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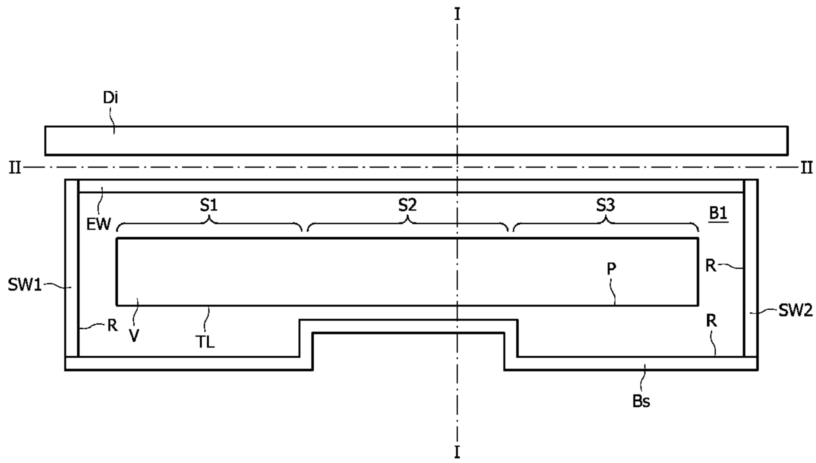
(54) Title: LCD BACKLIGHTING UNIT



(57) Abstract: The invention relates to a backlight system (Bl - BlO) for illuminating a display device, comprising a light emission window (EW) for emitting light in the direction of a display device (Di), and an electrically conductive plate (Bs), at least a part of which plate is arranged opposite to the light emission window, and at least one fluorescent lamp (TL) arranged between said light emission window and said electrically conductive plate, said at least one fluorescent lamp having a first end section (Sl), a middle section (S2), and a second end section (S3). The electrically conductive plate (Bs) has a construction such that, during operation of the backlight system, the degree of electrical coupling between the middle section of the at least one fluorescent lamp and a section of the electrically conductive plate associated with said middle section is higher than the degree of electrical coupling between the first end section and/or the second end section of the at least one fluorescent lamp and sections or a section of the electrically conductive plate associated with said first end section and/or said second end section, respectively. As a result, the ignition behavior of the lamp is improved. Furthermore, the light output of the lamp can be locally controlled.

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LCD backlighting unit

FIELD OF THE INVENTION

The invention relates to a backlight system for illuminating a display device, comprising a light emission window for emitting light in the direction of a display device, an electrically conductive plate of which at least a part is arranged opposite to the light emission window, and at least one fluorescent lamp arranged between said light emission window and said electrically conductive plate, said at least one fluorescent lamp having a first end section, a middle section, and a second end section.

The invention further relates to a display system, in particular a Liquid Crystal Display (LCD) system, comprising said backlight system.

BACKGROUND OF THE INVENTION

Fluorescent lamps are commonly known and are used inter alia in backlight systems. Such a backlight system is referred to as a “direct-lit” backlight or “direct-under” type of backlight system. The backlight systems are used inter alia for back lighting of (image) display devices, for example for television receivers and monitors. Such backlight systems are particularly suitable for use as backlights for non-emissive displays, such as liquid crystal display devices, also referred to as LCD panels, which are used in (portable) computers or (cordless) telephones. The backlight system is particularly suitable for use in large-screen LCD display devices for television and professional applications.

Said display devices generally include a substrate provided with a regular pattern of pixels, which are each driven by at least one electrode. The display device employs a control circuit for reproducing an image or a datagraphic representation in a relevant area of a (display) screen of the (image) display device. In an LCD device, the light originating from the backlight is modulated by means of a switch or a modulator, while various types of liquid crystal effects are utilized. In addition, the display may be based on electrophoretic or electromechanical effects.

In the fluorescent lamp mentioned in the opening paragraph, a tubular low-pressure mercury-vapor discharge lamp, for example one or more cold-cathode fluorescent lamps (CCFL), hot-cathode fluorescent lamps (HCFL), or external-electrode fluorescent lamps (EEFL) may be used as discharge lamps in the backlight system. Commonly, a phosphor coating is applied for enabling low-pressure mercury vapor discharge lamps to convert UV light into other wavelengths, for example UV-B light and UV-A light for tanning purposes (sun panel lamps), or into visible radiation for general illumination purposes. Discharge lamps having a phosphor coating are therefore also referred to as fluorescent lamps. The lamp voltage applied to a fluorescent lamp depends on several parameters,among them tube length, gas pressure, and mercury content. For a fluorescent lamp intended for a 32'' LCD panel, the rms lamp voltage is usually in the range of 500 V – 2 kV, typically 1 kV. Fluorescent lamps are normally driven with a high frequency voltage waveform that is close to a sinusoid. The frequency typically ranges from 20 to 100 kHz for a CCFL and a HCFL lamp, and is 1 MHz or higher for an EEFL lamp. A higher voltage has to be applied to the fluorescent lamp before ignition takes place, which voltage depends to a large extent on the temperature. For a CCFL lamp at 0 °C, for example, the typical rms ignition voltage is 2 kV.

Backlight systems constructed with one of the above-mentioned types of fluorescent lamps have a typical thickness of between 17 and 35 mm. In the case of backlight systems based on hot-cathode fluorescent lamps with a relatively large diameter of approximately 16 mm, specific optical constructions are required in order to manufacture thin backlight systems with a good light uniformity. There is a drive to design and construct much thinner backlight systems than indicated above.

An advantageous option for a backlight system for a display device, such as an LCD, is the use of an array of small CCFL or EEFL lamps. In a particular application, these lamps are arranged together between two glass panels, between which panels ribs are provided, thereby defining the separate discharge vessels of the lamps. The diameter of each lamp is typically about 3 mm. In order to comply with brightness specifications of the LCD, it is important to use a large number of lamps, typically 80, which are typically switched on for 4 to 35% of the time in the case of scanning backlighting. The performance of such an array of multiple small lamps is much better in terms of picture quality and size (thickness) than that of existing solutions with approximately 2 to 20 relatively large standard CCFL, EEFL, or HCFL lamps.

A known problem with an LCD-TV module is that moving images tend to exhibit motion artifacts as a result of blurring owing to the fact that the light modulators cannot instantly respond to changes in transmission levels. It has been shown that the use of a so-called scanning or blinking backlight unit reduces the blurring problem. Scanning backlight units typically comprise a plurality of light sources arranged in a panel-like fashion.

The scanning of the scanning backlight unit is typically performed by switching the light sources on and off in accordance with video signals provided to the display device. The video signals include image data to be displayed and synchronization data which render possible a synchronous scanning of the display device so as to form an image. The light sources are addressed sequentially in accordance with the synchronization data, illuminating a group of light modulators typically after the required transmission levels in the light modulators have been achieved.

Japanse patent application JP05-251050 discloses a backlight system having a fluorescent lamp and an electrically conducting plate opposite to the light emission window of the backlight system. The conducting plate is positioned in the vicinity of the lamp, along its longitudinal axis, in parallel with the lamp. The conducting plate extends from the first electrode of the fluorescent lamp to its second electrode, and it facilitates the ignition of the fluorescent lamp by locally increasing the electrical field.

It is a disadvantage of the known backlight system that the capacitive coupling between the fluorescent lamp and the electrically conducting plate after ignition of the lamp causes a capacitive current to flow to the conducting plate, which reduces the lamp current and consequently the light output of the fluorescent lamp as a whole. In addition, the light output of the backlight system is further negatively affected by the optical properties of the housing of the backlight system itself, which usually results in a lower light output at the borders of the backlight system compared with the central portion of the backlight system.

Furthermore, when an ignition voltage is applied to the lamp, the conducting plate creates a high electric field concentrated near both ends of the discharge space inside the fluorescent lamp. If the fluorescent lamp is dimmed by a pulse-width dimming mechanism, the number of (high-frequency) voltage pulses is limited, which may result in lamp flickering if the tube is not ignited over its full length. Improving the ignition behavior of the lamp would allow duty-cycle dimming at a relatively low duty cycle of less than 30 %, preferably in a range of 1 to 5 %.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved backlight system that solves the above-mentioned problems at least partially.

This object is achieved with a backlight system according to the invention, characterized in that the electrically conductive plate has a construction such that, during operation of the backlight system, the degree of electrical coupling between the middle section of the at least one fluorescent lamp and a section of the electrically conductive plate associated with said middle section is higher than the degree of electrical coupling between the first end section and/or the second end section of the at least one fluorescent lamp and sections or a section of the electrically conductive plate associated with said first end section and/or said second end section, respectively. It is noted that the term operation of the backlight system refers to the ignition phase of the fluorescent lamp as well as to the phase after ignition of the lamp has taken place.

