(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 August 2004 (12.08.2004)

PCT

(10) International Publication Number
WO 2004/068200 A1

(51) International Patent Classification[7]: G02B 5/30, 5/04, 27/28, H04N 9/31

(21) International Application Number: PCT/IB2004/050018

(22) International Filing Date: 14 January 2004 (14.01.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
03100165.4 28 January 2003 (28.01.2003) EP

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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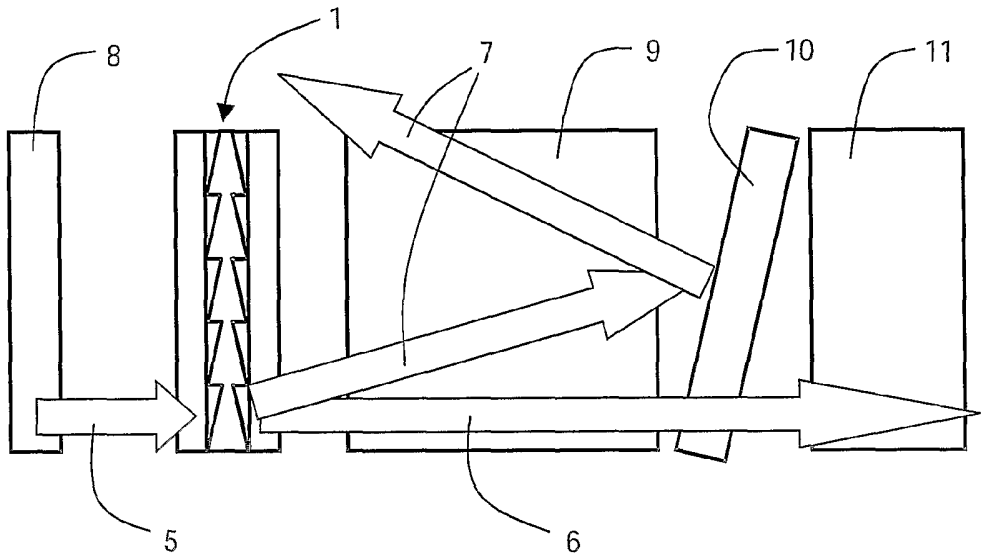
(54) Title: ANALYZERS FOR TRANSMISSIVE LCD-BASED PROJECTORS



(57) Abstract: The present invention relates to an imaging optical system for transmissive LCD projection-type video image display devices comprising analyzers (1, 10) as well as to a method for arranging such analyzers (1, 10) in such an imaging optical system. The imaging optical system comprises a light source for emitting illumination light, a transmissive liquid crystal light valve (8), a refractive analyzer device (1) arranged to pass light (6) of a first polarization mode in an imaging path and cause an angular deviation of light (7) of a second polarization mode with respect to said imaging path. The imaging system further comprises a reflective analyzer device (1) along said imaging path, and arranged to pass light (6) of the first polarization mode in said imaging path and reflect deviated light (7) of the second polarization mode out of said imaging path.

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Declaration under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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Analyzers for transmissive LCD-based projectors

FIELD OF THE INVENTION

The present invention relates to the field of analyzers for transmissive type LCD projection-type video image display devices, and particularly to an imaging optical system for a projection-type video image display device comprising such analyzers, as well as to a method of arranging such analyzers in the imaging optical system of a projection-type video image display device.

BACKGROUND OF THE INVENTION

Today, many transmissive LCD projection-type video image display devices produce limited brightness and have a limited lifetime. One limiting factor has been the use of absorptive analyzers, which are required to absorb large amounts of light when filtering out light of unwanted polarization. This has led, among other things, to undesired thermal effects, which have had a negative impact on the lifetime of the devices.

One prior-art approach is disclosed in JP 11 295 660, which proposes to enhance reliability against heat generated around a light valve in a transmission projection picture display constituted by the light valve utilizing polarized light. This projection picture display is constituted in such a way that a picture is displayed by regulating random light emitted from a light source to unidirectional polarized light by an incident-side polarizing plate, controlling the polarizing direction thereof for each pixel by the light valve and transmitting the polarized light only in one direction of polarization by an emitting-side polarizing plate, enlarged and projected by a projection lens. Since the emitting-side polarizing plate is a reflection polarizing plate and inclined with respect to the surface of the light valve, heat is suppressed from being generated near the light valve and the emitting-side polarizing plate. Thus, a deterioration of reliability is suppressed.

