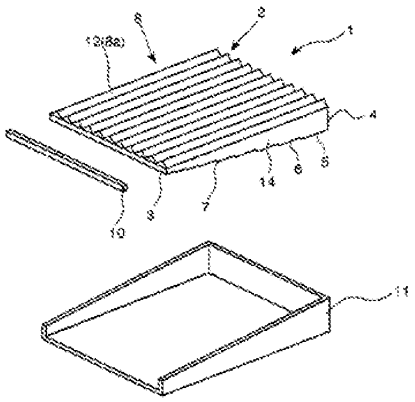
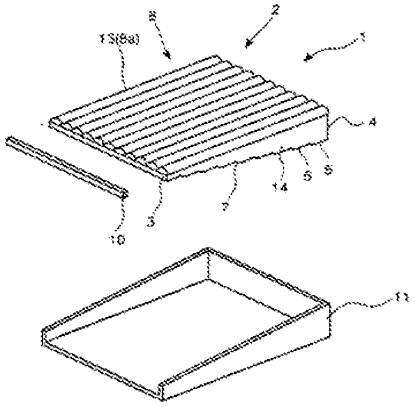
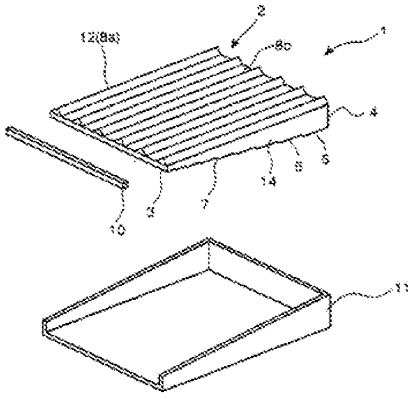
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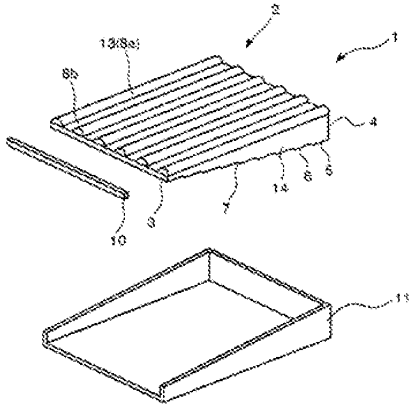
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【図３】

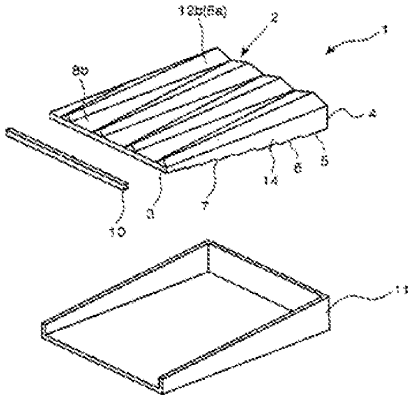


【図４】

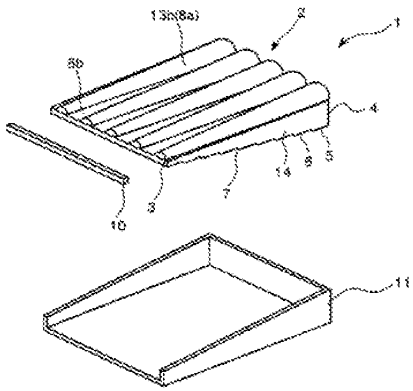


Microsoft Exhibit 1002 - Page 1195
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

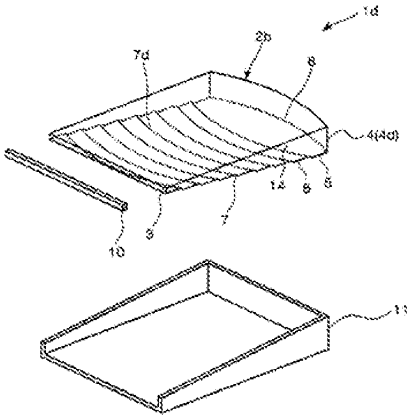
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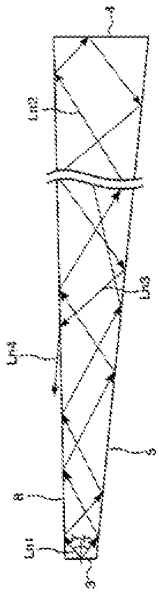
【図６】



【図７】

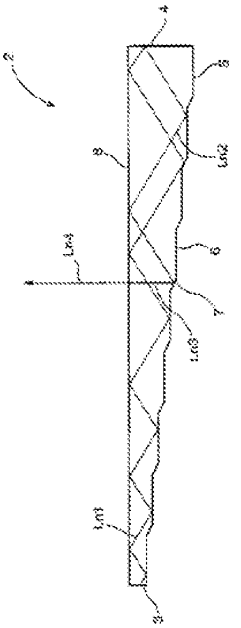


【図８】

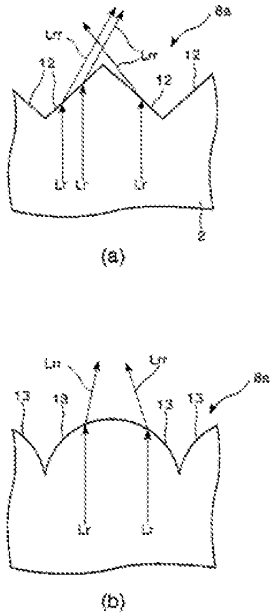


Microsoft Exhibit 1002 - Page 1196
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

