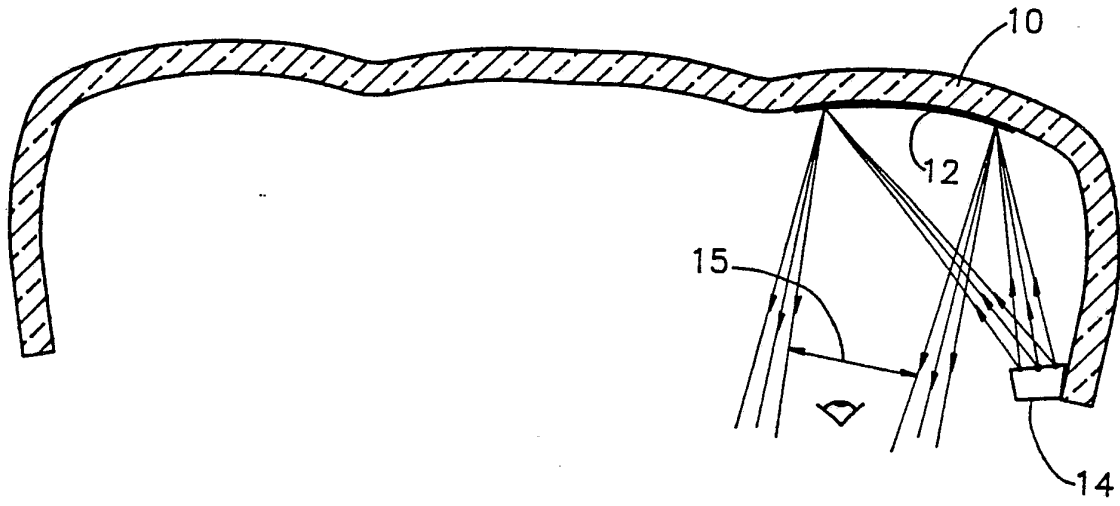


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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| <p>(21) International Application Number: PCT/US92/02708 (22) International Filing Date: 2 April 1992 (02.04.92) (71)(72) Applicants and Inventors: MORAN, Dan [US/IL]; 19 Aluf David Street, 52 226 Ramat Chen (IL). GERLITZ, Yonatan [IL/IL]; 23 Malchei Israel Street, 46 363 Herzlia (IL). (74) Agents: LERCH, Joseph, B. et al.; Darby & Darby, 805 Third Avenue, New York, NY 10022 (US). (81) Designated States: AU, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LU, MC, NL, SE).</p> | | <p>Published <i>With international search report.</i></p> |
| <p>(54) Title: VISUAL DISPLAY APPARATUS</p> | | |
|  | | |
| <p>(57) Abstract</p> <p>Display apparatus comprising a generally transparent injection moldable plastic substrate, a dichroic coating associated with the substrate, a solid state image generator operatively associated with the substrate and the dichroic coating, such that the image generated by the solid state image generator in a given wavelength range is reflected from the substrate to an observer while light of wavelengths outside of the given wavelength range passes through the substrate to the observer.</p> | | |

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1 SUMMARY OF THE INVENTION

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3 The present invention seeks to provide a
4 relatively inexpensive and simple superimposed display
5 which, due to its simplicity and cost effectiveness is
6 suitable for a wide range of applications.

7

8 There is thus provided in accordance
9 with a preferred embodiment of the present invention
10 display apparatus comprising a generally transparent
11 injection moldable plastic substrate, a dichroic
12 coating associated with the substrate, a solid state
13 image generator operatively associated with the
14 substrate and the dichroic coating, such that the image
15 generated by the solid state image generator in a given
16 wavelength range is reflected from the substrate to an
17 observer while light of wavelengths outside of the
18 given wavelength range passes through the substrate to
19 the observer.

20

21 In accordance with a preferred embodiment of
22 the invention, the substrate has optical power for
23 reflection and the image generator is disposed in the
24 focal plane of the substrate.

25

26 Further in accordance with a preferred
27 embodiment of the invention, the dichroic coating is
28 formed directly on the substrate. According to an
29 alternative embodiment of the invention, the dichroic
30 coating is formed on a coating substrate which is in
31 turn associated with the substrate.