The increased degree of capacitive coupling between the conductive plate and the fluorescent lamp at the middle section of the fluorescent lamp after ignition of the lamp, compared with the ends of the fluorescent lamp, causes an increased capacitive current to flow from the middle section of the fluorescent lamp to the conductive plate. As a result, the light output from the middle section of the fluorescent lamp decreases compared with the light output of the end sections of the fluorescent lamp. A local control of the light output of the lamp thus creates a required light distribution along the longitudinal axis of the lamp. The higher light output at an end section of the fluorescent lamp compensates for the optical properties of the backlight system at its borders, resulting in a more uniform light distribution of the backlight system, especially in the direction along the longitudinal axes of the fluorescent lamps. Furthermore, the electric field strength during the ignition phase of the lamp towards the centre of the fluorescent lamp increases, compared with the lamp ends, due to the increased degree of electrical coupling between the conductive plate and the middle section of the fluorescent lamp, leading to a substantially constant electric field along the longitudinal axis of the lamp. As a result, the ignition behavior of the fluorescent lamp is improved, reducing the ignition time of the lamp. The latter renders it possible to lower the duty cycle for pulse width dimming while maintaining ignition of the lamp over the full length of the discharge space.

An embodiment of the invention is characterized in that the electrically conductive plate has an angled or curved shape such that the average distance between the plate and said middle section is smaller than the average distance between the plate and said first end section, and smaller than the average distance between the plate and said second end section. By modifying the shape of the curved or angled plate, the degree of electrical coupling between the conducting plate and the lamp can be easily optimized for each section of the lamp.

An embodiment of the invention is characterized in that the electrically conductive plate comprises a plurality of holes, and in that the concentration of holes in a section of the plate associated with the middle section of the at least one fluorescent lamp is smaller than the concentration of holes in a section of the plate associated with the first end section of the at least one fluorescent lamp, and smaller than the concentration of holes in a section of the plate associated with the second end section of the at least one fluorescent lamp. The wording “concentration of holes” denotes the area occupied by holes per square meter of plate. The degree of electrical coupling between the conducting plate and the lamp can be easily optimized for each section of the lamp in that the number of holes and/or the size of the holes in the conducting plate is varied.

An embodiment of the invention is characterized in that a section of the electrically conductive plate associated with the middle section of the at least one fluorescent lamp comprises a first type of material, and in that a section of the electrically conductive plate associated with the first end section and the second end section of the at least one fluorescent lamp comprises a second type of material, the first type of material having a higher electrical conductivity than the second type of material. The use of materials with different electrical conductivity values for the conducting plate makes it possible to optimize the degree of electrical coupling between the conducting plate and each section of the lamp.

An embodiment of the invention is characterized in that the electrically conductive plate only extends along the middle section of the at least one fluorescent lamp. After ignition, the capacitive current to the conductive plate is concentrated near the center of the lamp tube, only decreasing the light output near this center of the tube. The electric field is more concentrated near the center of the tube during the ignition phase.

An embodiment of the invention is characterized in that the electrically conductive plate is at least a part of a reflector for reflecting light towards the light emission window. A relatively simple construction of the backlight is obtained in that the conducting plate and the reflector are combined into one component.

An embodiment of the invention is characterized in that backlight system is a scanning backlight system. The use of a scanning backlight system reduces the so-called motion blur.

An embodiment of the invention is characterized in that the at least one low-pressure discharge lamp is a cold-cathode fluorescent lamp. An advantage of a cold-cathode fluorescent lamp is that it does not require a continuous powering of the electrodes in a temporary standby state, reducing the power consumption as well as reducing the heat production of the discharge lamps.

An embodiment of the invention is characterized in that the at least one low-pressure discharge lamp is an external-electrode fluorescent lamp. An advantage of an external-electrode fluorescent lamp is that it has a relatively simple electrode construction that makes a reduction of the non-light-emitting ends of a fluorescent lamp possible.

An embodiment of the invention is characterized in that the backlight system further comprises a backing substrate at least a part of which is arranged substantially opposite to the light emission window, wherein ribs are provided between said light emission window and said backing substrate, said ribs being arranged substantially in a parallel direction so as to define the discharge spaces of the fluorescent lamps. The performance of such an array of multiple small lamps is much better in terms of picture quality and size (thickness) that of other solutions with approximately 2 to 20 large standard CCFL, EEFL, or HCFL lamps.

An embodiment of the invention is characterized in that the substrate thickness corresponding to the middle section of the fluorescent lamps is greater than the substrate thickness corresponding to the first end section and the second end section of the fluorescent lamps. The local capacitance of the lamp can thus be varied, with the result that the local capacitive current to the conductive plate is varied as well, after ignition of the lamp, so that the local light output of the lamp can be influenced.

An embodiment of the invention is characterized in that the system is a scanning backlight system, the system comprising multiple lamp sections, each lamp section comprising a plurality of fluorescent lamps, wherein, during operation, the lamp sections are switched on and off row by row, and wherein the electrically conductive plate furthermore has a construction such that, during operation of the backlight system, the degree of capacitive coupling between the fluorescent lamps near the border of a lamp section and the electrically conductive plate is substantially equal to the degree of capacitive coupling between the other fluorescent lamps of the lamp section and the electrically conductive plate. During operation, the electric field lines of a lamp near the border of a section are not shielded by the electrical field lines of a lamp of a neighboring section near the same border. The capacitive coupling between such a lamp and the electrically conducting plate is therefore greater than the capactive coupling between the other lamps of a lamp section and the electrically conducting plate, resulting in a lower light output of the lamps near the border of a lamp section. A more uniform light output of the backlight system is obtained in that the electrically conducting plate is so adapted that the capacitive coupling between all lamps of a lamp section and the electrically conducing plate is substantially equal.

According to the invention, a display system comprises a backlight system according to claim 1 that has a more uniform light distribution, and provides an operation with pulse-width dimming at a relatively low duty cycle without flickering on the display.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view of a first embodiment of a backlight system according to the invention taken on an axis parallel to the longitudinal axes of the fluorescent lamps.

Fig. 2 is a cross-sectional view of a backlight system according to the invention taken on I – I indicated in Fig. 1.

Fig. 3 is a cross-sectional view of a second embodiment of a backlight system according to the invention taken on an axis parallel to the longitudinal axes of the fluorescent lamps.

Fig. 4 is a cross-sectional view of a third embodiment of a backlight system according to the invention taken on an axis parallel to the longitudinal axes of the fluorescent lamps.

Fig. 5 is a cross-sectional view of a fourth embodiment of a backlight system according to the invention taken on an axis parallel to the longitudinal axes of the fluorescent lamps.

Fig. 6 is a cross-sectional view of a fifth embodiment of a backlight system according to the invention taken on an axis parallel to the longitudinal axes of the fluorescent lamps.

Fig. 7 is a cross-sectional view of a sixth embodiment of a backlight system according to the invention taken on an axis parallel to the longitudinal axes of the fluorescent lamps.

Fig. 8 is a cross-sectional view of a seventh embodiment of a backlight system according to the invention taken on I – I indicated in Figure 1.

Figure 9 is a plan view of an eighth embodiment of a backlight system according to the invention viewed along II – II indicated in Figure 1.

Fig. 10 is a cross-sectional view of a ninth embodiment of a backlight system according to the invention taken on I – I indicated in Figure 9.

Fig. 11 is a cross-sectional view of a tenth embodiment of a backlight system according to the invention taken on an axis parallel to the longitudinal axes of the fluorescent lamps.

The Figures are purely diagrammatic and not drawn to scale. Some dimensions have been particularly strongly exaggerated for reasons of clarity . Similar components in the Figures have been given the same reference numerals as much as possible.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows a backlight system B1 according to the invention, in which light is generated by a plurality of cold-cathode low-pressure mercury vapor discharge lamps TL, each comprising a discharge vessel V having a luminescent layer P typically arranged at an inner wall of the discharge vessel V. The fluorescent lamps TL are supplied with a symmetrical voltage waveform. Light is emitted towards the display device Di via a light emission window EW of the backlight system B1. Typically, the side walls SW1, SW2 as well as the backside Bs of the backlight system B1 comprise reflective layers R which reflect light emitted by the fluorescent lamps TL in a direction away from the light emission window EW back towards the light emission window EW. The backside Bs consists of a metal plate which is connected to ground. The backside Bs has one part that is associated with the middle section S2 of the lamps TL and that is positioned closer to the lamps TL than the other parts of the backside Bs. Each end of a fluorescent lamp TL comprises an electrode, not shown in Figure 1, for energizing the lamp. After ignition of the lamp TL, a gas discharge is maintained between the anode and the cathode due to the electric field created between the two electrodes. As a result of the mutual capacitance, i.e. capactive coupling, between the lamps TL and the backside Bs, a capacitive current flows from the lamps TL to the backside Bs. The degree of capactive coupling between the lamps TL and the backside Bs is a function of the distance between the lamps TL and the backside Bs. For end sections S1 and S3 of the lamps TL, the degree of capactive coupling, and therefore the capactive current to the backside Bs, is smaller than for the middle section S2 of the lamps TL. Due to the larger capacitive current from the middle section S2 to the backside Bs, the current flowing through the lamps TL between the anode and the cathode is reduced more strongly for the middle section S2 than for end sections S1 and S3, resulting in a relatively lower light output from the middle section S2 compared with the end sections S1, S3. An ignition voltage is applied to the electrodes for igniting the lamps TL. During the ignition phase of the lamps TL, the electric field is increased for the middle section S2 compared with the end sections S1 and S3, resulting in an electric field that is substantially constant along the longitudinal axis of the lamp.This improves the ignition behavior of the lamps TL, resulting in a shorter ignition time.