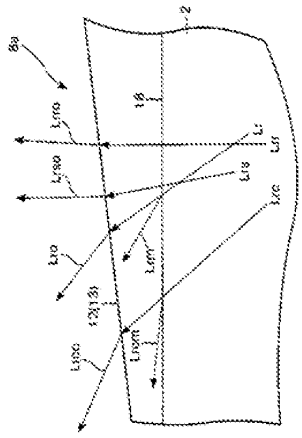
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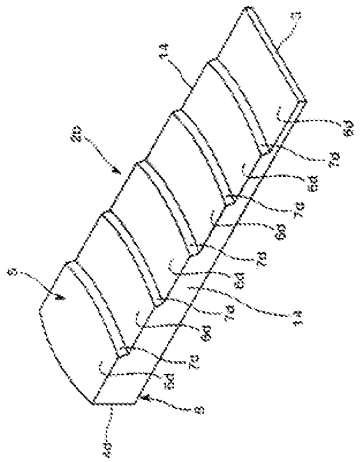
【図１０】



【図１１】

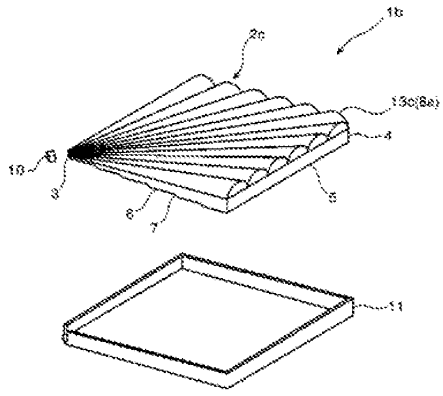


【図１２】

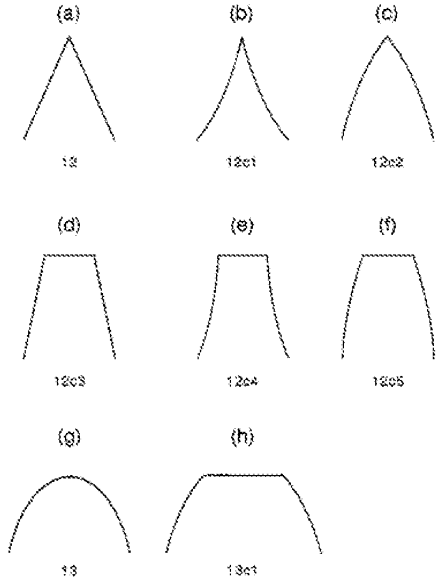


Microsoft Exhibit 1002 - Page 1197
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

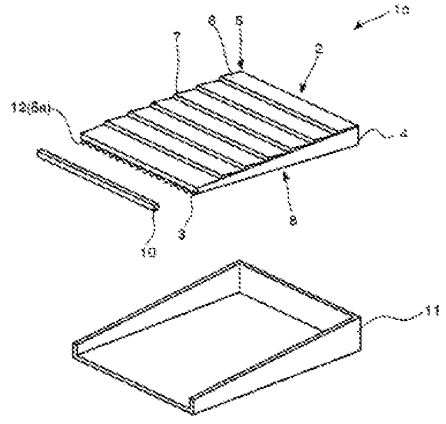
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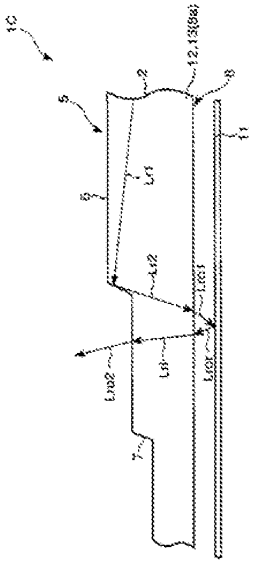
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【図15】

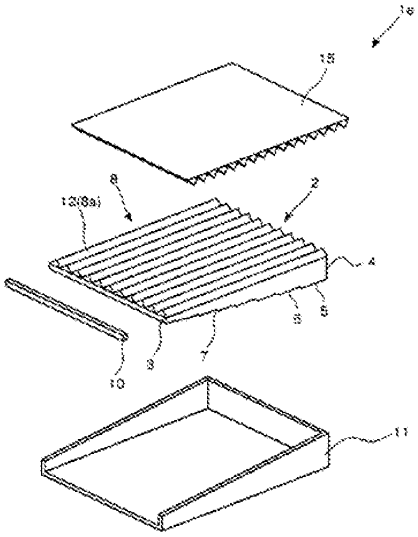


【図16】

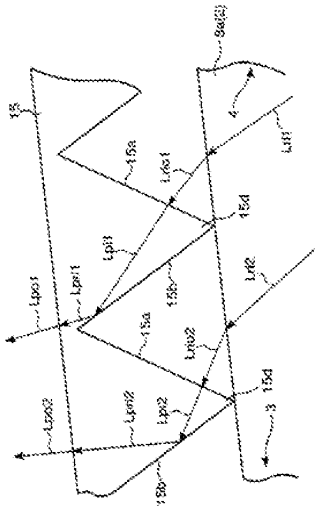


Microsoft Exhibit 1002 - Page 1198
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

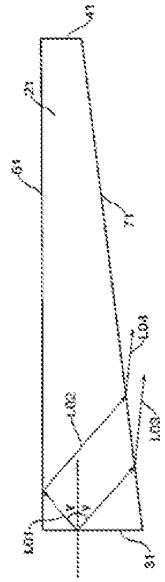
【図17】



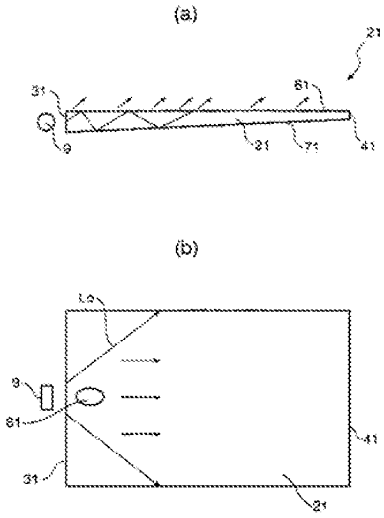
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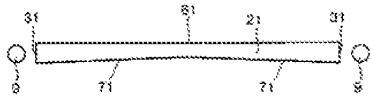
【図19】