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1 BRIEF DESCRIPTION OF THE DRAWINGS

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3 The present invention will be understood and
4 appreciated more fully from the following detailed
5 description taken in conjunction with the drawings in
6 which:

7 Fig. 1 is a schematic illustration of display
8 apparatus constructed and operative in accordance with
9 a preferred embodiment of the present invention;

10 Fig. 2A is a graph illustrating
11 transparency/reflection of a dichroic coating formed on
12 a polycarbonate visor for red illumination at an angle
13 of incidence of 15 degrees;

14 Fig. 2B is a graph illustrating
15 transparency/reflection of a dichroic coating formed on
16 a polycarbonate visor for green illumination at an
17 angle of incidence of 15 degrees;

18 Fig. 3 is a schematic illustration of display
19 apparatus for an automobile windshield constructed and
20 operative in accordance with a preferred embodiment of
21 the invention; and

22 Fig. 4 is a schematic illustration of display
23 apparatus for an automobile windshield constructed and
24 operative in accordance with a preferred embodiment of
25 the invention.

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1 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

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3 Reference is now made to Fig. 1 which
4 illustrates schematically imaging apparatus constructed
5 and operative in accordance with a preferred
6 embodiment. A substrate 10, typically formed of a
7 plastic material such as polycarbonate, defines goggles
8 or a visor, which is shown in section in Fig. 1. A
9 dichroic coating 12 is formed on the substrate 10,
10 preferably on an inner surface thereof, either by
11 direct vacuum deposition using a technique available
12 from Denton Vacuum of Cherry Hill, New Jersey, U.S.A.
13 or alternatively by means of a dichroic coated
14 substrate, such as a film of polycarbonate which is
15 adhered as by transparent adhesive to substrate 10.

16

17 According to a preferred embodiment of the
18 invention the substrate 10 is configured to have
19 optical power for reflection but no optical power for
20 transmission and may be formed with spheric or aspheric
21 curvature as appropriate.

22

23 An image generator 14 is arranged out of the
24 line of sight between the user's eye or eyes and the
25 substrate and so as to display an image which is
26 reflected by the dichroic coating 12 back to the user's
27 eye or eyes. A preferred image generator 14 may be a
28 solid state high brightness green or red 5 x 7 dot
29 matrix such as model numbers HDSP2002 or HDSP2003
30 manufactured by Hewlett Packard. The image generator
31 preferably provides a peak luminous intensity per LED
32 of approximately 1000 microcandle, with a duty cycle of
33 20 % for a LED area of 5.8×10^{-7} square feet,
34 providing an average brightness of 1000Ft Lm.

35

36 The transmission/reflection curves of two
37 suitable dichroic coatings are set forth in Figs. 2A
38 and 2B.

1 This average brightness is low compared with
2 an average brightness of 5000FtLm which can be realized
3 from a cathode ray tube. It is a particular feature of
4 the present invention that by use of the dichroic
5 coating on the substrate 10 and by avoiding any
6 attenuation through elimination of optics between the
7 coating 12 and the image generator 14, acceptable
8 contrast is provided even against clear sky.

9
10 It is a particular feature of the present
11 invention that due to the fact that no optics are
12 required or provided between coating 12 and the image
13 generator 14, an extremely wide exit pupil 15 is
14 provided, whose size is limited only by the size of the
15 substrate area covered by coating 12. As a result, the
16 user is free to move his head within a relatively large
17 volume, while still obtaining a good image of the
18 displayed information.

19
20 The configuration and arrangement of the
21 substrate 10 with respect to the eye or eyes of the
22 user are such that the image reflected from the image
23 generator 14 by the dichroic coating 12 to the eye or
24 eyes of the user arrives at the user's eyes in
25 generally parallel rays, as if coming from infinity and
26 thus does not require constant refocusing of the user's
27 eyes to see the reflected images.

28
29 Reference is now made to Fig. 3, which
30 illustrates display apparatus for an automobile
31 windshield constructed and operative in accordance with
32 a preferred embodiment of the invention and comprising
33 a windshield 30 typically formed of polycarbonate
34 optical plastic having a spherical or aspheric
35 curvature, such as an off-axis parabolic curvature. A
36 dichroic coating 32 is formed on the windshield 30. An
37 image generator 34, which may be identical to the image
38 generator 14 described hereinabove, is located

1 preferably in the focal plane of the windshield, such
2 that the images generated thereby are reflected by
3 dichroic coating 32 to the eyes of a driver in parallel
4 rays so as to appear to come from infinity.

5

6 Reference is now made to Fig. 4 which
7 illustrates an alternative arrangement of display
8 apparatus wherein the dichroic coating is not formed
9 directly on the window or windshield but rather on a
10 second substrate 40 which is adhered by any suitable
11 means onto the windshield.