However, this prior-art approach has limitations in its ability to provide a compact design and short back focal length of the projection lens, which will make a projector utilizing this approach fairly large and expensive.

OBJECT AND SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved imaging optical system for a projection-type video image display device.

This object is achieved by providing an imaging optical system comprising a refractive analyzer device arranged to pass light of a first polarization mode in an imaging path and cause an angular deviation of light of a second polarization mode with respect to said imaging path, a reflective analyzer device, arranged at a separation distance from said refractive analyzer device along said imaging path, and arranged to pass light of the first polarization mode in said imaging path and reflect deviated light of the second polarization mode out of said imaging path.

Thanks to the provision of the refractive analyzer device before the reflective analyzer device, the separation distance required to deviate unwanted light out of said imaging path can be kept low, thereby enabling a compact design where the back focal length of an associated projection lens can be kept short, whereby the production costs of projection-type video image display devices can be reduced.

Another object of the invention is to provide an improved method for configuring such analyzers in projection-type video image display devices.

This object is achieved by a method comprising the steps of: providing a refractive analyzer device arranged to pass light of a first polarization mode in an imaging path and cause an angular deviation of light of a second polarization mode with respect to said imaging path; providing a reflective analyzer device at a separation distance from said refractive analyzer device along said imaging path, said reflective analyzer being arranged to pass light of the first polarization mode in said imaging path and reflect deviated light of the second polarization mode out of said imaging path.

Still other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims. It should be further understood that the drawings are not necessarily drawn to scale and that, unless otherwise indicated, they are merely intended to conceptually illustrate the structures and procedures described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like reference characters denote similar elements throughout the several views:

Fig. 1 is a schematic view of a refractive analyzer;

Fig. 2 is a schematic view of a stacked refractive analyzer according to Figure 1;

Fig. 3 is a schematic view of a first embodiment of an analyzer configuration for a projection-type video image display device;

Fig. 4 is a schematic view of a second embodiment of an analyzer configuration for a projection-type video image display device.

DESCRIPTION OF EMBODIMENTS

Fig. 1 is a schematic view showing a basic constitution of a refractive analyzer 1. A uniaxially oriented birefringent layer 2 is sandwiched between two transparent carrier substrates 3. Each substrate 3 has a fine-pitch "sawtooth" structure 4, deposited on their respective inner surfaces. The fine pitch "saw-tooth" structure 4 is preferably made of layers of polyimide plastic (PI). An incident light beam 5 containing p and s-polarized light is shown falling on the refractive analyzer 1. The material properties are selected in such a way that the first polarization mode, e.g. the p-polarized light beam 6, does not observe a large variation of refractive indices, and as such observes the refractive analyzer as a plane-parallel plate, and is thus passed on along an imaging path. The second polarization direction, e.g. the s-polarized light 7, however, observes a large difference in refractive indices between the materials and is refracted in the interfaces, such that its direction of propagation is changed as the beam passes the refractive analyzer 1, causing an angular deviation with respect to the imaging path. As this refractive analyzer 1 is intended to be arranged in the imaging optical system of a projection-type video image display device, the optical demands imposed on imaging properties are very stringent. However, the differences in refractive indices are usually limited, such that the deviation from the propagation direction is usually limited, and thus use of one such refractive analyzer alone in the optical path of a projection-type video image display device is usually insufficient to provide a change of direction of the second polarization direction, which is sufficient to cause this second polarization direction to be diverted outside the imaging path.

Fig. 2 shows a solution for providing an increased change of direction of the second polarization light 7. This is achieved by stacking two or more of the refractive analyzers 1 in accordance with Figure 1. In this way, an increased degree of angular splitting can be achieved. The incident lightbeam 5, containing p and s-polarized light falls on the stack of refractive analyzers 1 and the unwanted second polarization direction, e.g. the s-polarized light beam 7, is deviated stepwise by each layer thereof. The wanted first polarization mode, e.g. the p-polarized light beam 6, passes straight through the refractive analyzer 1.