In an alternative embodiment, only that part of the backside Bs that is closest to the lamps TL, i.e. associated with the middle section S2 of the lamps TL, is made of a metal plate, while the other parts of the backside Bs are made of an electrically non-conductive material. In a further alternative embodiment, the metal plate is not part of the backside Bs of the backlight system B1, but coupled to a side of the backside Bs facing the discharge lamps TL. The backside Bs itself is made of an electrically non-conducting material.

Figure 2 is a cross sectional view of the backlight system B1 taken on the line I – I indicated in Figure 1.

Figure 3 shows a backlight system B2 according to the invention in which light is generated by a plurality of fluorescent lamps TL. The fluorescent lamps TL are supplied with a symmetrical voltage waveform. The electrically conductive backside Bs comprises two parts associated with the middle section S2 of the lamps TL, which parts are positioned closer to the fluorescent lamps TL than other parts of the backside Bs. After ignition of the lamps TL, the degree of capacitive coupling between the middle section S2 of the lamps TL and the backside Bs is higher than that between the end sections S1, S3 and the backside Bs, resulting in a larger decrease of the light output of the middle section S2 in comparison with the end sections S1, S3. During the ignition phase of the lamps TL, the ignition time is reduced owing to a substantially constant electric field along the longitudinal axis of the lamp.

Figure 4 shows a backlight system B3 according to the invention in which light is generated by a plurality of fluorescent lamps TL. The fluorescent lamps TL are supplied with a symmetrical voltage waveform. The electrically conductive backside Bs has an angled shape, such that the distance between the middle section S2 of the lamps TL and the backside Bs is smaller on average than the distance between the end sections S1, S3 and the backside Bs. After ignition of the lamps TL, the degree of capacitive coupling between the middle section S2 of the lamps TL and the backside Bs is higher than that between the end sections S1, S3 and the backside Bs, resulting in a larger decrease of the light output of the middle section S2 in comparison with end sections S1, S3. During the ignition phase of the lamps TL, the ignition time is reduced owing to a substantially constant electric field along the longitudinal axis of the lamp.

Figure 5 shows a backlight system B4 according to the invention in which light is generated by a plurality of fluorescent lamps TL. The fluorescent lamps TL are supplied with a symmetrical voltage waveform. The electrically conductive backside Bs has a curved shape, the distance between the middle section S2 of the lamps TL and the backside Bs being smaller on average than the distance between the end sections S1, S3 and the backside Bs. After ignition of the lamps TL, the degree of capacitive coupling between the middle section S2 of the lamps TL and the backside Bs is higher than that between the end sections S1, S3 and the backside Bs, resulting in a larger decrease of the light output of the middle section S2 in comparison with the end sections S1, S3. During the ignition phase of the lamps TL, the ignition time is reduced owing to a substantially constant electric field along the longitudinal axis of the lamp.

Figure 6 shows a backlight system B5 according to the invention in which light is generated by a plurality of fluorescent lamps TL. The fluorescent lamps TL are supplied with a symmetrical voltage waveform. The electrically conductive backside Bs has a flat shape, and the backside Bs has a plurality of holes of a fixed size. In the part of the backside Bs associated with the middle section S2 of the lamps TL, the concentration of the holes is smaller than in the other parts of the backside Bs. After ignition of the lamps TL, the degree of capacitive coupling between the middle section S2 of the lamps TL and the backside Bs is higher than that between the end sections S1, S3 of the lamps TL and the backside Bs, resulting in a larger decrease of the light output of middle section S2 in comparison with the end sections S1, S3. During the ignition phase of the lamps TL, the ignition time is reduced owing to a substantially constant electric field along the longitudinal axis of the lamp.

Figure 7 shows a backlight system B6 according to the invention in which light is generated by a plurality of fluorescent lamps TL. The fluorescent lamps TL are supplied with a symmetrical voltage waveform. The electrically conductive backside Bs has a flat shape, and the backside Bs has a plurality of holes of different sizes. In the part of the backside Bs associated with the middle section S2 of the lamps TL, the size of the holes is smaller than in the other parts of the backside Bs, resulting in a relatively smaller surface fraction occupied by holes in the part of the backside Bs associated with middle section S2 of the lamps TL. After ignition of the lamps TL, the degree of capacitive coupling between the middle section S2 of the lamps TL and the backside Bs is higher than that between the end sections S1, S3 of the lamps TL and the backside Bs, resulting in a larger decrease of the light output of middle section S2 in comparison with the end sections S1, S3. During the ignition phase of the lamps TL, the ignition time is reduced owing to a substantially constant electric field along the longitudinal axis of the lamp.

Figure 8 shows an alternative backlight system B7 according to the invention in a cross sectional view of the backlight system taken on I – I in Figure 1, in which light is generated by a plurality of fluorescent lamps TL. The part of the backside Bs associated with the middle section S2 of the lamps TL is not a flat plate, but has parts closer to the lamps TL in the vicinity of the lamps TL, and parts more remote from the lamps TL in between the lamps TL.

In an alternative embodiment, the discharge lamps TL are EEFL lamps. The EEFL lamps each comprise a discharge vessel at whose ends conductive coatings functioning as electrodes are applied. The electrodes are adapted for capacitive coupling of radio-frequency electrical energy into the ionizable substance inside the discharge vessel. EEFL lamps usually operate at a relatively high, high-frequency voltage waveform of 1 MHz or more. In another alternative embodiment, the fluorescent lamps are HCFL lamps, operating at a voltage waveform having a frequency of typically 40 – 80 kHz, or at an increased frequency of 1 MHz or more.

In a further alternative embodiment, the parts of the backside Bs associated with the first end section S1 and the second end section S3 of the fluorescent lamps TL are made of a semiconductor material, and the part of the backside Bs associated with the middle section S2 of the discharge lamps TL is made of an electrically conductive material, for example aluminum. After ignition of the lamps TL, the degree of capacitive coupling between the middle section S2 of the lamps TL and the backside Bs is higher than that between the end sections S1, S3 of the lamps TL and the backside Bs, resulting in a larger decrease of the light output of the middle section S2 in comparison with the end sections S1, S3. During the ignition phase of the lamps TL, the ignition time is reduced owing to a substantially constant electric field along the longitudinal axis of the lamp.

Figure 9 is a plan view of a further alternative backlight system B8 viewed along II – II in Figure 1. The backlight system B8 comprises eighty lamps TL of the CCFL type. Each lamp TL comprises a discharge space V, a first electrode 4, and a second electrode 5 positioned opposite to the first electrode 4. The backlight system B8 comprises two glass plates (not shown) between which ribs 6 are provided, thus defining multiple neighboring discharge spaces V. Each section 7 of ten neighboring lamps TL, in particular neighboring discharge spaces V, may be coupled to the other sections via a channel 8 for easier evacuation and subsequent filling of these lamps sections 7. In this embodiment, eight lamp sections 7 are present, of which three are shown. During operation of the backlight system B8, sections 7 are switched on and off row by row so as to generate a scanning backlight illumination for a display device. The lamps TL are positioned between the light emission window EW and the electrically conductive backside Bs, both not shown in Figure 9. An alternating voltage is applied to the electrodes 4, 5 of the lamps TL. For reasons of simplicity, however, this Figure only depicts an instantaneous view, wherein a positive voltage is applied to the first electrodes 4 and a negative voltage is applied to the second electrodes 5. After ignition of the lamps TL, the degree of capacitive coupling between the middle section S2 of the lamps TL and the backside Bs is higher than that between the end sections S1, S3 and the backside Bs, resulting in a larger decrease of the light output of the middle section S2 in comparison with the end sections S1, S3. During the ignition phase of the lamps TL, the ignition time is reduced owing to a substantially constant electric field along the longitudinal axis of the lamp. In a further alternative embodiment, the glass thickness of the middle section S2 of the lamps TL is greater than the glass thickness of the first end section S1 and the second end section S3 of the lamps TL. Since the dielectric constant of glass is much higher than that of air, the local capacitance of the lamp can be varied, whereby the local capacitive current to the conductive plate is varied as well, thus further influencing the local light output of the lamp. In an alternative embodiment, the multiple neighboring discharge spaces V are defined by ribs provided between a glass plate and the light emission window EW.

