representative of a desired indicium; and

(d) moving the focus of the beam relative to said portion so as to create the mark with a predetermined shape.

27. A method in accordance with claim 26, wherein the body is transparent to electromagnetic radiation at wavelengths within the visible region.

28. A method in accordance with claim 26, wherein at least a portion of the body is opaque to electromagnetic radiation at wavelengths within the visible region such that the mark may only be detected by optical instruments operating at an appropriate wavelength within the electromagnetic spectrum.

29. A method in accordance with claim 26, wherein the mark is three dimensional.

30. An apparatus for forming a sub-surface mark within a body, at least a portion of said body being of a material to be marked, said apparatus comprising:

means for creating a high energy density beam to which the material is transparent;

means for focusing the beam at a location in the material, within said portion, and spaced from the surfaces of said portion so as to cause a plasma by localised ionisation of the material at said location and the creation at said location of a mark in the form of an area of increased opacity to electromagnetic radiation, substantially without any detectable change at said surfaces or at the surfaces of said body, the mark including at least one from the group of numerals, letters and symbols that is representative of a desired indicium; and

means for moving the focus of the beam relative to said portion so as to create the mark with a predetermined shape.

31. An apparatus in accordance with claim 30, wherein the high energy density beam is a focusable particle beam.

32. An apparatus in accordance with claim 30, wherein the means for creating a high energy density beam is a laser.

33. An apparatus in accordance with claim 32, wherein the laser has a peak energy density at the focus of at least 10 J/cm^2 .

34. An apparatus in accordance with claim 32 or claim 33, wherein the laser has a power density at the focus of at least 10^7 W/cm^2 and is pulsed with a pulse duration of less than 10^{-6} seconds.

35. An apparatus in accordance with claim 32, wherein the laser is a Nd-YAG laser.

36. An apparatus in accordance with claim 32, wherein the means for focusing the beam includes a lens element of variable focal length.

37. An apparatus in accordance with claim 32, further comprising a secondary source of visible laser radiation for facilitating alignment of the high energy density beam.

38. An apparatus in accordance with claim 30, wherein the means for moving the focus of the beam includes at least one movable mirror disposed in the path of the beam.

39. An apparatus in accordance with claim 38, wherein the means for moving the focus further includes a programmed computer for controlling the movement of the at least one movable mirror.

40. An apparatus in accordance with claim 38 or claim 39, wherein the at least one movable mirror is a galvanometer mirror.

41. An article of manufacture, comprising:

a body of material having at least a portion with an internal zone of damage resulting from a plasma created by localized ionization, the internal zone of damage being spaced from the surfaces of the portion and the surfaces of the body to form a mark within the portion, the mark having an area of increased opacity to electromagnetic radiation substantially without any detectable change to the surface, the mark including at least one from the group of numerals, letters and symbols that is representative of a desired indicium.

42. An article of manufacture in accordance with claim 41, wherein the body is transparent to electromagnetic radiation at wavelengths within the visible region.

43. An article of manufacture in accordance with claim 41, wherein the body is glass or plastic.

44. An article of manufacture in accordance with claim 41, wherein at least a portion of the body is opaque to electromagnetic radiation at wavelengths within the visible region such that the mark may only be detected by optical instruments operating at an appropriate wavelength within the electromagnetic spectrum.

45. An article of manufacture in accordance with claim 41, wherein the mark is three dimensional.

46. An article of manufacture in accordance with claim 41, wherein the article is a container.

47. An article of manufacture, comprising:

a body of material having at least a portion with a mark resulting from a plasma created by localized ionization, the mark being spaced from the surfaces of the portion and the surfaces of the body, the mark having an area of increased opacity to electromagnetic radiation substantially without any detectable change to the surface, the mark having one or more numerals, letters or symbols or a combination thereof representative of a desired indicium.

48. An article of manufacture in accordance with claim 47, wherein the body is transparent to electromagnetic radiation at wavelengths within the visible region.

49. An article of manufacture in accordance with claim 47, wherein the body is glass or plastic.

50. An article of manufacture in accordance with claim 47, wherein at least a portion of the body is opaque to electromagnetic radiation at wavelengths within the visible region such that the mark may only be detected by optical instruments operating at an appropriate wavelength within the electromagnetic spectrum.

51. An article of manufacture in accordance with claim 47, wherein the mark is three dimensional.

52. An article of manufacture in accordance with claim 47, wherein the article is a container.

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