Fig. 3 illustrates a first embodiment of a possible analyzer configuration shown in a simplified light path of a projection-type video image display device. The shown light path comprises a liquid crystal (LCD) light valve 8, a refractive analyzer 1 in accordance with Figure 1, a dichroic prism 9, a reflective analyzer 10 and a projection lens 11. In accordance with this configuration, the refractive analyzer 1 is used in combination with a reflective analyzer 10, e.g. a so-called Moxtek® plate. The refractive analyzer 1 and the reflective analyzer 10 are positioned at such a separation distance from each other that the dichroic recombination prism 9 fits in between them. An incident light beam 5 containing p and s-polarized light from the LCD light valve 8 falls on the refractive analyzer 1. In this configuration, the unwanted second polarization mode, e.g. the s-polarization direction, illustrated by arrows 7, can travel over a larger distance to become separated from the wanted first polarization mode, e.g. the p-polarized light beam, illustrated by arrow 6. The wanted first polarization mode (p-polarized) light beam 6 passes through the projection lens 11 to be incident on a screen (not shown) while the unwanted second polarization mode (s-polarized) light beam is reflected out of the imaging path. Through this configuration, the required angular deviation introduced by the refractive analyzer 1 for diverting the unwanted light out of the main light path is reduced, whereby the number of layers of the refractive analyzer 1 can be reduced, preferably to one single layer in accordance with Figure 1. However, if required, it is possible to employ a stack of refractive analyzers 1, in accordance with Figure 2, in the first embodiment according to Figure 3.

Fig. 4 shows a second embodiment essentially corresponding to the Figure 3 embodiment but with the difference that the reflective analyzer 10 is arranged at an angle relative to the imaging path, whereby the deviation of the unwanted beam 7 can be further increased.

A method for arranging analyzers in the imaging optical system of a projection-type video image display device will be described hereinafter. The method comprises the steps of: providing a refractive analyzer device arranged to pass light of a first

polarization mode (e.g. p-polarized light) in an imaging path and cause an angular deviation of light of a second polarization mode (e.g. s-polarized light) with respect to the imaging path; providing a reflective analyzer device at a separation distance from said refractive analyzer device along said imaging path, said reflective analyzer being arranged to pass light of the first polarization mode in the imaging path and reflect deviated light of the second polarization mode out of said imaging path.

In a further embodiment, the method further comprises the step of providing a dichroic prism in said imaging path between said refractive analyzer and said reflective analyzer, thus providing said separation distance.

In a further embodiment, the method comprises the step of providing a refractive analyzer which comprises at least one uniaxially oriented birefringent layer, where each respective birefringent layer is sandwiched between two transparent carrier substrates, each of which has a fine-pitch sawtooth structure deposited on their respective sides facing one of said birefringent layers.

In a still further embodiment, the method comprises the step of providing a refractive analyzer which comprises two or more uniaxially oriented birefringent layers.

Thus, while there have been shown and described and pointed out fundamental novel features of the invention as applied to a preferred embodiment thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Moreover, it should be recognized that structures and/or elements and/or method steps shown and/or described in connection with any disclosed form or embodiment of the invention may be incorporated in any other disclosed or described or suggested form or embodiment as a general matter of design choice. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.

CLAIMS:

1. An imaging optical system for a projection-type video image display device comprising: a light source for emitting illumination light, a transmissive liquid crystal light valve (8), a refractive analyzer device (1) arranged to pass light (6) of a first polarization mode in an imaging path and cause an angular deviation of light (7) of a second polarization mode with respect to said imaging path, a reflective analyzer device (10), arranged at a separation distance from said refractive analyzer device (1) along said imaging path, and arranged to pass light (6) of the first polarization mode in said imaging path and reflect deviated light (7) of the second polarization mode out of said imaging path.

2. The imaging optical system of claim 1, further comprising a dichroic prism (9) arranged in said imaging path between said refractive analyzer (1) and said reflective analyzer (10) providing said separation distance.

3. The imaging optical system of claim 1, wherein said refractive analyzer (1) comprises at least one uniaxially oriented birefringent layer (2), where each respective birefringent layer (2) is sandwiched between two transparent carrier substrates (3), each of which has a fine-pitch sawtooth structure (4) deposited on their respective sides facing one of said birefringent layers (2).

