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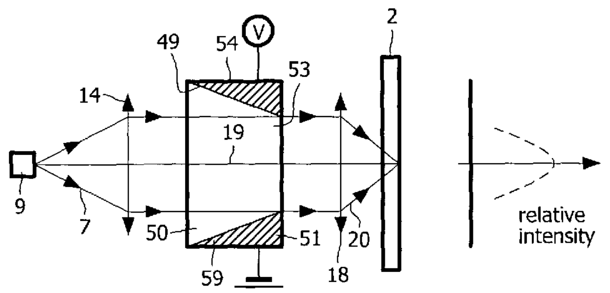
(54) Title: OPTICAL SCANNING DEVICE



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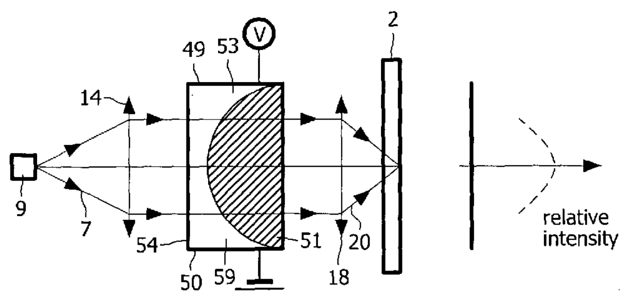

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(57) Abstract: An optical scanning device (1) is described for reading information from and writing information to an optical record carrier (2) such as a CD or a DVD. The device has two modes, a reading mode and a writing mode and can be electrically switched between the two modes in order to provide a system where the optimum parameters of the optics are utilized for reading and writing. The writing mode requires maximum coupling efficiency between incident radiation (12) and the record carrier (2) and low rim intensity of the radiation beam. The reading mode requires maximum rim intensity but low incident radiation power. Accordingly, a cell is positioned on the optical path of the system, the cell (49) containing a fluid (51) that can be moved into and out of the optical path of the radiation to alter the characteristics of the incident radiation accordingly.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Optical scanning device

FIELD OF THE INVENTION

The present invention relates to an optical scanning device for scanning an optical record carrier. More specifically, but not exclusively, it relates to an optical scanning device capable of reading information from and writing information to an information layer on the optical record carrier.

BACKGROUND OF THE INVENTION

In optical storage, a radiation beam is incident on an information layer on the optical record carrier. Reading and writing information to and from the information layer place different requirements on the radiation spot used to scan the optical record carrier. Such optical record carriers can include Compact Discs (CDs) and Digital Versatile Discs (DVDs).

When reading information from the optical record carrier, the radiation spot size determines the mark size that is readable. It is therefore desirable that the spot size is small, so as to allow the reading of small mark sizes on optical record carriers having a high information density. Furthermore, the smaller the spot size, the less likelihood of crosstalk.

In order to obtain the small spot size required for reading information from the record carrier, it is desirable that the intensity distribution of the optical beam incident on the lens system within the optical scanning device is relatively flat. In other words, for reading it is desirable that the radiation beam has a high rim intensity. (The rim intensity is the relative intensity of the beam at the edge of the entrance pupil of the objective lens system compared to the intensity along the optical axis.) This high rim intensity results in a low coupling efficiency.

When writing information to a carrier, the radiation spot size is less critical. However, it is desirable that the optical path from the radiation source to the information carrier is efficient (i.e. low loss). This reduces the power consumption of the radiation source, a factor that is particularly important for small, portable applications. Additionally, as the radiation sources are typically lasers, the lifetime of the laser can be extended if the light path between the laser and the record carrier is efficient as it is possible to operate the laser at lower drive currents to generate the required radiation intensity incident on the record carrier.

In writing mode, it is mainly the central part of the radiation spot that is used. This central part of the beam has the highest intensity and therefore produces the highest temperature incident on the record carrier. Accordingly, to have the maximum radiation power incident on the record carrier, the rim intensity must be low (typically 60-70% of the central peak intensity) in order to achieve the required coupling efficiency.