12

13 The arrangement of Fig. 4 is particularly
14 useful for retrofit applications and for applications
15 where coating of a large substrate is impractical or
16 unacceptably costly.

17

18 It will be appreciated by persons skilled in
19 the art that the present invention is not limited by
20 what has been particularly shown and described
21 hereinabove. Rather the scope of the present invention
22 is defined only by the claims which follow:

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C L A I M S

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- 3 1. Display apparatus comprising:
4 a generally transparent injection moldable
5 plastic substrate;
6 a dichroic coating associated with said
7 substrate; and
8 a solid state image generator operatively
9 associated with the substrate and the dichroic coating,
10 such that the image generated by the solid state image
11 generator in a given wavelength range is reflected from
12 the substrate to an observer while light of wavelengths
13 outside of the given wavelength range passes through
14 the substrate to the observer.
15
- 16 2. Apparatus according to claim 1 and wherein
17 said substrate has optical power in reflection and the
18 image generator is disposed in the focal plane of the
19 substrate.
20
- 21 3. Apparatus according to claim 1 and wherein
22 said dichroic coating is formed directly on the
23 substrate.
24
- 24 4. Apparatus according to claim 2 and wherein
25 said dichroic coating is formed directly on the
26 substrate.
27
- 28 5. Apparatus according to claim 1 and wherein
29 said dichroic coating is formed on a coating substrate
30 which is in turn associated with the substrate.
31
- 32 6. Apparatus according to claim 2 and wherein
33 said dichroic coating is formed on a coating substrate
34 which is in turn associated with the substrate.
35
- 36 7. An automobile comprising:
37 a windshield;
38 a dichroic coating associated with said

1 windshield; and

2 a solid state image generator operatively
3 associated with the windshield and the dichroic
4 coating, such that the image generated by the solid
5 state image generator in a given wavelength range is
6 reflected from the windshield to an observer while
7 light of wavelengths outside of the given wavelength
8 range passes through the windshield to the observer.

9

10 8. Apparatus according to claim 1 and wherein no
11 optical elements are interposed between said image
12 generator and said coating, thereby providing a wide
13 exit pupil.

14

15 9. Apparatus according to claim 2 and wherein no
16 optical elements are interposed between said image
17 generator and said coating, thereby providing a wide
18 exit pupil.

19

20 10. Apparatus according to claim 7 and wherein no
21 optical elements are interposed between said image
22 generator and said coating, thereby providing a wide
23 exit pupil.

24

25 11. Apparatus according to claim 1 and wherein
26 the arrangement of the image generator and the coating
27 is such that the resulting exit pupil is effectively
28 limited only by the area of the substrate that is
29 coated by said coating.

30

31 12. Apparatus according to claim 2 and wherein
32 the arrangement of the image generator and the coating
33 is such that the resulting exit pupil is effectively
34 limited only by the area of the substrate that is
35 coated by said coating.

36

37 13. Apparatus according to claim 7 and wherein
38 the arrangement of the image generator and the coating

1 is such that the resulting exit pupil is effectively
2 limited only by the area of the substrate that is
3 coated by said coating.

4

5 14. Apparatus according to claim 1 and wherein
6 the displayed image appears to an observer as being
7 located at infinity.

8

9 15. Apparatus according to claim 2 and wherein
10 the displayed image appears to an observer as being
11 located at infinity.

12

13 16. Apparatus according to claim 7 and wherein
14 the displayed image appears to an observer as being
15 located at infinity.