Figure 10 shows another further alternative backlight system B9 in a cross-section taken on the line I – I indicated in Figure 9. The cross section I – I cuts through the first end sections S1 of the lamps TL. Figure 10 shows only one lamp section 7 and a part of its two neighboring lamp sections for reasons of clarity. At the border 10 between section 7 and its first neighboring section, the distance between the lamps TL`, TL`` and the backside Bs is greater than the distance between the lamps TL and the backside Bs. Similarly, at the border 11 between section 7 and its second neighboring section, the distance between the lamps TL```, TL```` and the backside Bs is greater than the distance between the lamps TL and the backside Bs. At a certain moment in time during the operation of the backlight system B9, the lamps of section 7 are switched on while the lamps of its two neighboring sections are switched off. The capacitive coupling between each of the lamps TL``, TL```, TL of section 7 and the backside Bs is substantially the same owing to the construction of the backside Bs according to Figure 10, resulting in a substantially uniform light output of all these lamps, as the capacitive current losses of these lamps are substantially equal. If the backside Bs were substantially flat, the capacitive coupling between the lamps TL``, TL``` and the backside Bs would be larger than that between the lamps TL of section 7 and the backside Bs, resulting in less light output from lamps TL``, TL``` than from lamps TL of section 7. This is because the electric field lines of the lamps TL``, TL``` are not shielded by the electric field lines of lamps TL` and TL````, respectively, these lamps TL`, TL```` being switched off. The shape of the backside Bs of backlight system B9, with an increased distance between lamps TL``, TL``` and backside Bs, compensates for this effect, and a more uniform light output of the backlight system B9 is obtained. The parts of the backside Bs associated with the middle sections S2 and second end sections S3 of lamps TL of Figure 9 have a similar shape, i.e. at the border 10 as well as at the border 11, the distance between the lamps TL`, TL``, TL``` and TL```` and the backside Bs being larger than the distance between the lamps TL and the backside Bs. In an alternative embodiment, the shape of the backside Bs associated with the lamps TL`, TL``, TL```, TL```` is semicircular or semi-oval. In a further alternative embodiment, the backside Bs is substantially flat and the parts of the backside Bs associated with the lamps TL`, TL`` and the lamps TL```, TL```, respectively, comprise a plurality of holes, along the longitudinal axes of these lamps. In a further alternative embodiment, these holes are filled with a material having a lower electrical conductivity than the material of the other parts of the backside Bs.

Figure 11 shows a backlight system B10 according to the invention in which light is generated by a plurality of low-pressure mercury vapor discharge lamps TL, each comprising a discharge vessel V having a luminescent layer P typically arranged at an inner wall of the discharge vessel V. The low-pressure mercury vapor discharge lamps TL are supplied with an asymmetrical voltage waveform. The electrode on the side A of the lamp TL is connected to ground or to a very low potential. The electrode on the side B of the lamp TL is connected to a power supply not shown in Figure 11. The backside Bs has an angled shape, the distance between the section S2 of the lamp TL and the backside Bs being smaller on average than the distance between the section S1 of the lamp TL and the backside Bs. The distance between the section S3 of the lamp TL and the backside Bs is smaller on average than the distance between the section S2 of the lamp TL and the backside Bs. During the ignition phase of the lamp TL, the electric field is increased near section S3 compared with sections S1 and S2 in order to reduce the ignition time of the lamp TL.

Owing to the construction of commonly used backlight systems, the light emission window EW of the backlight system B1 often has a non-uniform light distribution along the longitudinal axes of the discharge lamps, resulting in less light output at the borders of the backlight system. The present invention varies the degree of capacitive coupling of the discharge lamps TL along the discharge space between the electrodes and the electrically conductive plate in the backside Bs after ignition of the lamps TL. It thus provides a local decrease in the light output of the discharge lamps TL in the middle section S2 compared with the end sections S1, S3. The relatively higher light output at the end sections S1,S3 of the fluorescent lamps TL compensates for the effects of the optical properties of the backlight system B1, and as a result a more uniform light distribution of the backlight system B1 along the longitudinal axes of the discharge lamps TL is obtained. During the ignition phase of the lamps TL, furthermore, the electric field strength is increased near the middle section S2 of the discharge lamps TL compared with their end sections S1, S3. As a result, the electric field is more or less constant along the longitudinal axes of the lamps TL, improving the ignition behavior and reducing the ignition time of the lamps TL. The latter renders it possible to reduce the duty cycle during pulse-width dimming of the lamps TL. The shape and dimensions of the conducting plate in the backside Bs of the backlight system B1 – B9 can be adapted such that the appropriate degrees of electrical coupling between the conducting plate Bs and respective the first end section S1, middle section S2, and second end section S3 of the discharge lamp TL are achieved during operation of the discharge lamps TL.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. Backlight system (B1 – B10) for illuminating a display device, comprising:

- a light emission window (EW) for emitting light in the direction of a display device (Di), and
- an electrically conductive plate (Bs) of which at least a part is arranged opposite to the light emission window, and
- at least one fluorescent lamp (TL) arranged between said light emission window and said electrically conductive plate, said at least one fluorescent lamp having a first end section (S1), a middle section (S2), and a second end section (S3),

characterized in that
the electrically conductive plate (Bs) has a construction such that, during operation of the backlight system, the degree of electrical coupling between the middle section of the at least one fluorescent lamp and a section of the electrically conductive plate associated with said middle section is higher than the degree of electrical coupling between the first end section and/or the second end section of the at least one fluorescent lamp and sections or a section of the electrically conductive plate associated with said first end section and/or said second end section, respectively.

2. System according to claim 1, characterized in that the electrically conductive plate has an angled or curved shape such that the average distance between the plate and said middle section (S2) is smaller than the average distance between the plate and said first end section (S1), and smaller than the average distance between the plate and said second end section (S3).

3. System according to claim 1, characterized in that the electrically conductive plate comprises a plurality of holes, and in that the concentration of holes in a section of the plate associated with the middle section (S2) of the at least one fluorescent lamp is smaller than the concentration of holes in a section of the plate associated with the first end section (S1) of the at least one fluorescent lamp, and smaller than the concentration of holes in a

section of the plate associated with the second end section (S3) of the at least one fluorescent lamp.

4. System according to claim 1, characterized in that a section of the electrically conductive plate associated with the middle section (S2) of the at least one fluorescent lamp comprises a first type of material, and in that a section of the electrically conductive plate associated with the first end section (S1) and the second end section (S3) of the at least one fluorescent lamp comprises a second type of material, the first type of material having a higher electrical conductivity than the second type of material.

5. System according to claim 1, characterized in that the electrically conductive plate only extends along the middle section of the at least one fluorescent lamp.

6. System according to claim 1, characterized in that the electrically conductive plate forms at least a part of a reflector for reflecting light towards the light emission window (EW).

7. System according to claim 1, characterized in that the backlight system is a scanning backlight system.

8. System according to claim 1, characterized in that the at least one fluorescent lamp is a cold-cathode fluorescent lamp.

9. System according to claim 1, characterized in that the at least one fluorescent lamp is an external-electrode fluorescent lamp.

10. System according to claim 1, characterized in that the backlight system further comprises a backing substrate, at least a part of which backing substrate is arranged substantially opposite to the light emission window, wherein ribs are provided between said light emission window and said backing substrate, said ribs being arranged substantially in a parallel direction so as to define discharge spaces of the fluorescent lamps.

11. System according to claim 10, characterized in that the substrate thickness corresponding to the middle section (S2) of the fluorescent lamps is greater than that

corresponding to the first end section (S1) and the second end section (S3) of the fluorescent lamps.

12. System according to claim 1, characterized in that

- the system is a scanning backlight system,
- the system comprises multiple lamp sections (7), each lamp section (7) comprising a plurality of fluorescent lamps (TL, TL``, TL```), wherein, during operation, the lamp sections (7) are switched on and off row by row,
- and wherein the electrically conductive plate (Bs) further has a construction such that, during operation of the backlight system, the degree of capacitive coupling between the fluorescent lamps (TL``, TL```) near the border of a lamp section (7) and the electrically conductive plate (Bs) is substantially equal to the degree of capacitive coupling between the other fluorescent lamps (TL) of the lamp section (7) and the electrically conductive plate (Bs).