From the above, it can be seen that writing and reading information to and from the information layer in an optical record carrier requires different values for the rim intensity. As a result, in a system designed to both read and write information from and to the information layer of the record carrier, the rim intensity of the radiation beam is generally a compromise. In other words, a rim intensity is chosen that is generally not optimum for reading or writing.

Accordingly, it would be desirable for the optical scanning device to be capable of switching between a low rim intensity situation when writing information to the optical record carrier, to a high rim intensity situation when reading information from the optical record carrier.

JP2000356792 discloses an optical element capable of controlling the quantity of radiation transmitted in an optical system. However, only the quantity of the radiation transmitted can be changed using the optical element disclosed.

It is an aim of embodiments of the present invention to provide and optical scanning system suitable for addressing the above-mentioned problems.

SUMMARY OF THE INVENTION

According to the invention there is provided an optical scanning device for an optical record carrier, said device including a radiation source for generating a radiation beam to be scanned across the record carrier and optical elements for directing the beam to form a spot on a layer for carrying information on the optical record carrier, said optical elements including a cell comprising at least two immiscible fluids having different transmission characteristics, a first fluid being controllably moveable into and out of the optical path of the radiation beam such that the intensity of the radiation beam is controllably changed from a first configuration, suitable for writing information to the information layer on the optical record carrier, to a second configuration suitable for reading information from the information layer on the optical record carrier.

Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a typical optical scanning system suitable for incorporating a rim intensity switch in accordance with one form of the invention;

Figure 2a is a schematic diagram showing a rim intensity switch in situation in a simplified light path optimized for writing information to an information layer on an optical record carrier, in accordance with one form of the invention; and

Figure 2b is a schematic diagram showing a rim intensity switch in situation in a simplified light path optimized for reading information from an information layer on an optical record carrier, in accordance with one form of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows elements of an optical scanning device, arranged in accordance with an embodiment of the invention, including an optical head for scanning an optical record carrier 2. The record carrier is in the form of an optical disk comprising a transparent layer 3, on one side of which an information layer 4 is arranged. The side of the information layer facing away from the transparent layer is protected from environmental influences by a protection layer 5. The side of the transparent layer facing the device is called the entrance face 6. The transparent layer 3 acts as a substrate for the record carrier by providing mechanical support for the information layer. Alternatively, the transparent layer may have the sole function of protecting the information layer, while the mechanical support is provided by a layer on the other side of the information layer, for instance by the protection layer 5 or by a further information layer and a transparent layer connected to the information layer 4. Information may be stored in the information layer 4 of the record carrier in the form of optically detectable marks arranged in substantially parallel, concentric or spiral tracks, not indicated in Figure 1. The marks may be in any optically readable form, e.g. in the form of pits, or areas with a reflection coefficient or a direction of magnetisation different from their surroundings, or a combination of these forms.

The scanning device 1 comprises a radiation source in the form of a semiconductor laser 9 emitting a radiation beam 7. The radiation beam is used for scanning the information layer 4 of the optical record carrier 2. A beam splitter 13 reflects the diverging radiation beam 12 on the optical path towards a collimator lens 14, which converts the diverging beam 12 into a collimated beam 15. The collimated beam 15 is incident on a transparent electro-optical element 49, which modifies the wavefront of the collimated beam. The beam 17 from the electro-optical element 49 is incident on an objective system 18. The objective system may comprise one or more lenses and/or a grating. The objective system 18 has an optical axis 19. The objective system 18 changes the beam 17 to a converging beam 20 incident on the entrance face 6 of the record carrier 2. The objective system has a spherical aberration correction characteristic adapted for passage of the radiation beam through the thickness of the transparent layer 3. The converging beam 20 forms a spot 21 on the information layer 4.

Radiation reflected by the information layer 4 forms a diverging beam 22, transformed into a substantially collimated beam 23 by the objective system 18 and subsequently into a converging beam 24 by the collimator lens 14. The beam splitter 13 separates the forward and reflected beams by transmitting at least part of the converging beam 24 towards a detection system 25. The detection system captures the radiation and converts it into electrical output signals 26 which are processed by signal processing circuits 27, 29 and 31 which are located in the scanning device separately from the optical head 1. A signal processor 27 converts these output signals to various other signals.