【図20】



【図21】



Microsoft Exhibit 1002 - Page 1199
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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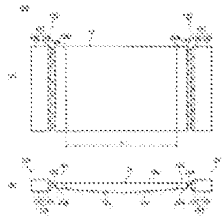
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G02F 1/13357 (2006.01)
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(21)Application number : 2007-041522
(22)Date of filing : 21.02.2007

(71)Applicant : FUJIFILM CORP
(72)Inventor : IWASAKI OSAMU

(54) PLANAR LIGHTING APPARATUS

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a planar lighting apparatus which can emit a high color rendering and high luminous light from a light emitting surface and can make a light emitting surface enlarged.
SOLUTION: The planar lighting apparatus is provided with a light source and a light guide plate which is provided with a light incident surface into which a light emitted from the light source enters and a light emitting surface for emitting a light incident from the light incident surface. The light source is provided with a plurality of LED chips which emit light of light emitting wavelengths having two or more of main peak wavelengths.



Microsoft Exhibit 1002 - Page 1201
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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(21)出願番号　特願2007-41522(P2007-41522)
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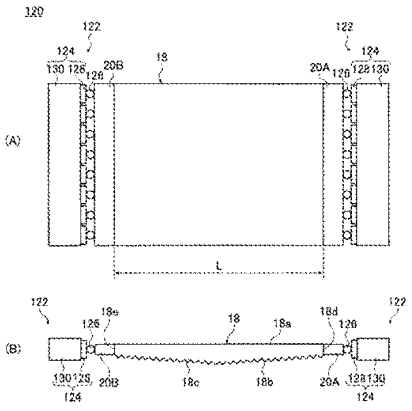
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Fターム(参考)　2H038 AA55 BA06
2H091 FA23Z FA45Z LA11 LA16 LA20 LA30

最終頁に続く

(54)【発明の名称】面状照明装置

(57)【要約】
【課題】光射出面から演色性が高くかつ輝度が高い光を射出させることができ、光射出面の大型化が可能な面状照明装置を提供することにある。
【解決手段】光源と、光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、光源は、複数の、２つ以上の主要ピーク波長を有する発光波長の光を射出するＬＥＤチップを有することにより上記課題を解決する。
【選択図】図１１



Microsoft Exhibit 1002 - Page 1202
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【特許請求の範囲】
【請求項1】
光源と、前記光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、
前記光源は、複数の、２つ以上の主要ピーク波長を有する発光波長の光を射出するＬＥＤチップを有する面状照明装置。
【請求項2】
複数の互いに異なる発光波長の光を射出するＬＥＤチップで構成された光源と、前記光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、
前記ＬＥＤチップは、２つ以上の主要ピーク波長を有する発光波長の光を射出する面状照明装置。
【請求項3】
前記ＬＥＤチップは、光を発光する発光面を備えるＬＥＤと、前記ＬＥＤの発光面に配置され、前記ＬＥＤから射出された光の一部の波長を変換する波長変換部材とを有する請求項１または２に記載の面状照明装置。
【請求項4】
前記ＬＥＤは、赤色、青色、緑色、紫色、紫外、近紫外、赤外、近赤外のいずれか１つの波長領域の光を発光する請求項３に記載の面状照明装置。
【請求項5】
前記波長変換部材は、光が透過することにより発光する蛍光体である請求項３または４に記載の面状照明装置。
【請求項6】
前記ＬＥＤチップは、赤色、青色、緑色の全てに主要ピークを有する光を射出する請求項項１～５のいずれかに記載の面状照明装置。
【請求項7】
前記ＬＥＤチップは、前記光入射面に対向した位置に、列状に配置されている請求項１～６のいずれかに記載の面状照明装置。
【請求項8】
前記ＬＥＤチップは、前記導光板の前記光出射面に垂直な方向の長さをａとし、前記ＬＥＤの配列方向における長さをｂとし、前記ＬＥＤの配置間隔をｐとしたときに、ｐ＞ｂ＞ａの関係を満足する請求項７に記載の面状照明装置。
【請求項9】
前記光源は、前記ＬＥＤチップを列状に配置したＬＥＤアレイを２つ以上有し、
機械的接合方法及び化学的接合方法の少なくとも一方を用い、前記ＬＥＤアレイの前記ＬＥＤチップと他の前記ＬＥＤアレイの前記ＬＥＤチップとの間隔を所定距離離間させて積層させた構成を有する請求項７または８に記載の面状照明装置。
【請求項10】
光源と、前記光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、
前記光源は、少なくとも１つの、単色の光を射出するＬＥＤを有する面状照明装置。
【請求項11】
複数の互いに異なる発光波長の光を射出するＬＥＤで構成されたＬＥＤユニットを備える光源と、前記光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、
前記ＬＥＤは、単色の光を射出する面状照明装置。
【請求項12】
前記ＬＥＤユニットを構成する前記ＬＥＤは、赤色発光ダイオード、緑色発光ダイオード及び青色発光ダイオードである請求項１１に記載の面状照明装置。