4. The imaging optical system of claim 3, wherein said refractive analyzer (1) comprises two or more uniaxially oriented birefringent layers (2).

5. A projection-type video image display device comprising the imaging optical system of any one of claims 1 to 4.

6. A method for arranging analyzers in the imaging optical system of a projection-type video image display device, wherein said method comprises the steps of:

providing a refractive analyzer device arranged to pass light of a first polarization mode in an imaging path and cause an angular deviation of light of a second polarization mode with respect to said imaging path;

providing a reflective analyzer device at a separation distance from said refractive analyzer device along said imaging path, said reflective analyzer being arranged to pass light of the first polarization mode in said imaging path and reflect deviated light of the second polarization mode out of said imaging path.

7. The method of claim 6, further comprising the step of providing a dichroic prism in said imaging path between said refractive analyzer and said reflective analyzer, thus providing said separation distance.

8. The method of claim 6, further comprising the step of providing a refractive analyzer which comprises at least one uniaxially oriented birefringent layer, where each respective birefringent layer is sandwiched between two transparent carrier substrates, each of which has a fine-pitch sawtooth structure deposited on their respective sides facing one of said birefringent layers.

9. The method of claim 8, further comprising the step of providing a refractive analyzer which comprises two or more uniaxially oriented birefringent layers.