One of the signals is an information signal 28, the value of which represents information read from the information layer 4. The information signal is processed by an information processing unit for error correction 29. Other signals from the signal processor 27 are the focus error signal and radial error signal 30. The focus error signal represents the axial different in height between the spot 21 and the information layer 4. The radial error signal represents the distance in the plane of the information layer 4 between the spot 21 and the centre of a track in the information layer to be followed by the spot.

The focus error signal and the radial error signal are fed into a servo circuit 31, which converts these signals to a focus error signal for controlling a mechanical focus actuator (not shown) in the optical head and a tracking error signal 32 for controlling the electro-optical element 16, respectively. The mechanical focus actuator controls the position of the objective system 18 in the focus direction 33, thereby controlling the actual position of the spot 21 such that it coincides substantially with the plane of the information layer 4. A further mechanical actuator, such as a radially movable arm, alters the position of the optical head 1 in a radial direction 34 of the disk 2, thereby coarsely controlling the radial position of the spot 21 to lie above a track to be followed in the information layer 4. The tracks in the record carrier 2 run in a direction perpendicular to the plane of Figure 1.

Figures 2a and 2b show an electrowetting cell 49 comprising two immiscible liquids 50, 51 contained within a cavity 53. The cavity 53 is formed from a cylinder 54 of conductive material coated with a layer of insulating material 55. The inner side of the cylinder is provided with a fluid contact layer 56. The conductive cylinder 54 forms a common first electrode for the immiscible liquids 50, 51. The second electrode 57 comprises an annular conductive layer 58 having a central transparent area for passing radiation. It may also be a transparent conducting layer (such as ITO) of any shape.

The first immiscible liquid 50 has a refractive index n1 and the second immiscible liquid 51 has a refractive index n2, where n1 and n2 are substantially equal. For example, liquid 50 may be water (n1=1.349) and liquid 51 may be an oil such as polydimethyl(8-12%)-phenylmethylsiloxame copolymer (n2=1.425). Alternatively, liquid 50 may be an oil and liquid 51 may be water. It will also be appreciated that the cell need not contain immiscible liquids but any immiscible fluids capable of performing similar functions may be used. Furthermore, liquids other than oils and water performing the same function may be considered.

A surface 59 between the immiscible liquids will form and can be controlled by application of a voltage to the cylinder 54. It will be appreciated that the level of voltage required to control the surface between the liquids will depend on the two liquids 50, 51 chosen. The shape and curvature of the surface 59 can be changed using controllable voltage sources (not shown).

Figures 2a and 2b show two desirable configurations for the surface formed between the two immiscible liquids 50, 51. In Figure 2a, the voltage is applied to the cylinder 54 such that the second immiscible liquid is removed from the optical path of the radiation emitted by the radiation source and transmitted through the objective lens system and incident on the optical record carrier 2. Figure 2a is a schematic diagram of the system in the optimum mode for writing information to the information layer 4. That is to say the light efficiency of the radiation source 9 is high but the corresponding rim intensity is low. As in writing mode maximum coupling efficiency is required, the electrowetting cell 49 must not lead to significant transmission losses. Accordingly, the voltage applied to the conductive cylinder 54 acts so as to remove the low transmission liquid 51 from the optical path. In this way only the high transmission liquid 50 is in the optical path of the radiation 7 emitted by the radiation source 9 and incident on the lens system in the optical scanning device. Additionally, in this configuration, the rim intensity of the radiation beam 7 is unaltered.