Microsoft Exhibit 1002 - Page 1203
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【請求項13】
さらに、前記光源と前記光入射面との間に配置され、前記光源から射出された光が透過する光透過部を有する請求項１～１２のいずれかに記載の面状照明装置。
【請求項14】
前記光透過部は、前記光源及び前記導光板と非接触で配置されている請求項１３に記載の面状照明装置。
【請求項15】
前記光源は、第１光源と第２光源とで構成され、
前記導光板は、前記第１光源及び前記第２光源の間に配置され、前記第１光源に対向し、前記光射出面の一辺を含む第１光入射面と、前記第２光源に対向し前記一辺の対辺を含む第２入射面とを有し、前記第１光入射面及び第２光入射面から中央に向かうに従って厚みが厚くなる形状である請求項１～１４のいずれかに記載の面状照明装置。
【請求項16】
前記導光板は、第１及び第２光入射面から入射して内部を伝搬する光を散乱する散乱粒子を含有する請求項１５に記載の面状照明装置。
【請求項17】
前記導光板は、前記散乱粒子の散乱断面積をΦ、光の入射方向の半分の長さをL_G、散乱粒子の密度をN_p、補正係数をK_Cとし、K_Cを０．００５以上０．１以下とすると、$1.1 \leqq \Phi \cdot N_p \cdot L_G \cdot K_C \leqq 8.2$を満足する請求項１６に記載の面状照明装置。
【請求項18】
前記導光板の前記光射出面は、外形が矩形状である請求項１５～１７のいずれかに記載の面状照明装置。
【請求項19】
前記導光板の前記光射出面が平坦に形成されており、前記導光板は、前記光射出面の反対側に、前記光射出面の前記一辺に平行な前記光射出面の２等分線に対し、互いに対称に傾斜して形成された第１傾斜面と第２傾斜面を有する請求項１５～１８のいずれかに記載の面状照明装置。
【請求項20】
前記導光板は、前記２等分線に垂直な断面形状において、前記第１傾斜面と前記第２傾斜面の接続部がR形状である請求項１９に記載の面状照明装置。
【請求項21】
所定の偏光成分を選択的に透過させ、それ以外の偏光成分を反射させる偏光分離フィルムが前記導光板の前記光射出面上に、前記導光板と一体に形成されている請求項１５～２０のいずれかに記載の面状照明装置。
【請求項22】
前記導光板の前記光射出面が、前記光射出面の前記一辺に平行な前記光射出面の２等分線に対して互いに対称に傾斜する第１傾斜面と第２傾斜面とによって形成されており、更に、前記光射出面の反対側の面も、前記光射出面の前記一辺に平行な前記光射出面の２等分線に対して互いに対称に傾斜する第３傾斜面と第４傾斜面とによって形成されている請求項１５～１８のいずれかに記載の面状照明装置。
【請求項23】
前記導光板の前記光射出面が、前記光射出面の前記一辺に平行な前記光射出面の２等分線に対して互いに対称に傾斜する第１傾斜面と第２傾斜面とによって形成されており、前記光射出面の反対側の面が平坦に形成されている請求項１５～１８のいずれかに記載の面状照明装置。
【請求項24】
前記導光板を２つ以上有し、
前記導光板の前記光射出面の一辺と前記光入射面の一辺を含む面と、他の前記導光板の前記光射出面の一辺と前記入射面の一辺を含む面とが隣接して配置されている請求項１５～２３のいずれかに記載の面状照明装置。

Microsoft Exhibit 1002 - Page 1204
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【請求項25】
前記導光板は、前記第１光入射面及び前記第２光入射面を除く面の少なくとも一面に複数の拡散反射体が配置されている請求項１５～２４のいずれかに記載の面状照明装置。
【請求項26】
前記拡散反射体は、前記第１光入射面及び前記第２光入射面から離れるに従って、密に配置されている請求項２５に記載の面状照明装置。
【請求項27】
前記拡散反射体は、前記第１傾斜面及び前記第２傾斜面に配置される請求項２５または２６に記載の面状照明装置。
【請求項28】
前記導光板は、前記第１光入射面側の一部及び前記第２光入射面側の一部が、他の部分とは異なる材料で形成されており、前記第１光入射面側の一部及び前記第２光入射面側の一部の材料の屈折率をＮｍとし、他の部分の材料の屈折率をＮｉとしたときに、Ｎｍ＞Ｎｉの関係を満足する請求項１５～２７のいずれかに記載の面状照明装置。
【請求項29】
さらに、前記導光板の、前記第１光入射面近傍の前記光射出面、前記第１光入射面近傍の前記第１傾斜面、前記第２光入射面近傍の前記光射出面、及び前記第２光入射面近傍の前記第２傾斜面にそれぞれ配置された反射素材を有する請求項１５～２８のいずれかに記載の面状照明装置。
【請求項30】
前記光入射面は、表面粗さが３８０ｎｍ以下である請求項１５～２９のいずれかに記載の面状照明装置。
【発明の詳細な説明】
【技術分野】
【0001】
本発明は、液晶表示装置などに用いられる面状照明装置に関する。
【背景技術】
【0002】
液晶表示装置には、液晶表示パネルの裏面側から光を照射し、液晶表示パネルを照明するバックライトユニットが用いられている。バックライトユニットは、照明用の光源が発する光を拡散して液晶表示パネルを照射する導光板、導光板から出射される光を均一化するプリズムシートや拡散シートなどの部品を用いて構成される。
【0003】
現在、大型の液晶テレビのバックライトユニットは、照明用の光源の直上に導光板を配置した、いわゆる直下型と呼ばれる方式が主流である（例えば、実開平５－４１３３号公報参照）。この方式では、光源である冷陰極管を液晶表示パネルの背面に複数本配置し、内部を白色の反射面として均一な光量分布と必要な輝度を確保している。
【0004】
しかしながら、直下型のバックライトユニットでは、光量分布を均一にするために、液晶表示パネルに対して垂直方向の厚みが３０ｍｍ程度必要である。今後バックライトユニットは、さらに薄型のものが望まれるであろうが、直下型では光量むらの観点から１０ｍｍ以下の厚みをもつバックライトユニットを実現することは困難であると考えられる。
【0005】
そこで、薄型のバックライトユニットして、タンデム方式が提案されている（例えば、特開平２－２０８６３１号公報、特開平１１－２８８６１１号公報及び特開２００１－３１２９１６号公報参照。）。
【0006】
【特許文献1】実開平５－４１３３号公報
【特許文献2】特開平２－２０８６３１号公報
【特許文献3】特開平１１－２８８６１１号公報
【特許文献4】特開２００１－３１２９１６号公報