13. Display system, in particular a Liquid Crystal Display system, comprising a backlight system according to claim 1.

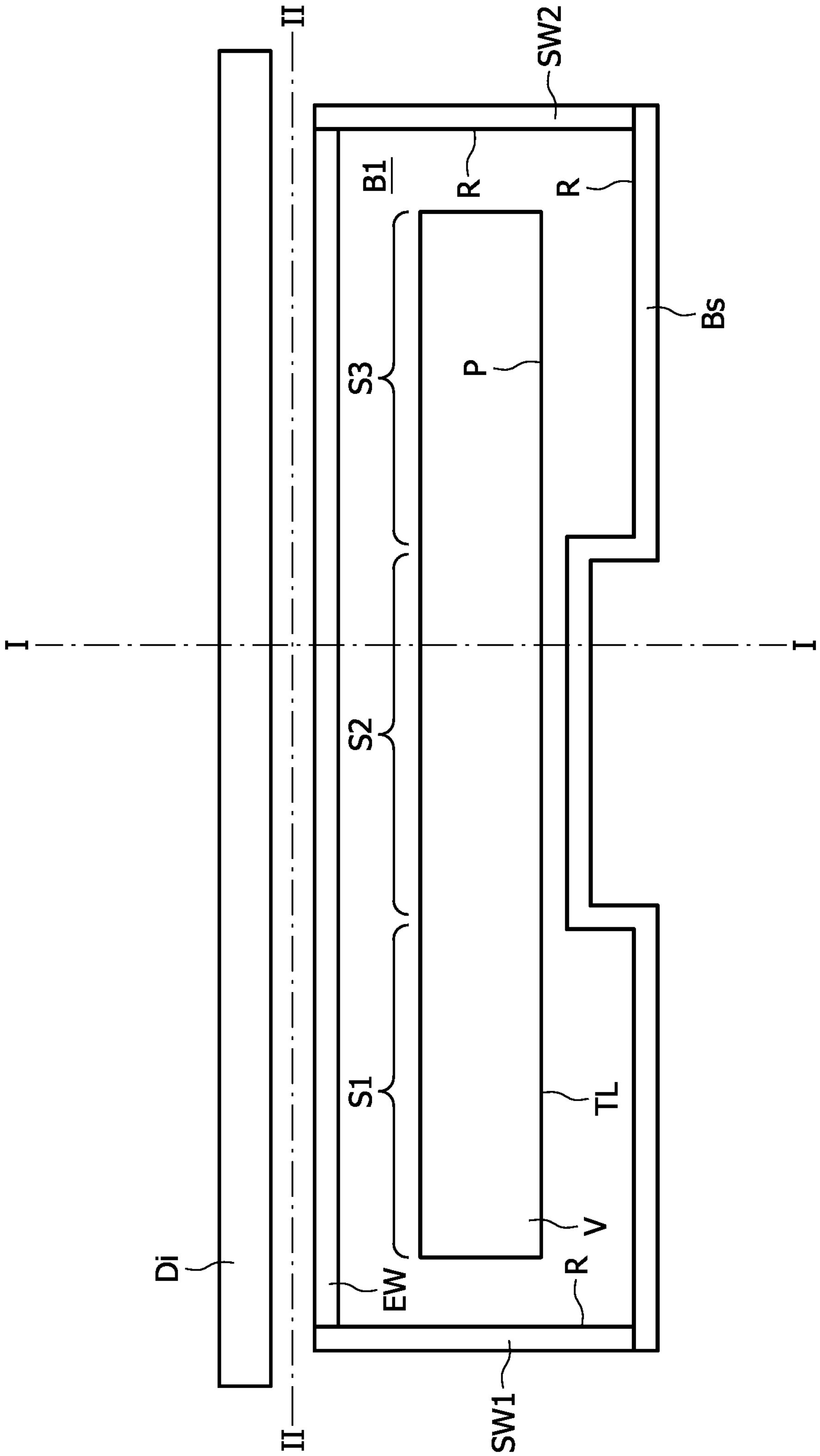

FIG. 1

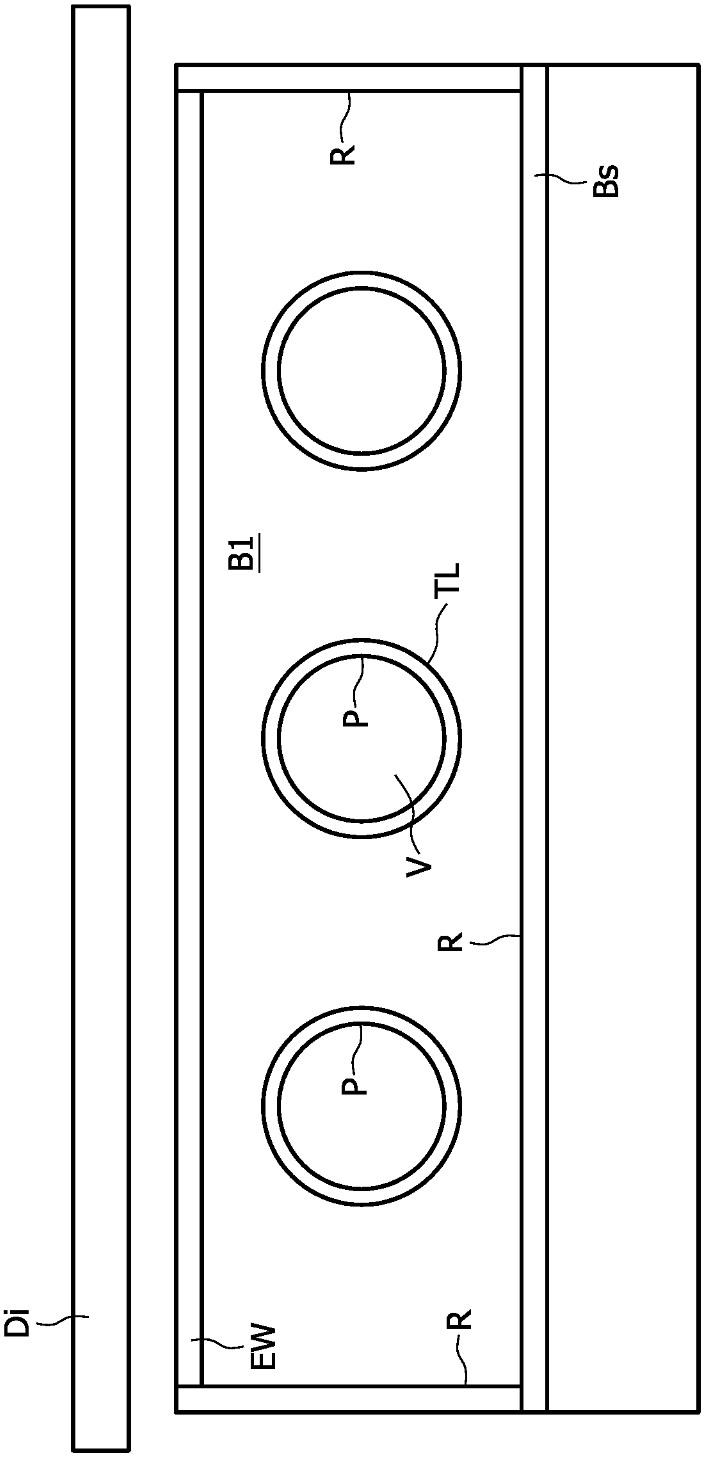

FIG. 2

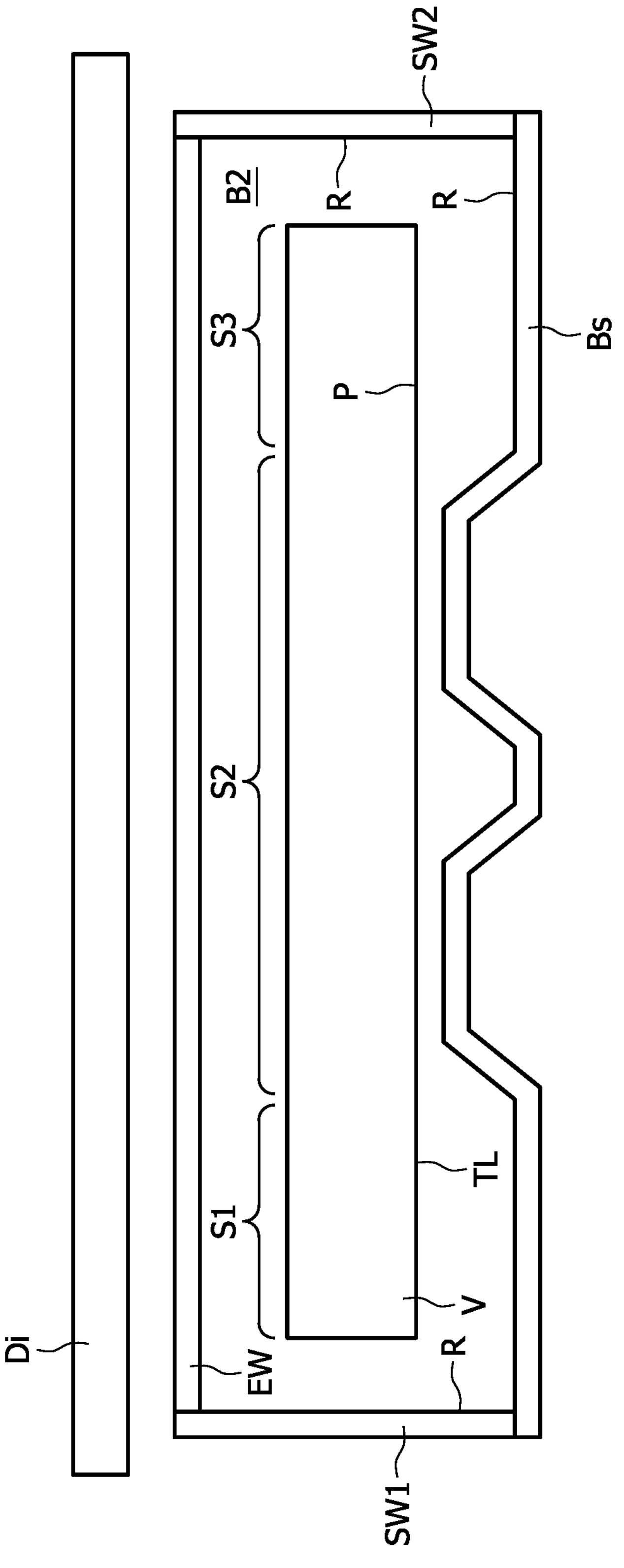

FIG. 3

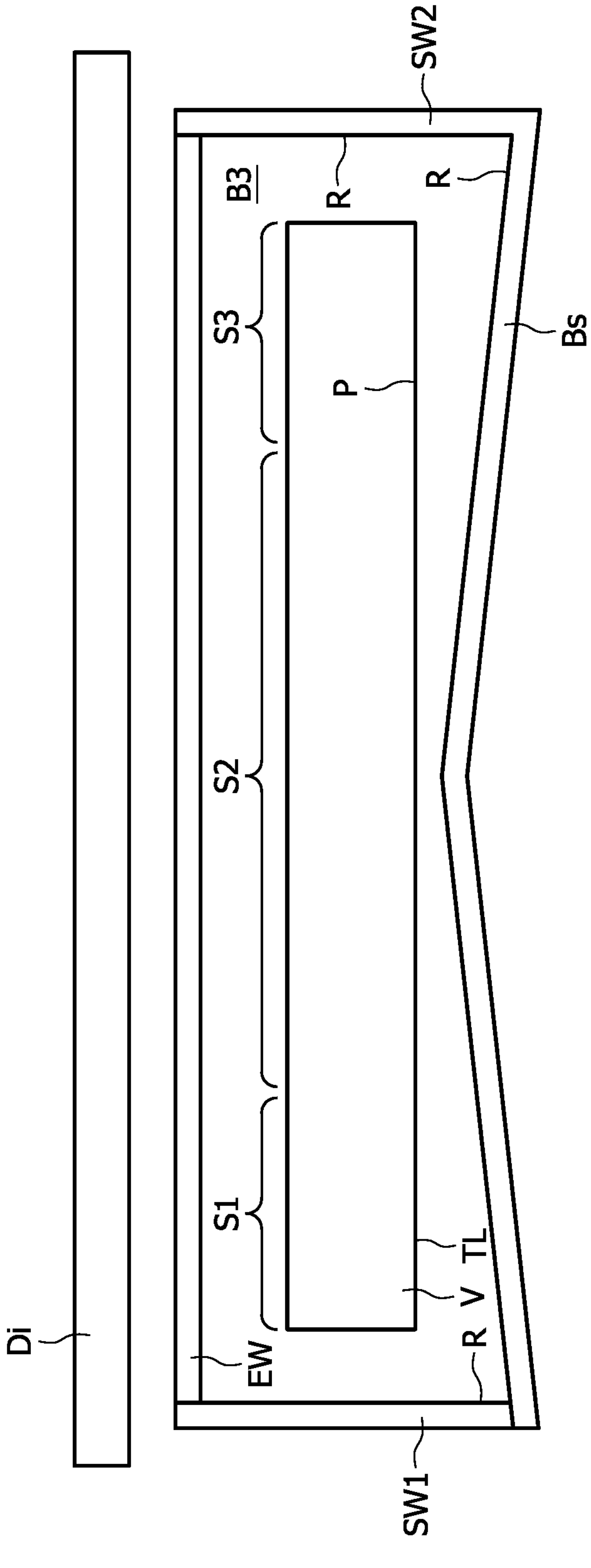

FIG. 4

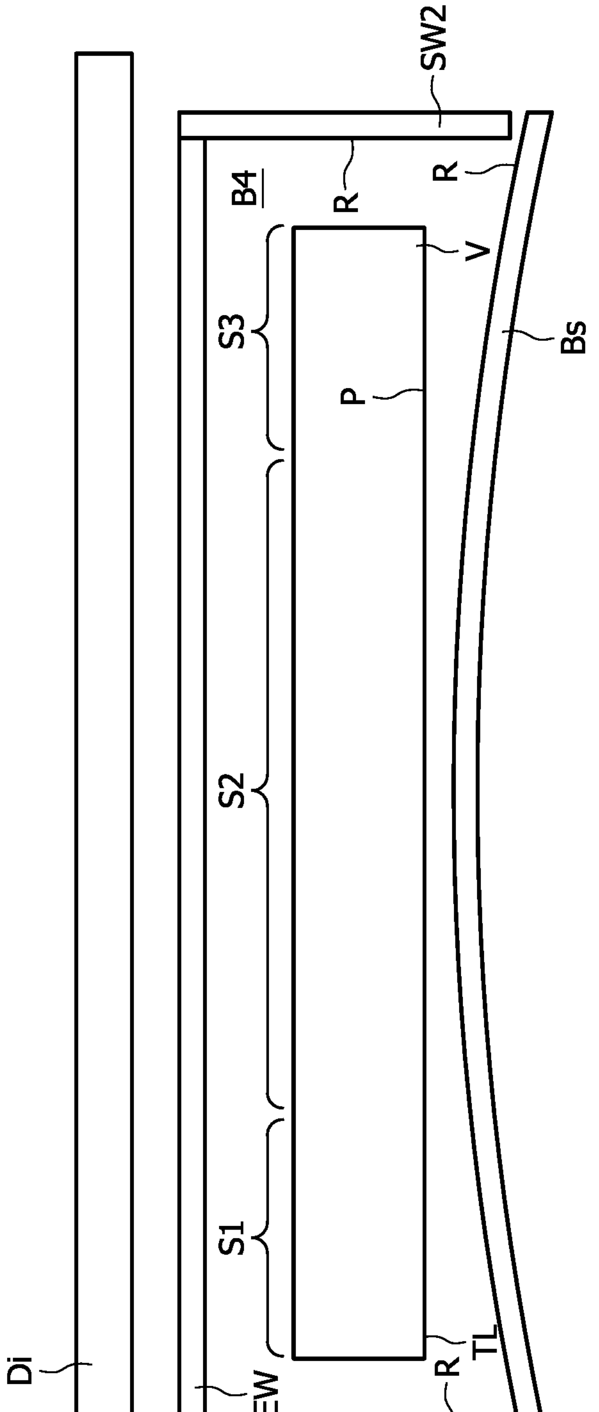

FIG. 5

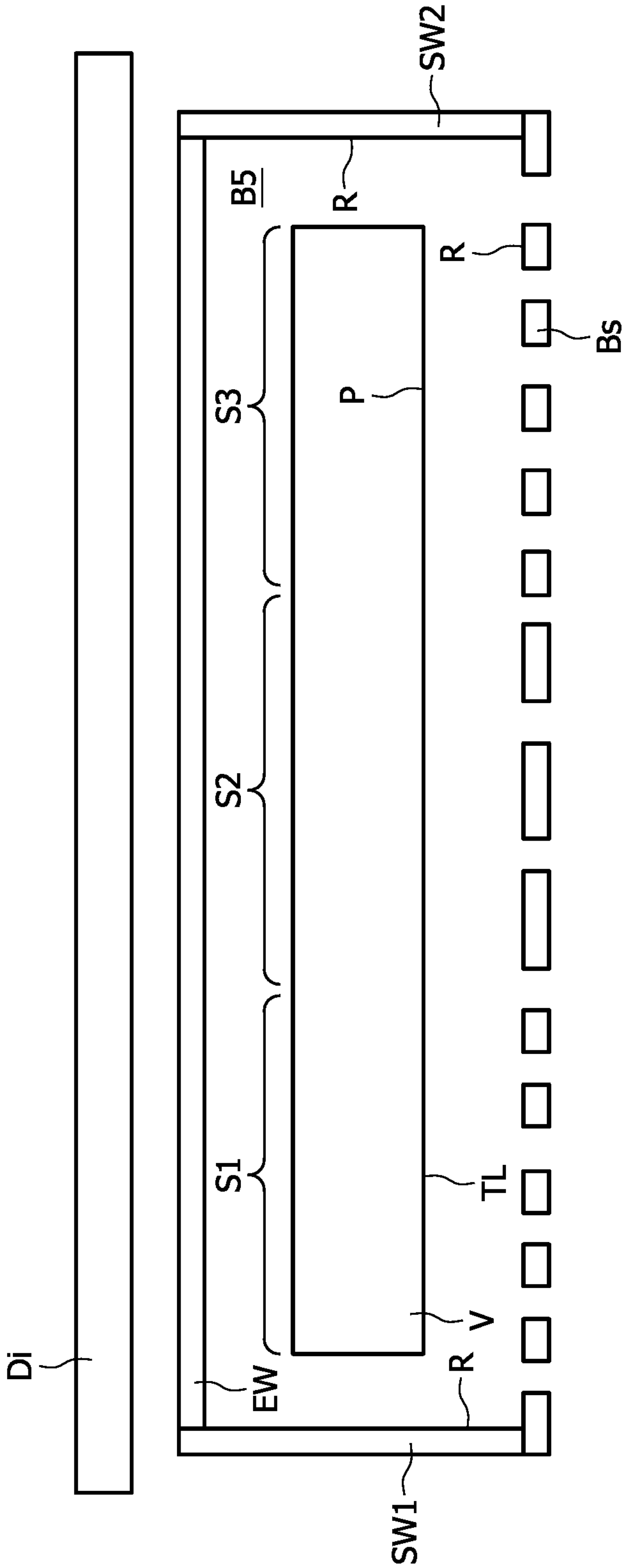

FIG. 6

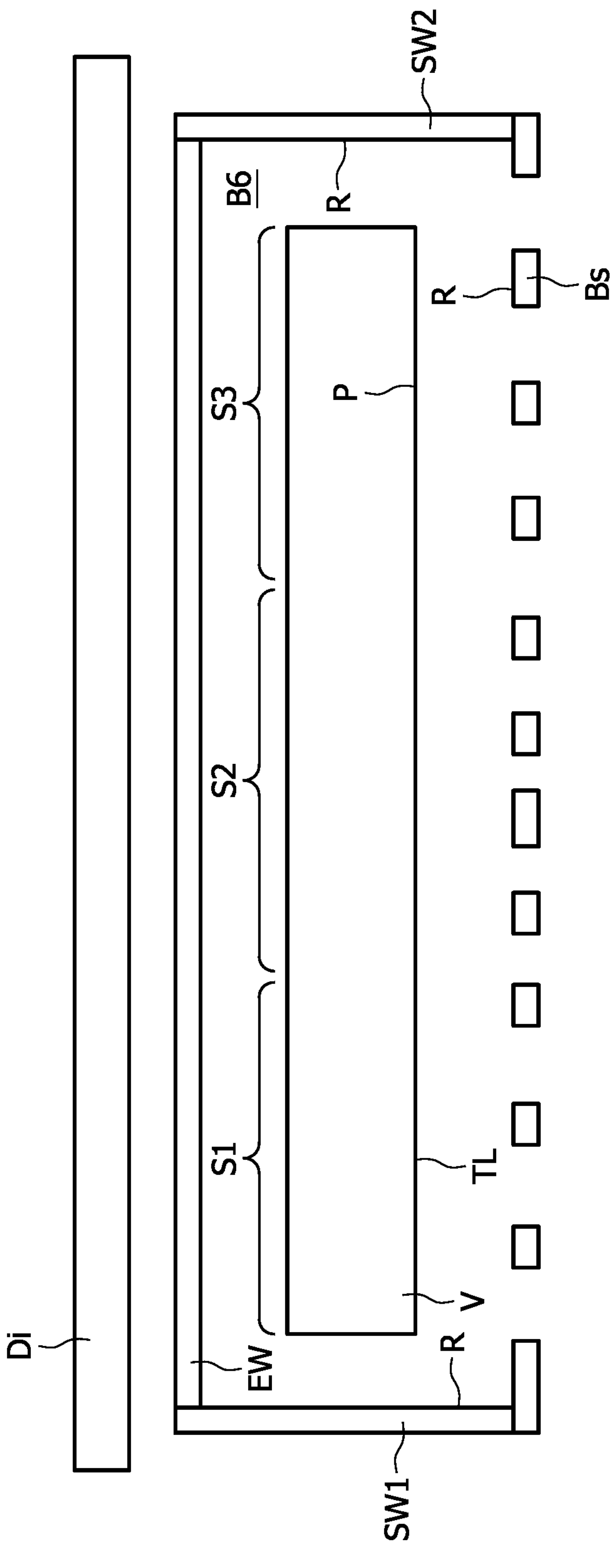

FIG. 7

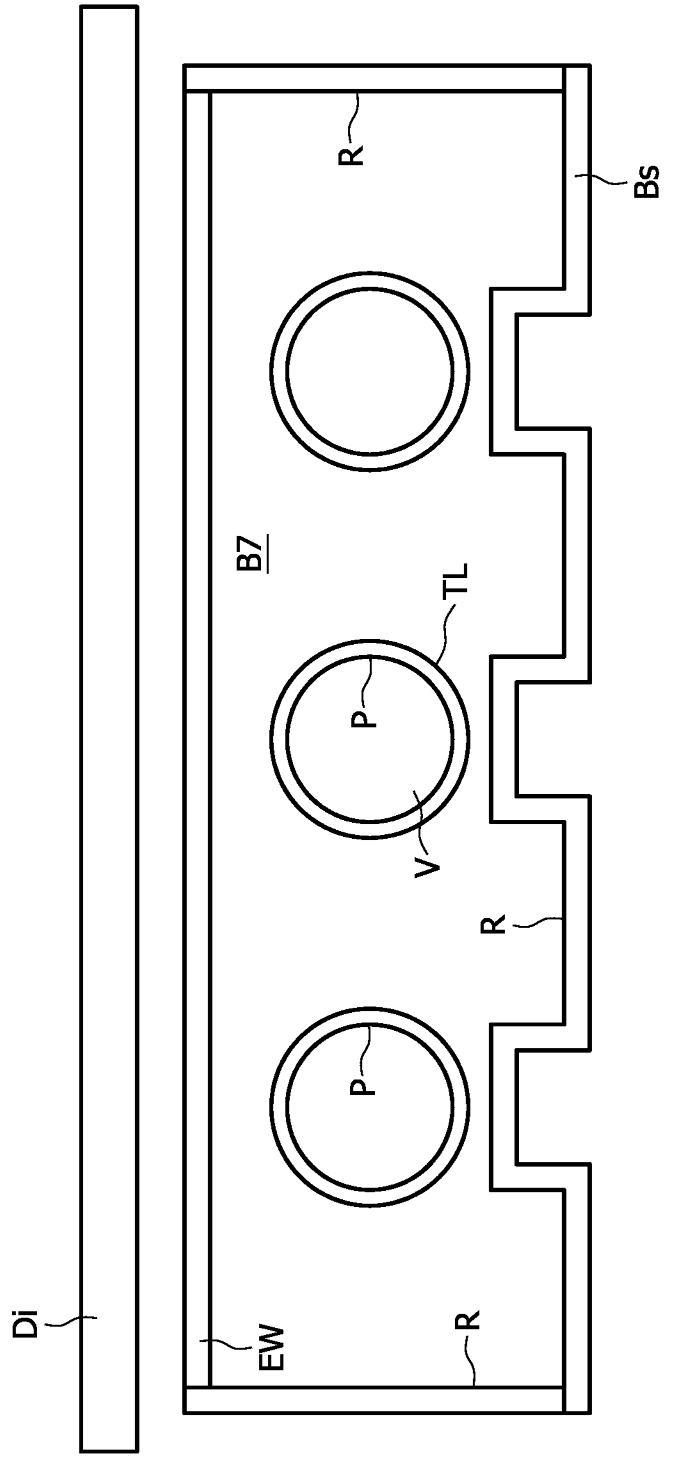

FIG. 8

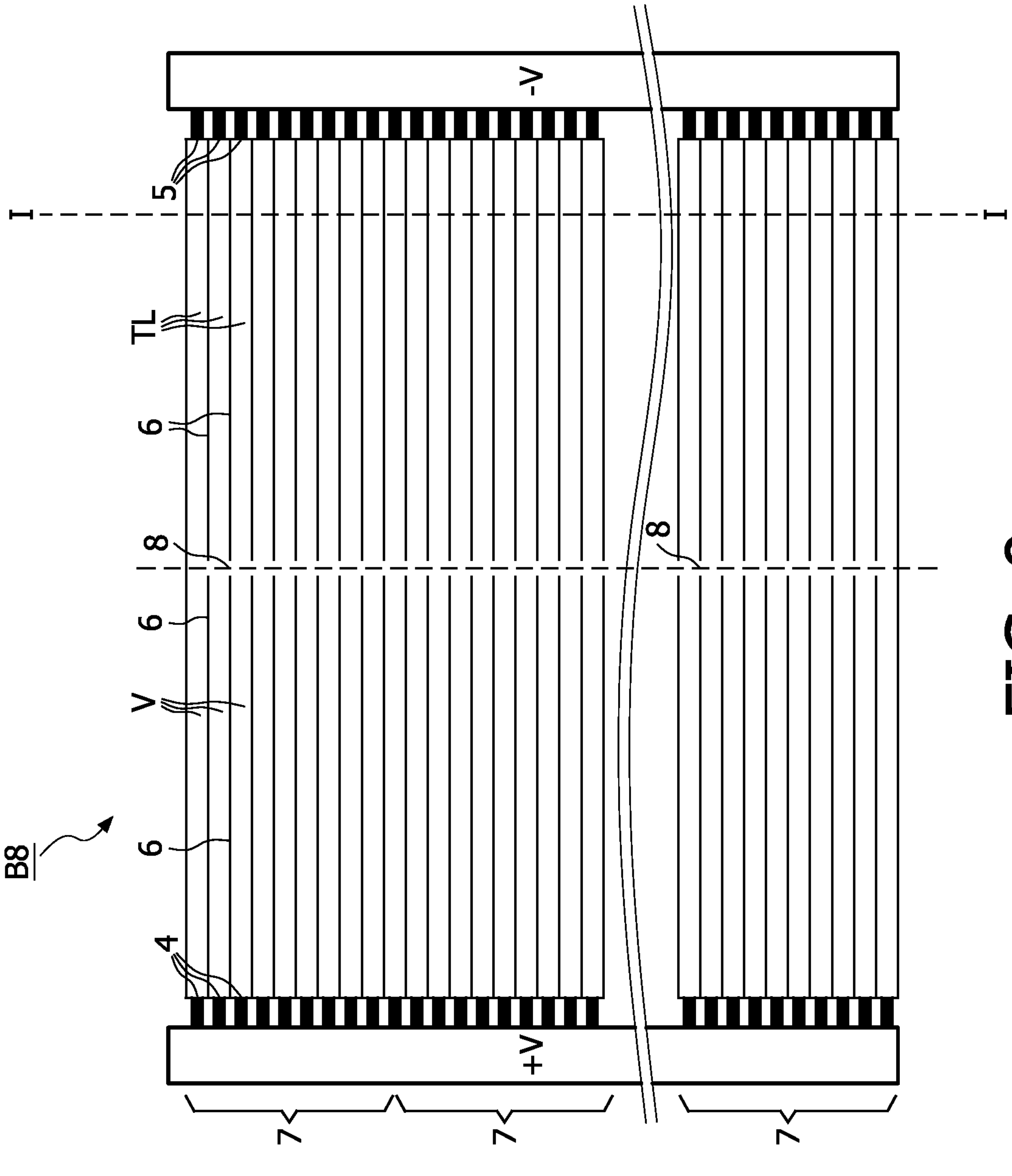

FIG. 9

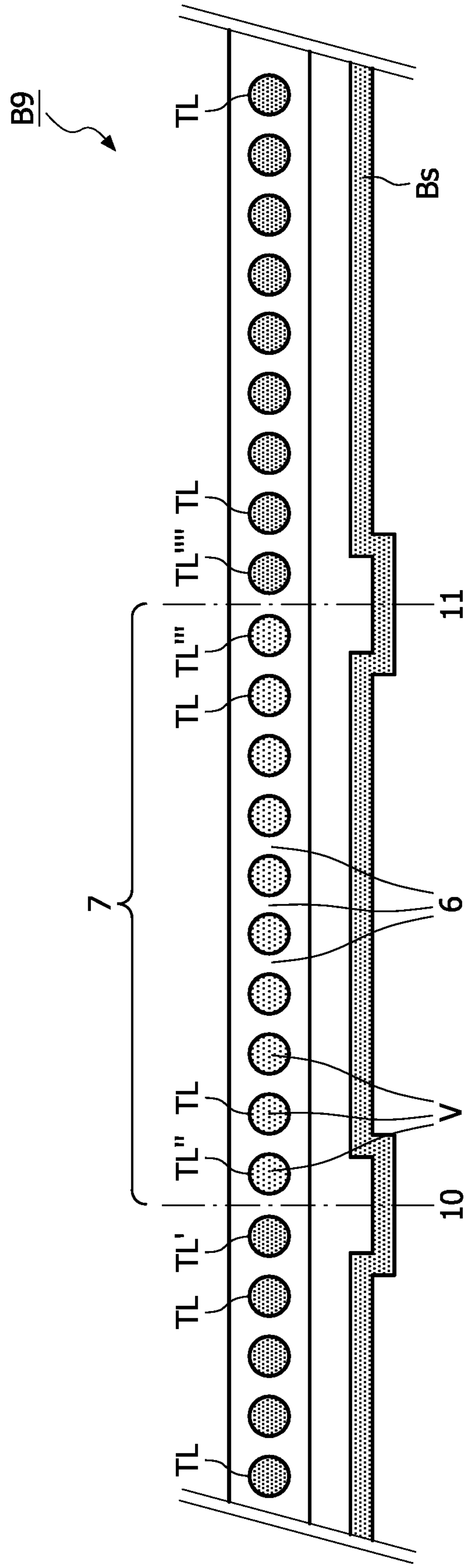

FIG. 10

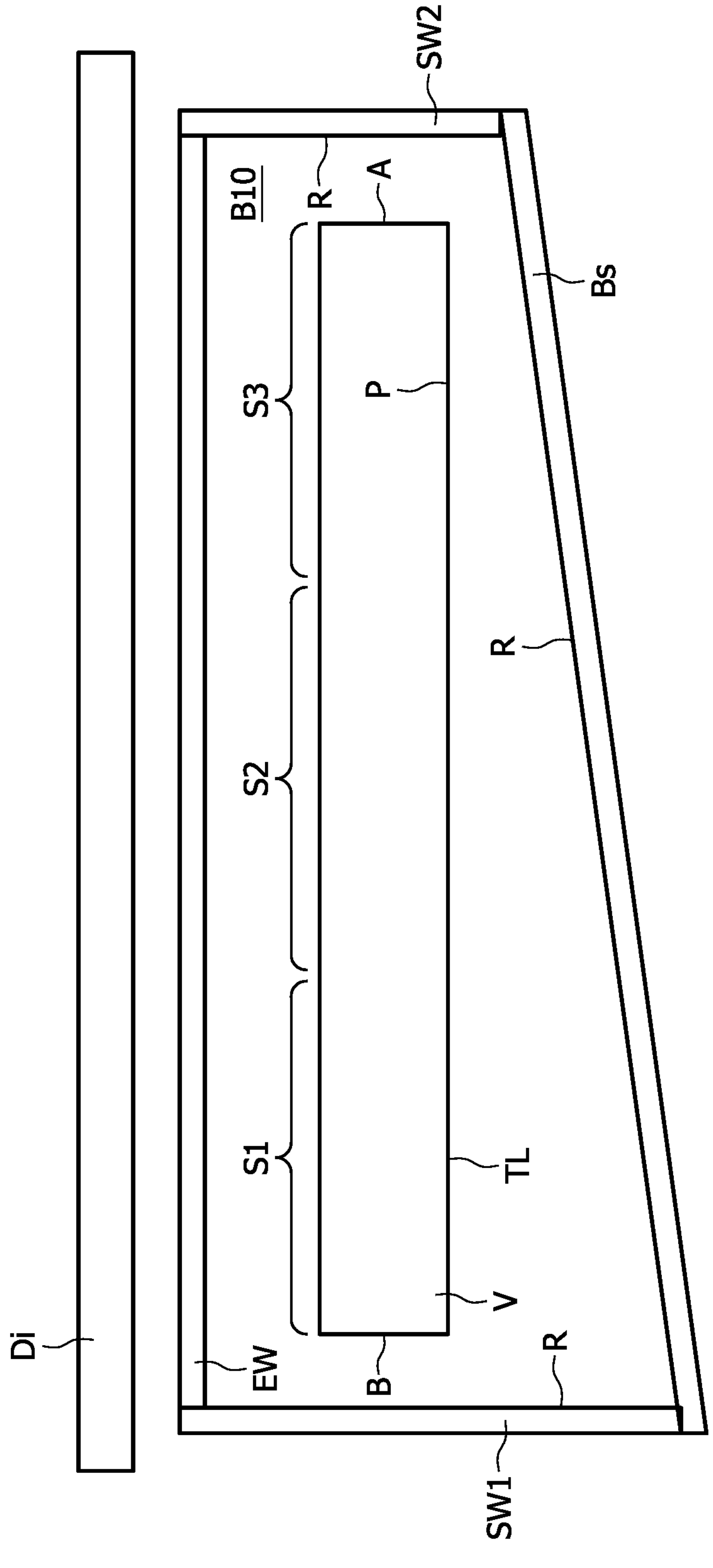

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/053613

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02F1/13357 H01J61/54 H01J61/56 F21V23/00 G09G3/34