Figure 2b shows the system in the optimum mode for reading information from the information layer 4 of the optical record carrier 2. For optimum reading from an information layer on a record carrier 2, a relatively lower radiation beam power is required, whilst the rim intensity of the beam should be preferably higher. A voltage applied to the conductive cylinder 54 causes a meniscus 59 to form between the liquids 50, 51 in the optical path of the optical scanning system. As can be seen from Figure 2b, the liquid with low transmission properties is now interposed between the radiation source 9 and the optical record carrier 2. In this way, radiation incident on the electrowetting cell 49 must now be transmitted through the low transmission liquid 51. Furthermore, the thickness of the low transmission liquid 51 is greater at the optical axis (i.e. the centre of the radiation beam 7) and as a result, the centre intensity of the radiation beam 7 will be more significantly reduced in comparison with the rim intensity of the radiation beam. As a result, the rim intensity of the radiation beam will increase at the expense of a lower overall transmission. Accordingly, in reading mode more radiation source power is required when the low transmission liquid is present in the optical path than in the writing mode, as per Figure 2a. Advantageously, a higher laser power gives rise to a lower laser noise, so this additional requirement is acceptable.

It will be appreciated that a difference of $\pm$ 0.02 in transmissity of the liquids 50, 51 is acceptable, and variations of up to $\pm$ 0.05 will provide the same effect. Furthermore, the shape of the meniscus 60 is not critical. The meniscus shown in the diagrams is indicative only. Other shapes of meniscus achieved by varying the voltage applied to the conductive cylinder may be considered.

It will also be appreciated that changing the liquids 50, 51 in the electrowetting cell 49 enables other characteristics of the overall transmissivity of the optical scanning device to be altered. Furthermore, changing the position and application of the voltage to the electrowetting cell will change to shape of the meniscus between the liquids 50, 51 which may again change the transmission properties of the optical scanning device.

It will further be appreciated that more than two immiscible liquids may be contained within the electrowetting cell 49 in order to further control the transmission characteristics of the radiation incident on the information layer of the optical record carrier.

Although the foregoing refers to laser radiation, it will be appreciated that any suitable form of electromagnetic radiation may be used and the invention is not limited to visible radiation.

Additionally, although at present this technology is most applicable to CD and DVD technology it may be equally applicable to future developing technologies and as such is not limited to CD and DVD applications.

The above embodiments are to be understood as illustrative examples of the invention. Further embodiments of the invention are envisaged. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

CLAIMS:

1. An optical scanning device for an optical record carrier, said device including a radiation source for generating a radiation beam to be scanned across the record carrier and optical elements for directing the beam to form a spot on a layer for carrying information on the optical record carrier, said optical elements including a cell comprising at least two immiscible fluids having different transmission characteristics, a first fluid being controllably moveable into and out of the optical path of the radiation beam such that the intensity of the radiation beam is controllably changed from a first configuration, suitable for writing information to the information layer on the optical record carrier, to a second configuration suitable for reading information from the information layer on the optical record carrier.

2. An optical scanning device according to claim 1, in which the rim intensity of the radiation beam in the first configuration is relatively low and the rim intensity of the radiation beam in the second configuration is relatively high.

3. An optical scanning device according to claim 1 or 2, in which a surface is formed between the first fluid and at least one other fluid in the second configuration, said surface taking the form of a meniscus, thereby providing a variable thickness of first fluid across the optical path of the radiation beam incident on the optical element, such that the rim intensity of the radiation beam varies depending on the switching state of the optical element 49.

4. An optical scanning device according to claim 3, in which the presence of the first liquid in the optical path of the radiation beam is controlled by application of a voltage to the cell, such that the first liquid can be electrically disposed between the radiation source and the optical record carrier.

5. An optical scanning device according claim 3 or 4, in which the shape of the meniscus is controlled by application of a voltage to the cell, thereby controlling the rim intensity of the radiation beam in the second configuration.

6. An optical scanning device according to any preceding claim, in which the indices of refraction of the immiscible fluids in the cell do not vary by more than ±0.05.

7. An optical scanning device according to any preceding claim in which the fluids include oil, water or air.

8. An optical scanning device according to any preceding claim in which the optical scanning device forms the optical pick up of a CD, a re-writable CD, a DVD, a re-writable DVD or a Blu-ray Disc recording system.