Microsoft Exhibit 1002 - Page 1205
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【発明の開示】
【発明が解決しようとする課題】
【0007】
しかしながら、タンデム方式のバックライトユニットでは、薄型のものを実現することが可能であるが、冷陰極管とリフレクタの相対寸法の関係により光利用効率で直下型より劣っている。また、導光板に形成された溝に冷陰極管を収容する形状の導光板を用いる場合、導光板の厚みを薄くすると、溝に配置された冷陰極管の直上における輝度が強くなり、光出射面の輝度むらが顕著になる。
【0008】
そのため、タンデム方式のバックライトユニットの薄型化には限界があった。
本発明は、かかる実情に鑑みてなされたものであり、薄型な形状であり、かつ均一で輝度むらが少ない照明光を出射することができる面状照明装置を提供することを目的とする。
さらに、本発明は、光射出面から演色性が高くかつ輝度が高い光を射出させることができ、光射出面の大型化が可能な面状照明装置を提供することを他の目的とする。
【課題を解決するための手段】
【0009】
前記課題を解決するために、本発明の第１の形態は、光源と、前記光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、前記光源は、複数の、２つ以上の主要ピーク波長を有する発光波長の光を射出するＬＥＤチップを有する面状照明装置を提供するものである。
前記課題を解決するために、本発明の第２の形態は、複数の互いに異なる発光波長の光を射出するＬＥＤチップで構成された光源と、前記光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、前記ＬＥＤは、２つ以上の主要ピーク波長を有する発光波長の光を射出する面状照明装置を提供するものである。
【0010】
ここで、第１の形態及び第２の形態の面状照明装置において、前記ＬＥＤチップは、光を発光する発光面を備えるＬＥＤと、前記ＬＥＤの発光面に配置され、前記ＬＥＤチップから射出された光の一部の波長を変換する波長変換部材とを有することが好ましい。
また、前記ＬＥＤは、赤色、青色、緑色、紫色、紫外、近紫外、赤外、近赤外のいずれか１つの波長領域の光を発光することが好ましい。
また、前記波長変換部材は、光が透過することにより発光する蛍光体であることが好ましい。
さらに、前記ＬＥＤチップは、赤色、青色、緑色の全てに主要ピークを有する光を射出する。
【0011】
また、前記ＬＥＤチップは、前記光入射面に対向した位置に、列状に配置されていることが好ましい。
また、前記ＬＥＤチップは、前記導光板の前記光出射面に垂直な方向の長さをａとし、前記ＬＥＤの配列方向における長さをｂとし、前記ＬＥＤの配置間隔をｐとしたときに、ｐ＞ｂ＞ａの関係を満足することが好ましい。
さらに、前記光源は、前記ＬＥＤチップを列状に配置したＬＥＤアレイを２つ以上有し、機械的接合方法及び化学的接合方法の少なくとも一方を用い、前記ＬＥＤアレイの前記ＬＥＤチップと他の前記ＬＥＤアレイの前記ＬＥＤチップとの間隔を所定距離離間させて積層させた構成を有することが好ましい。
【0012】
また、前記課題を解決するために、本発明の第３の形態は、光源と、前記光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、前記光源は、少なくとも１つの、単色の光を射出するＬＥＤを有する

Microsoft Exhibit 1002 - Page 1206
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

面状照明装置を提供するものである。

さらに、前記課題を解決するために、本発明の第４の形態は、複数の互いに異なる発光波長の光を射出するＬＥＤで構成されたＬＥＤユニットを備える光源と、前記光源から射出された光が入射する光入射面及び前記光入射面から入射した光を射出する光射出面を備える導光板とを有し、前記ＬＥＤは、単色の光を射出する面状照明装置を提供するものである。

ここで、第３の形態及び第４形態の面状照明装置において、前記ＬＥＤユニットを構成する前記ＬＥＤは、赤色発光ダイオード、緑色発光ダイオード及び青色発光ダイオードであることが好ましい。

【0013】

また、第１～第４形態の面状照明装置は、さらに、前記光源と前記光入射面との間に配置され、前記光源から射出された光が透過する光透過部を有することが好ましい。

また、前記光透過部は、前記光源及び前記導光板と非接触で配置されていることが好ましい。

【0014】

さらに、前記光源は、第１光源と第２光源とで構成され、

前記導光板は、前記第１光源及び前記第２光源の間に配置され、前記第１光源に対向し、前記光射出面の一辺を含む第１光入射面と、前記第２光源に対向し前記一辺の対辺を含む第２入射面とを有し、前記第１光入射面及び第２光入射面から中央に向かうに従って厚みが厚くなる形状であることが好ましい。

また、前記導光板は、第１及び第２光入射面から入射して内部を伝搬する光を散乱する散乱粒子を含有することが好ましい。

また、前記導光板は、前記散乱粒子の散乱断面積をΦ、光の入射方向の半分の長さをL_G、散乱粒子の密度をN_p、補正係数をK_Cとし、K_Cを０．００５以上０．１以下とすると、$1.1 \leqq \Phi \cdot N_p \cdot L_G \cdot K_C \leqq 8.2$を満足することが好ましい。

また、前記導光板の前記光射出面は、外形が矩形状であることが好ましい。

【0015】

また、前記導光板の前記光射出面が平坦に形成されており、前記導光板は、前記光射出面の反対側に、前記光射出面の前記一辺に平行な前記光射出面の２等分線に対し、互いに対称に傾斜して形成された第１傾斜面と第２傾斜面を有することが好ましい。

また、前記導光板は、前記２等分線に垂直な断面形状において、前記第１傾斜面と前記第２傾斜面の接続部がＲ形状であることが好ましい。

また、所定の偏光成分を選択的に透過させ、それ以外の偏光成分を反射させる偏光分離フィルムが前記導光板の前記光射出面上に、前記導光板と一体に形成されていることが好ましい。

【0016】

また、前記導光板の前記光射出面が、前記光射出面の前記一辺に平行な前記光射出面の２等分線に対して互いに対称に傾斜する第１傾斜面と第２傾斜面とによって形成されており、更に、前記光射出面の反対側の面も、前記光射出面の前記一辺に平行な前記光射出面の２等分線に対して互いに対称に傾斜する第３傾斜面と第４傾斜面とによって形成されていることが好ましい。