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FIG.1

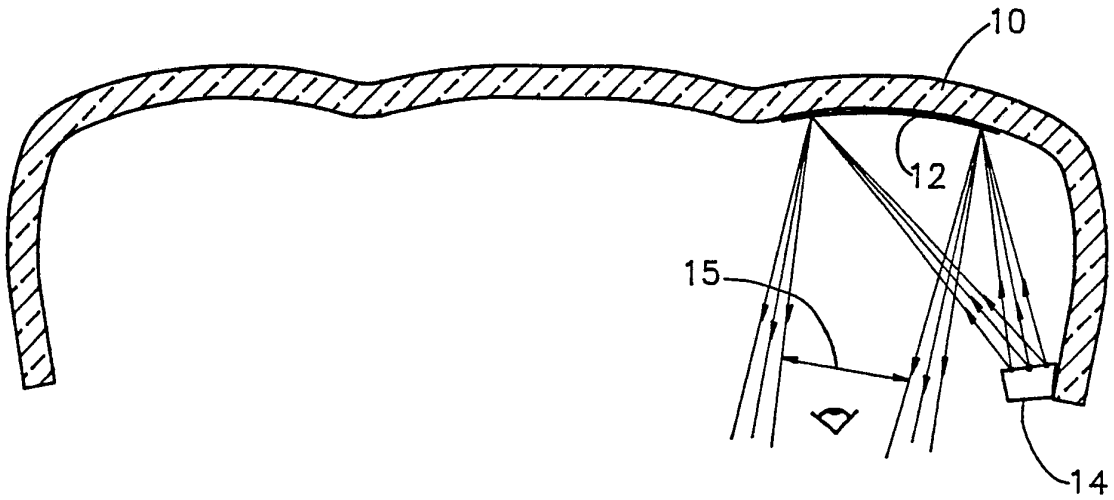
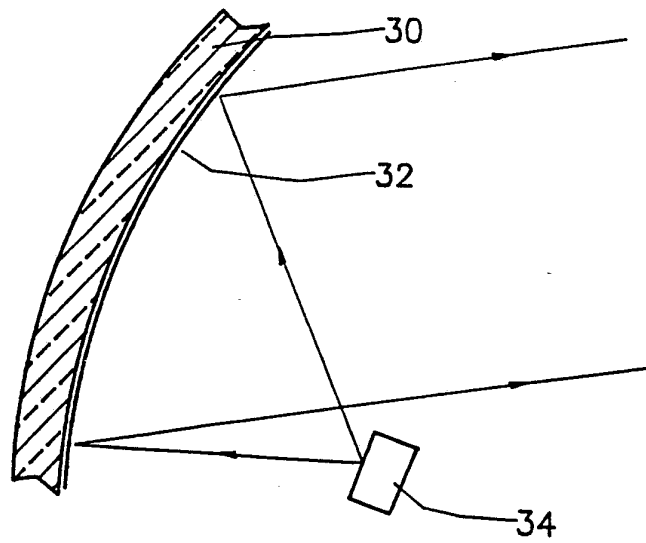
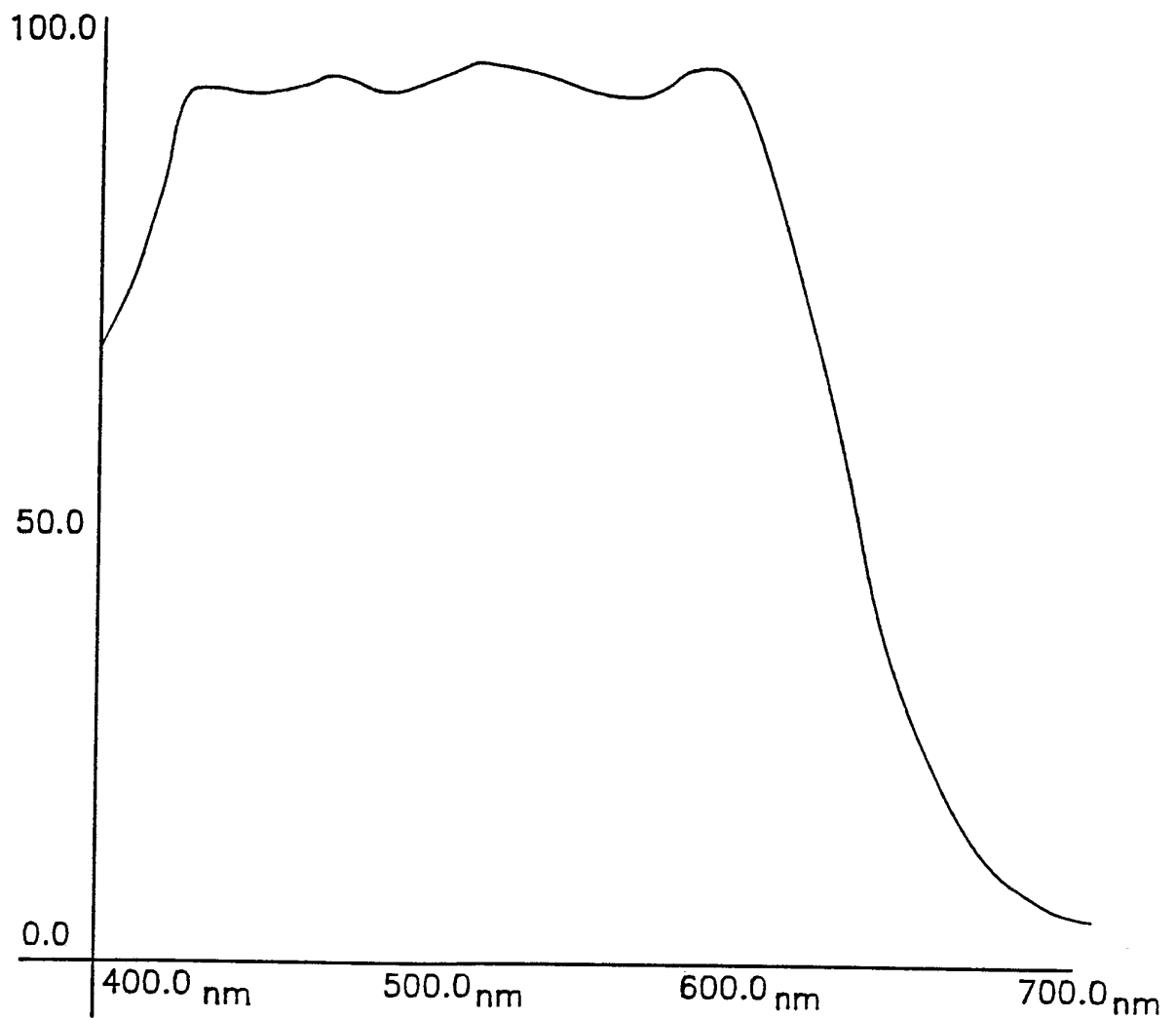