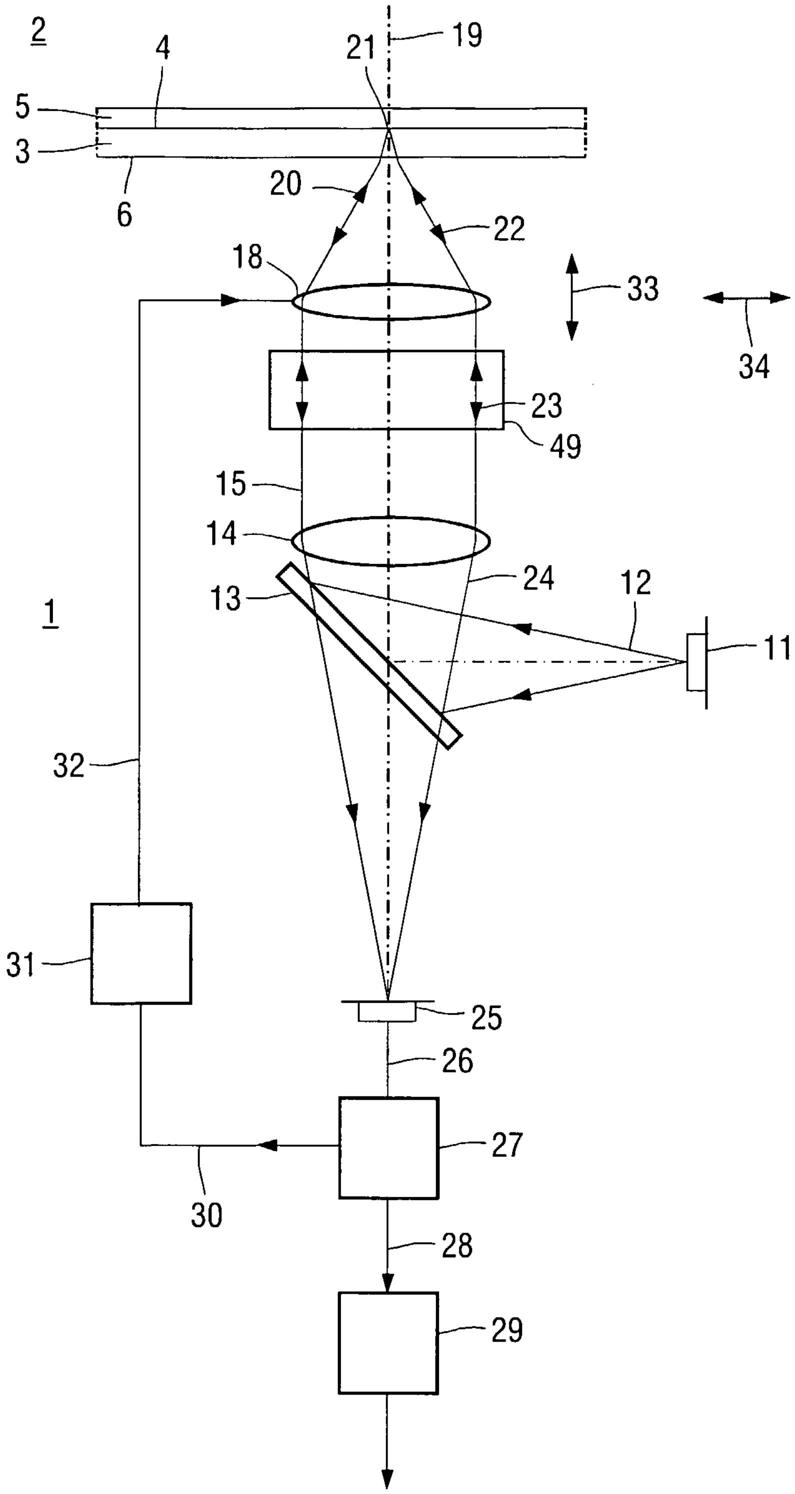
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FIG.1