【0017】

また、前記導光板の前記光射出面が、前記光射出面の前記一辺に平行な前記光射出面の２等分線に対して互いに対称に傾斜する第１傾斜面と第２傾斜面とによって形成されており、前記光射出面の反対側の面が平坦に形成されていることが好ましい。

【0018】

また、前記導光板を２つ以上有し、前記導光板の前記光射出面の一辺と前記光入射面の一辺を含む面と、他の前記導光板の前記光射出面の一辺と前記入射面の一辺を含む面とが隣接して配置されていることが好ましい。

また、前記導光板は、前記第１光入射面及び前記第２光入射面を除く面の少なくとも一

Microsoft Exhibit 1002 - Page 1207
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

面に複数の拡散反射体が配置されていることが好ましい。

また、前記拡散反射体は、前記第１光入射面及び前記第２光入射面から離れるに従って、密に配置されていることが好ましい。

また、前記拡散反射体は、前記第１傾斜面及び前記第２傾斜面に配置されることが好ましい。

また、前記導光板は、前記第１光入射面側の一部及び前記第２光入射面側の一部が、他の部分とは異なる材料で形成されており、前記第１光入射面側の一部及び前記第２光入射面側の一部の材料の屈折率をＮｍとし、他の部分の材料の屈折率をＮｉとしたときに、Ｎｍ＞Ｎｉの関係を満足することが好ましい。

さらに、前記導光板の、前記第１光入射面近傍の前記光射出面、前記第１光入射面近傍の前記第１傾斜面、前記第２光入射面近傍の前記光射出面、及び前記第２光入射面近傍の前記第２傾斜面にそれぞれ配置された反射素材を有することが好ましい。

また、前記光入射面は、表面粗さが３８０ｎｍ以下であることが好ましい。

【発明の効果】

【0019】

本発明によれば、光源としてＬＥＤを用いることで、光射出面から演色性が高く、かつ演色性の高い光を射出させることができる。さらに、導光板の光入射面からより離れた位置まで光を届かせることができ、装置を大型化することができる。

さらに、所定の間隔離れて配置された第１光源と第２光源の間に導光板が配置された構成とし、その導光板を、光射出面と、第１光源に対向する第１光入射面と、第２光源に対向する第２入射面とを有し、第１光入射面及び第２光入射面から中央に向かうに従って厚みが厚くなる形状とすることで、薄型化を実現することができるとともに、均一で且つむらが少ない面状の照明光を出射することができる。

さらに、導光板に内部を伝搬する光を散乱する散乱粒子を含有させることで、導光板に入射した光を散乱させることができ、均一で且つむらが少ない面状の照明光を出射することができ、さらにより薄型化することができる。

【発明を実施するための最良の形態】

【0020】

本発明に係る面状照明装置を備える液晶表示装置について、添付の図面に示す実施形態を基に詳細に説明する。

図１（Ａ）は、本発明の第１の実施形態に係る面状照明装置を備える液晶表示装置の概略を示す斜視図であり、図１（Ｂ）は液晶表示装置の概略断面図である。また、図２（Ａ）は、本発明に係る面状照明装置（以下、バックライトユニットという）に用いられる導光板と光源の概略平面図であり、図２（Ｂ）は、導光板の概略断面図である。

液晶表示装置１０は、バックライトユニット２と、そのバックライトユニット２の光射出面側に配置される液晶表示パネル４と、液晶表示パネル４を駆動する駆動ユニット６とを有して構成される。

【0021】

液晶表示パネル４は、予め特定の方向に配列してある液晶分子に、部分的に電界を印加してこの分子の配列を変え、液晶セル内に生じた屈折率の変化を利用して、液晶表示パネル４の表面上に文字、図形、画像などを表示する。

駆動ユニット６は、液晶表示パネル４内の透明電極に電圧をかけ、液晶分子の向きを変えて液晶表示パネル４を透過する光の透過率を制御する。

【0022】

バックライトユニット２は、液晶表示パネル４の背面から、液晶表示パネル４の全面に光を照射する照明装置であり、液晶表示パネル４の画像表示面と略同一形状の光射出面を有する。

【0023】

本発明の第１の実施形態に係るバックライトユニット２は、図１（Ａ）、図１（Ｂ）、図２（Ａ）及び図２（Ｂ）に示すように、２つの光源１２と、拡散フィルム１４と、偏光

Microsoft Exhibit 1002 - Page 1208
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

分離フィルム１６と、導光部材としての導光板１８と、光混合部２０と、反射シート２２とを有する。以下、バックライトユニット２を構成する各構成部品について説明する。

【0024】

まず、光源１２について説明する。

２つの光源１２は、図１（Ｂ）に示されるように、それらの間に導光板１８が挟まれるように配置される。光源１２は、ＬＥＤアレイ２４とカップリングレンズ４０を備える。ＬＥＤアレイ２４は、赤色、緑色及び青色の３種類の発光ダイオード（以下、それぞれＲ－ＬＥＤ３２、Ｇ－ＬＥＤ３４及びＢ－ＬＥＤ３６という）を用いて形成される複数のＲＧＢ－ＬＥＤ３０が一列に配置されて構成されている。図３に、複数のＲＧＢ－ＬＥＤ３０の配置の様子を模式的に示す。図３に示すように、Ｒ－ＬＥＤ３２、Ｇ－ＬＥＤ３４及びＢ－ＬＥＤ３６が規則的に配置されている。

また、図４に示すように、ＲＧＢ－ＬＥＤ３０は、Ｒ－ＬＥＤ３２、Ｇ－ＬＥＤ３４及びＢ－ＬＥＤ３６からそれぞれ出射する光が所定の位置において交差するように、３種類のＬＥＤ（Ｒ－ＬＥＤ３２、Ｇ－ＬＥＤ３４及びＢ－ＬＥＤ３６）の光軸の向きが調整されている。このように３種類のＬＥＤを調整することによって、それらＬＥＤの光が混色されて白色光とされる。