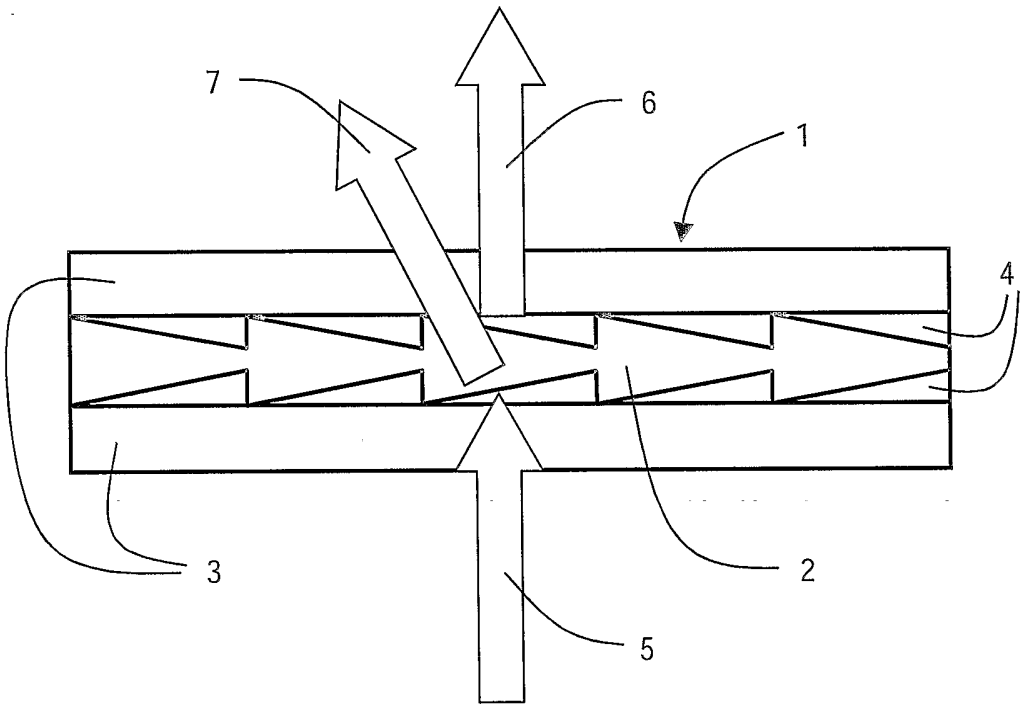

FIG.1

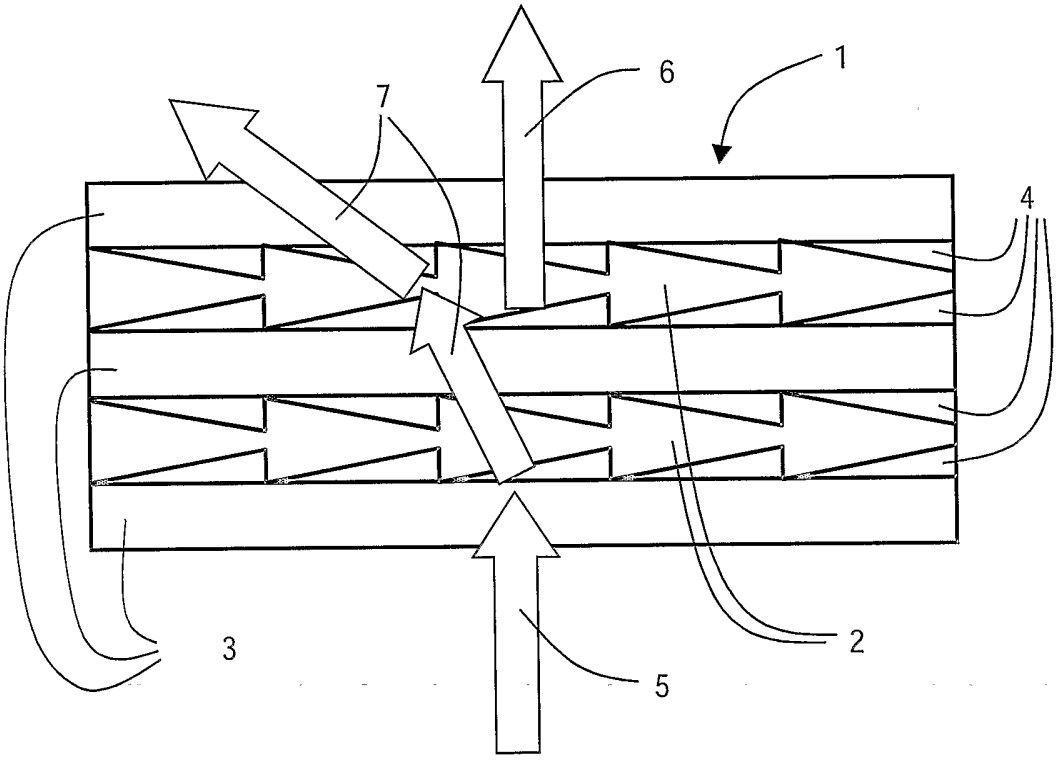

FIG.2

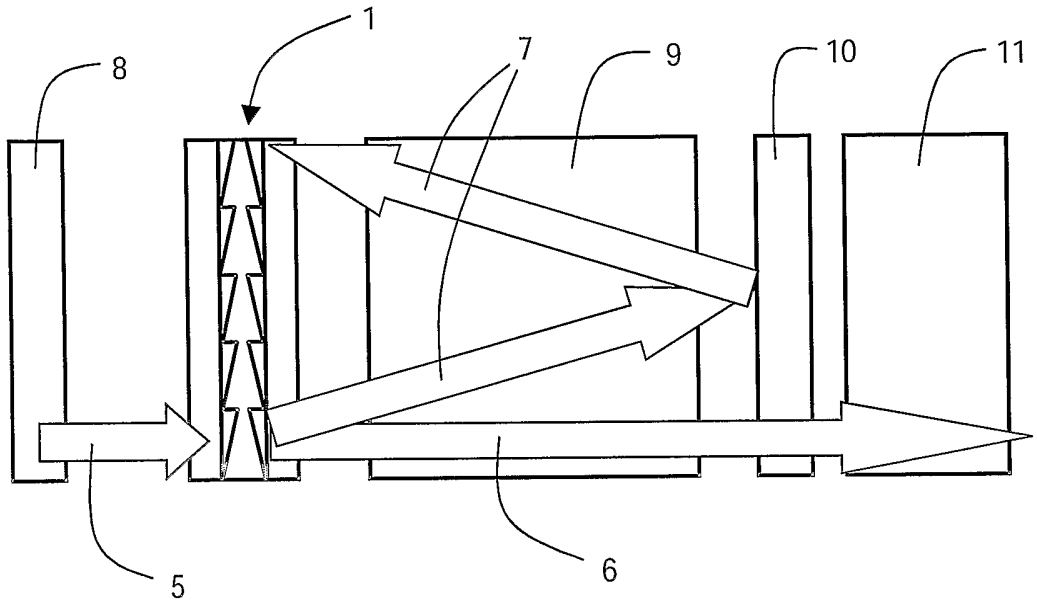

FIG.3

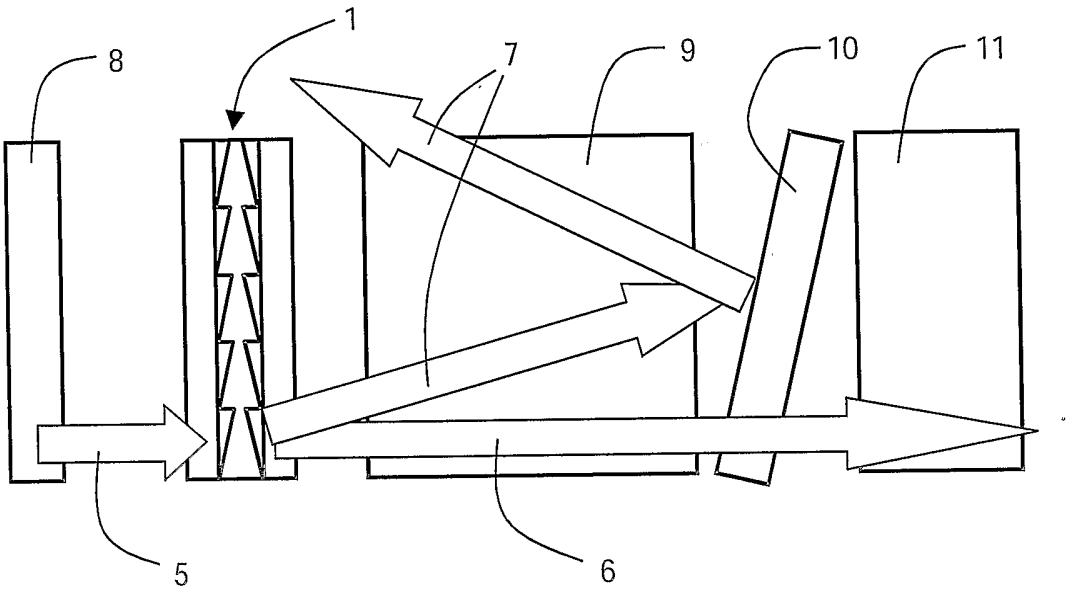

FIG.4

INTERNATIONAL SEARCH REPORT

In onal Application No
PCT/IB2004/050018

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B5/30 G02B5/04 G02B27/28 H04N9/31

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)
IPC 7 G02B H04N

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 1 180 711 A (SEIKO EPSON CORP) 20 February 2002 (2002-02-20) paragraphs '0087!,'0097!-'0105! figures 7A,7B,8	1,2,6,7 3-5,8,9
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 01, 31 January 2000 (2000-01-31) & JP 11 295660 A (MATSUSHITA ELECTRIC IND CO LTD), 29 October 1999 (1999-10-29) cited in the application abstract	1-9
A	US 5 900 977 A (HIKMET RIFAT A M) 4 May 1999 (1999-05-04) column 7, line 45 -column 8, line 17 figure 2B	1,3-6,8, 9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
25 May 2004	04/06/2004

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

tional Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 914 811 A (LIU SHANGQUIQ ET AL) 22 June 1999 (1999-06-22) column 5, line 42 -column 6, line 2 figure 3	3,4,8,9

INTERNATIONAL SEARCH REPORT

Ir tional Application No
PCT/IB2004/050018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1180711 A	20-02-2002	EP 1180711 A1	20-02-2002
		US 2003071972 A1	17-04-2003
		CN 1363052 T	07-08-2002
		WO 0155778 A1	02-08-2001
		JP 2001281615 A	10-10-2001
		TW 528887 B	21-04-2003
		TW 528888 B	21-04-2003
		US 2003179345 A1	25-09-2003
JP 11295660 A	29-10-1999	NONE	
US 5900977 A	04-05-1999	CN 1161086 A ,B	01-10-1997
		DE 69630101 D1	30-10-2003
		EP 0778956 A1	18-06-1997
		WO 9701779 A1	16-01-1997
		JP 10505435 T	26-05-1998
US 5914811 A	22-06-1999	NONE	