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)
G02F H01J G09G

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, WPI Data, PAJ, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 02/15227 A (SIEMENS AG [DE]; MURR JOCHEN [DE]; WAMMES KLAUS [DE]) 21 February 2002 (2002-02-21) page 2, line 34 - page 3, line 4 page 6, line 9 - page 8, line 8; figures 3-5	1,2,6,13
X	US 2005/146653 A1 (BABA MASASHI [JP] ET AL) 7 July 2005 (2005-07-07)	1,6,8,13
Y	paragraph [0008] paragraph [0031] - paragraph [0040]; figure 2	2,4,5,7,10

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

[X] See patent family 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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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 2007	27/02/2007

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	Stang, Ingo

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/053613

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/080925 A1 (MOON SEUNG-HWAN [KR]) 29 April 2004 (2004-04-29)	1,13
Y	paragraph [0009] - paragraph [0015] paragraph [0065] - paragraph [0074] paragraph [0085]; figures 6-10	3
Y	US 6 181 071 B1 (YUUKI AKIMASA [JP] ET AL) 30 January 2001 (2001-01-30) * embodiment 3 *figures 9-12	2,3,5
Y	JP 11 231144 A (SEIKO EPSON CORP) 27 August 1999 (1999-08-27) abstract; figure 1	4
Y	US 6 494 587 B1 (SHAW JAMES E [US] ET AL) 17 December 2002 (2002-12-17)	7
A	column 2, line 30 - line 41 column 3, line 32 - line 34; figures 2A-2C	12
Y	US 2002/105259 A1 (KIM DAEIL [US]) 8 August 2002 (2002-08-08)	10
A	paragraph [0034] - paragraph [0035] paragraph [0038]; figures 2-4	11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2006/053613

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 0215227	A	21-02-2002	DE	10039966	A1	07-03-2002
			EP	1309984	A1	14-05-2003
			JP	2004507044	T	04-03-2004
			US	2004051431	A1	18-03-2004
US 2005146653	A1	07-07-2005	JP	2005195778	A	21-07-2005
US 2004080925	A1	29-04-2004	CN	1492270	A	28-04-2004
			JP	2004145295	A	20-05-2004
			KR	20040036954	A	04-05-2004
US 6181071	B1	30-01-2001	JP	3237561	B2	10-12-2001
			JP	10240146	A	11-09-1998
			TW	382684	B	21-02-2000
JP 11231144	A	27-08-1999	NONE			
US 6494587	B1	17-12-2002	NONE			
US 2002105259	A1	08-08-2002	AU	2002235441	A1	30-07-2002
			WO	02058093	A2	25-07-2002