このように、光源としてＬＥＤを用いることで、光源から射出される光を後述する導光板のより奥まで届かせることができる。

３原色のＬＥＤ（Ｒ－ＬＥＤ３２、Ｇ－ＬＥＤ３４及びＢ－ＬＥＤ３６）を用いて構成されたＲＧＢ－ＬＥＤ３０は、従来バックライト用光源として使用される冷陰極管（ＣＣＦＬ）と比較して色再現領域が広く色純度が高いため、このＲＧＢ－ＬＥＤ３０をバックライト用光源として使用した場合には、従来よりも色再現性が高くなり、鮮やかな色彩の画像を表示することが可能になる。

【0025】

図３及び図４に示すように、ＲＧＢ－ＬＥＤ３０の各ＬＥＤの光射出側にカップリングレンズとして３つのボールレンズ４２、４４及び４６が配置されている。ボールレンズ４２、４４及び４６は、各ＬＥＤに対応して配置されている。すなわち、１つのＲＧＢ－ＬＥＤ３０について３つのボールレンズ４２、４４及び４６が組み合わされて用いられている。各ＬＥＤ（Ｒ－ＬＥＤ３２、Ｇ－ＬＥＤ３４及びＢ－ＬＥＤ３６）から出射した光は、ボールレンズ４２、４４及び４６によって平行光にされる。そして、所定の位置で交わって白色光にされた後、導光板１８の光混合部２０に入射する。３つのボールレンズ４２、４４及び４６を組み合わせて用いたカップリングレンズは、３軸を持ったレンズであり、ＲＧＢ－ＬＥＤの各ＬＥＤの光を１点に絞り込んでミキシングすることができる。

ここでは、カップリングレンズとしてボールレンズを用いたが、これに限らず、ＬＥＤが発する光を平行光にすることができれば特に限定されない。カップリングレンズには、例えば、シリンドリカルレンズ、レンチキュラ、かまぼこ型のレンズ、フレネルレンズなどを用いることもできる。

【0026】

次に、バックライトユニット２の導光板１８について説明する。

導光板１８は、図２（Ａ）に示すように、略矩形形状の平坦な光射出面１８ａと、光射出面１８ａの反対側に位置し、光射出面１８ａの一辺に平行で、光射出面１８ａを２等分する２等分線Ｘに対して互いに対称で、光射出面１８ａに対して所定の角度で傾斜する２つの傾斜面（第１傾斜面１８ｂと第２傾斜面１８ｃ）と、２つのＬＥＤアレイ２４に対向し、それらＬＥＤアレイ２４からの光が入射される２つの光入射面（第１光入射面１８ｄと第２光入射面１８ｅ）とを有している。第１傾斜面１８ｂ及び第２傾斜面１８ｃは、２等分線Ｘを境にして、光射出面１８ａに対し傾斜している。導光板１８は、第１光入射面１８ｄ及び第２光入射面１８ｅから中央に向かうに従って厚さが厚くなっており、中央部が最も厚く、両端部が最も薄くなっている。

つまり、導光板１８は、略板状形状であり、光射出面１８ａが板の正面（面積の大きい面）、第１光入射面１８ｄ及び第２光入射面１８ｅが板の側面（厚み方向の細長い面）、

Microsoft Exhibit 1002 - Page 1209
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

第１傾斜面１８ｂ及び第２傾斜面１８ｃが板の裏面となる。

光射出面１８ａに対する第１傾斜面１８ｂ及び第２傾斜面１８ｃの角度は特に限定されない。

また、第１傾斜面１８ｂ及び第２傾斜面１８ｃには、光入射面１８ｄ及び１８ｅと平行な方向にプリズム列が形成されている。このようなプリズム列の代わりに、プリズムに類する光学素子を規則的に形成することもできる。例えば、レンチキュラーレンズ、凹レンズ、凸レンズ、ピラミッド型など、レンズ効果を有する光学素子を導光板の傾斜面に形成することもできる。

【0027】

図２に示す導光板１８では、第１光入射面１８ｄ及び第２光入射面１８ｅから入射した光は、導光板１８の内部に含まれる散乱体（詳細は後述する）によって散乱されつつ、導光板１８内部を通過し、直接、もしくは、第１傾斜面１８ｂ及び第２傾斜面１８ｃで反射した後、光射出面１８ａから出射する。このとき、第１傾斜面１８ｂ及び第２傾斜面１８ｃから一部の光が漏出する場合もあるが、漏出した光は導光板１８の第１傾斜面１８ｂ及び第２傾斜面１８ｃを覆うようにして配置される反射シート（図示せず）によって反射され再び導光板１８の内部に入射する。

【0028】

導光板１８は、透明樹脂に、光を散乱させるための散乱粒子が混練分散されて形成されている。導光板１８に用いられる透明樹脂の材料としては、例えば、ＰＥＴ（ポリエチレンテレフタレート）、ＰＰ（ポリプロピレン）、ＰＣ（ポリカーボネート）、ＰＭＭＡ（ポリメチルメタクリレート）、ベンジルメタクリレート、ＭＳ樹脂、あるいはＣＯＰ（シクロオレフィンポリマー）のような光学的に透明な樹脂が挙げられる。導光板１８に混練分散させる散乱粒子としては、アトシパール、シンコーン、シリカ、ジルコニア、誘電体ポリマなどを用いることができる。このような散乱粒子を導光板１８の内部に含有させることによって、均一で輝度むらが少ない照明光を光出射面から出射することができる。