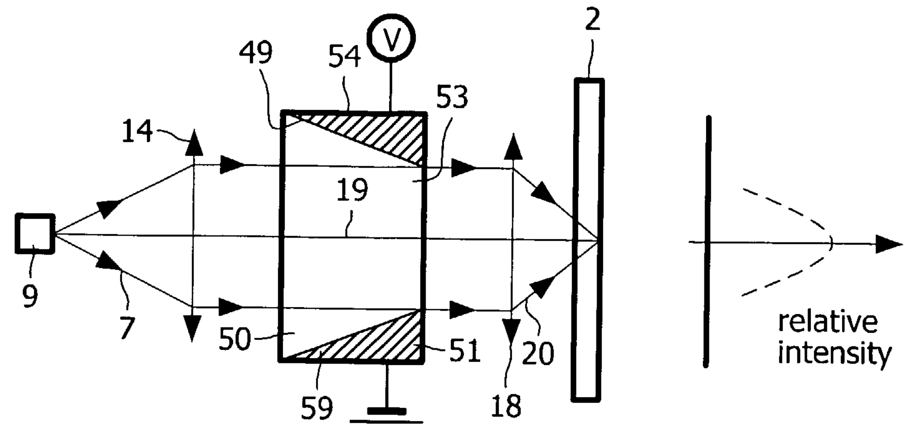
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FIG. 2a

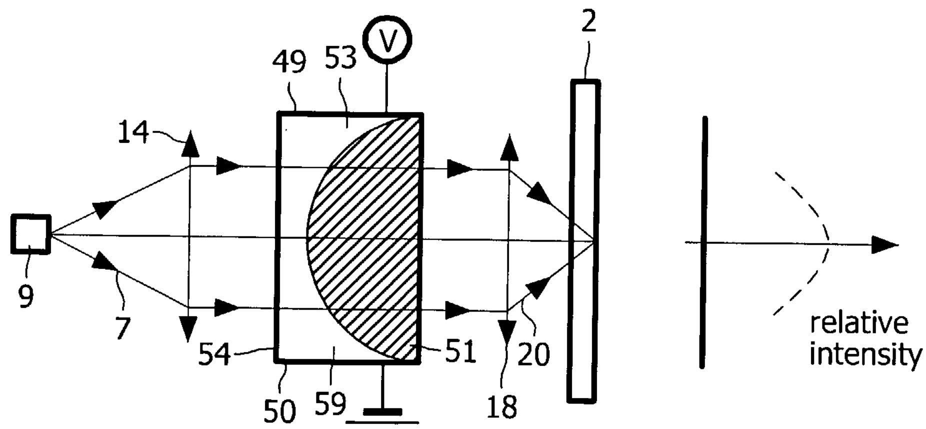
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FIG. 2b

INTERNATIONAL SEARCH REPORT

Inte nal Application No
PCT/IB2005/053070

A. CLASSIFICATION OF SUBJECT MATTER
G11B7/135 G02B26/02 G02B3/14

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)
G11B G02B

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/027489 A (KONINKLIJKE PHILIPS ELECTRONICS N.V; FEENSTRA, BOKKE, J; HAYES, ROBERT) 1 April 2004 (2004-04-01) the whole document -----	1-8
Y	WO 2004/027769 A (KONINKLIJKE PHILIPS ELECTRONICS N.V; TUKKER, TEUNIS, W; HENDRIKS, BERN) 1 April 2004 (2004-04-01) the whole document -----	1-8
Y	EP 1 069 450 A (CANON KABUSHIKI KAISHA) 17 January 2001 (2001-01-17) the whole document -----	1-8
Y	US 2002/176148 A1 (ONUKI ICHIRO ET AL) 28 November 2002 (2002-11-28) the whole document -----	1-8
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
15 December 2005	22/12/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Skaropoulos, N

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INTERNATIONAL SEARCH REPORT

Inter ial Application No
PC I / IB2005/053070

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2004/059628 A (KONINKLIJKE PHILIPS ELECTRONICS N.V; SCHLEIPEN, JOHANNES) 15 July 2004 (2004-07-15) the whole document -----	1-8
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INTERNATIONAL SEARCH REPORT

ɔrmation on patent family members

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