FIG.3



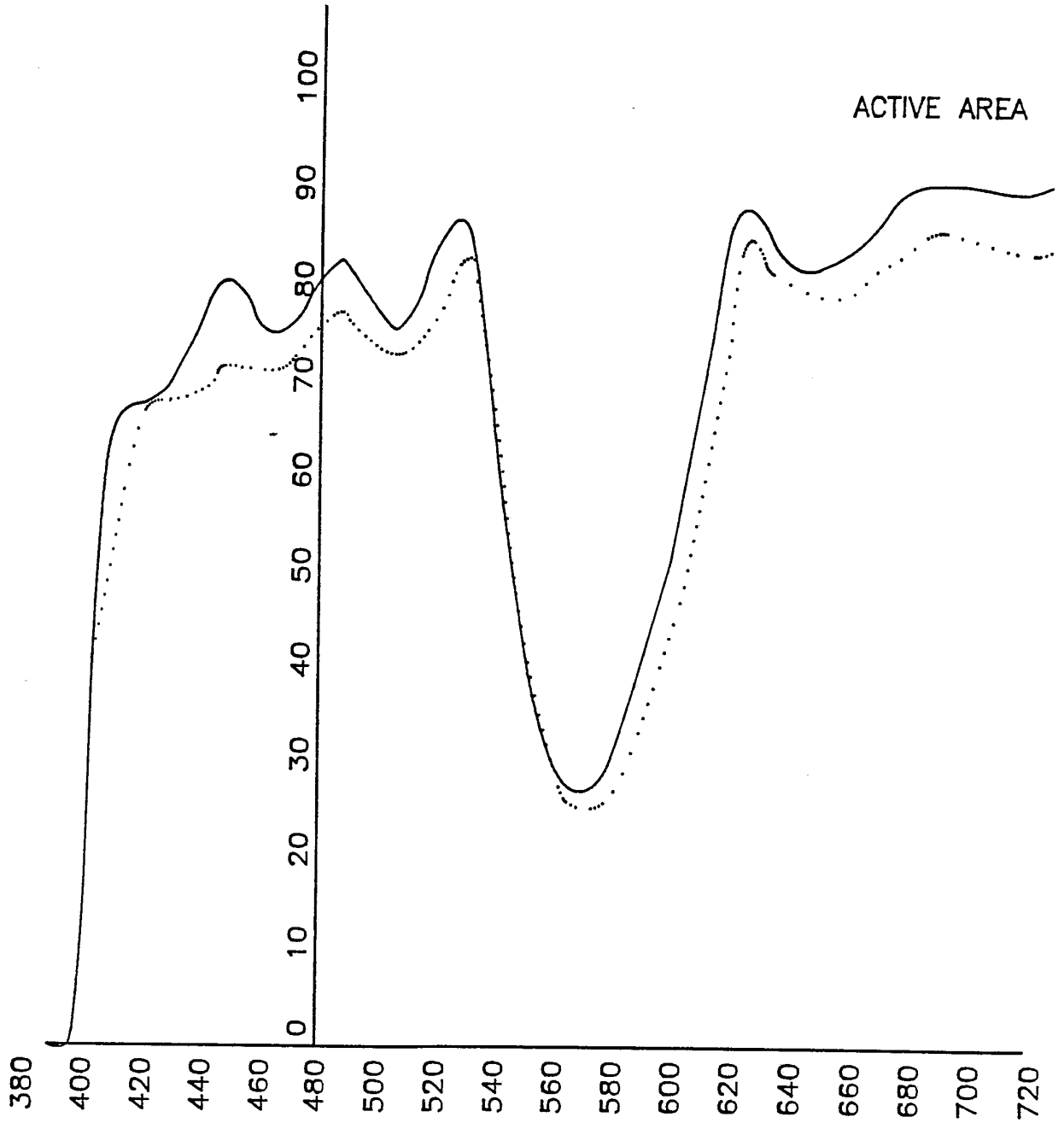
2/4



DATA MODE : (1) %T
BAND WIDTH : 0.50nm
 λ SET : 700.0 ~ 400.0nm
 λ SCALE : 20nm/cm
%T ABS SCALE : 0.0 ~ 100.0 %T

FIG.2A

3/4



MATERIAL : POLYCARBONATE
INSTRUMENT : PERKIN ELMER 330
SCALE Y : 0 ~ 100 % T
SCALE X : 20nm/cm

FIG.2B

4/4

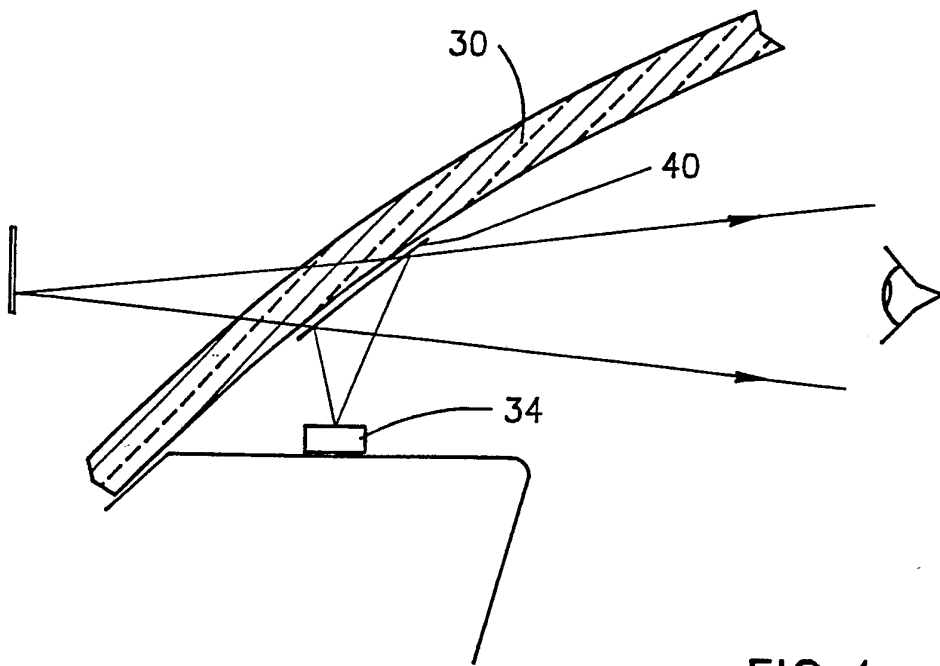


FIG.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/02708

A. CLASSIFICATION OF SUBJECT MATTER
 IPC(5) :G02B 27/14, 5/26, 1/10
 US CL :359/631,630,634
 According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
 Minimum documentation searched (classification system followed by classification symbols)
 U.S. : 359/631,630,634 359/629,633

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|---------------------------------------|
| X Y | EP,A, 329,110 Roberts 23 August 1989 (See Entire Document) | <u>1,3-8,10,11,13</u> 2,9,12,14-16 |
| Y | US,A, 3,887,273 Griffiths 03 June 1975 (See Entire Document) | 2,9,12,14-16 |
| X | US,A, 4,990,899 Gerlitz et al 05 February 1991 (See Entire Document) | 1-4,7-16 |
| A | US,A, 5,066,102 Hirano 19 November 1991 (See Entire Document) | 1-16 |
| A | US,A, 3,899,241 Malobicky, Jr. et al 12 August 1975 (See Entire Document) | 1-16 |

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