このような導光板１８は、押出成形法や射出成形法を用いて製造することができる。

【0029】

また、導光板１８に含まれる散乱粒子の散乱断面積をΦ、光の入射する方向において導光板の光入射面から光射出面に直交する方向の厚みが最大となる位置までの長さ、本実施形態では、導光板の光の入射する方向（導光板１８の第１光入射面１８ｄに垂直な方向、以下「光軸方向」ともいう。）の半分の長さをL_G、導光板１８に含まれる散乱粒子の密度（単位体積あたりの粒子数）をN_p、補正係数をK_Cとした場合に、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値が１．１以上であり、かつ８．２以下であり、さらに、補正係数K_Cの値が０．００５以上０．１以下であるという関係を満たしている。導光板１８は、このような関係を満たす散乱粒子を含んでいるので、均一で輝度むらが少ない照明光を光出射面から出射することができる。

【0030】

一般的に、平行光束を等方媒質に入射させた場合の透過率Ｔは、Ｌａｍｂｅｒｔ－Ｂｅｅｒ則により下記式（１）で表される。

$$T = I / I_0 = \exp(-\rho \cdot x) \quad \cdots (1)$$

ここで、ｘは距離、I_0は入射光強度、Ｉは出射光強度、ρは減衰定数である。

【0031】

上記減衰定数ρは、粒子の散乱断面積Φと媒質に含まれる単位体積当たりの粒子数N_pとを用いて下記式（２）で表される。

$$\rho = \Phi \cdot N_p \quad \cdots (2)$$

したがって、導光板の光軸方向の半分の長さをL_Gとすると、光の取り出し効率E_{out}は、下記式（３）で与えられる。ここで、導光板の光軸方向の半分の長さL_Gは、導光板１８の光入射面に垂直な方向における導光板１８の一方の光入射面から導光板１８の中心までの長さとなる。

また、光の取り出し効率とは、入射光に対する、導光板の光入射面から光軸方向に長さ

Microsoft Exhibit 1002 - Page 1210
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

L_G離間した位置に到達する光の割合であり、例えば、図２に示す導光板１８の場合は、端面に入射する光に対する導光板の中心（導光板の光軸方向の半分の長さとなる位置）に到達する光の割合である。

$$E_{out} \propto \exp(-\Phi \cdot N_p \cdot L_G) \cdots (3)$$

【0032】

ここで式（３）は有限の大きさの空間におけるものであり、式（１）との関係を補正するための補正係数K_Cを導入する。補正係数K_Cは、有限の空間の光学媒質中で光が伝搬する場合に経験的に求められる無次元の補正係数である。そうすると、光の取り出し効率E_{out}は、下記式（４）で表される。

$$E_{out} = \exp(-\Phi \cdot N_p \cdot L_G \cdot K_C) \cdots (4)$$

【0033】

式（４）に従えば、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値が３．５のときに、光の取り出し効率$E_{out}$が３％であり、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値が４．７のときに、光の取り出し効率$E_{out}$が１％である。

この結果より、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値が大きくなると、光の取り出し効率$E_{out}$が低くなることが分かる。光は導光板の光軸方向へ進むにつれて散乱するため、光の取り出し効率E_{out}が低くなると考えられる。

【0034】

したがって、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値は大きいほど導光板として好ましい性質であることが分かる。つまり、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値を大きくすることで、光の入射面と対向する面から射出される光を少なくし、光射出面から射出される光を多くすることができる。すなわち、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値を大きくすることで、入射面に入射する光に対する光射出面から射出される光の割合（以下「光利用効率」ともいう。）を高くすることができる。具体的には、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値を１．１以上とすることで、光利用効率を５０％以上にすることができる。

ここで、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値は大きくすると、導光板１８の光射出面１８ａから出射する光の照度むらが顕著になるが、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値を８．２以下とすることで、照度むらを一定以下（許容範囲内）に抑えることができる。なお、照度と輝度は略同様に扱うことができる。従って、本発明においては、輝度と照度とは、同様の傾向があると推測される。

以上より、本発明の導光板の$\Phi \cdot N_p \cdot L_G \cdot K_C$の値は、１．１以上かつ８．２以下であるという関係を満たすことが好ましく、２．０以上かつ７．０以下であることがより好ましい。また、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値は、３．０以上であればさらに好ましく、４．７以上であれば最も好ましい。

また、補正係数K_Cは、０．００５以上０．１以下であることが好ましい。

【0035】

以下、具体例とともに、導光板についてより詳細に説明する。

まず、散乱断面積Φ、粒子密度N_p、導光板の光軸方向の半分の長さL_G、補正係数K_Cを種々の値とし、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値が異なる各導光板について、計算機シミュレーションにより光利用効率を求め、さらに照度むらの評価を行った。ここで、照度むら［％］は、導光板の光射出面から射出される光の最大照度をI_{Max}とし、最小照度をI_{Min}とし、平均照度をI_{Ave}としたときの［（$I_{Max}-I_{Min}$）／I_{Ave}］×１００とした。

測定した結果を下記表１に示す。また、表１の判定は、光利用効率が５０％以上かつ照度むらが１５０％以下の場合を○、光利用効率が５０％より小さいまたは照度むらが１５０％より大きいの場合を×として示す。

また、図５に、$\Phi \cdot N_p \cdot L_G \cdot K_C$の値と光利用効率（光入射面に入射する光に対して光射出面から射出される光の割合）との関係を測定した結果を示す。

【0036】

Microsoft Exhibit 1002 - Page 1211
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【表1】

	Φ[m^2]	N_p[個／m^3]	L_G[m]	K_C	$\Phi N_p L_G K_C$	光利用効率[%]	照度むら[%]	判定
実施例1	2.0×10^{-12}	2.2×10^{14}	0.3	0.03	3.51	81.6	84	○
実施例2	2.0×10^{-12}	4.3×10^{14}	0.3	0.02	6.21	84.7	149	○
実施例3	2.0×10^{-12}	8.6×10^{14}	0.1	0.02	3.86	82.8	82	○
実施例4	1.1×10^{-10}	1.5×10^{13}	0.3	0.008	3.91	83.0	105	○
実施例5	1.1×10^{-10}	2.0×10^{13}	0.3	0.007	4.98	84.3	142	○
実施例6	1.1×10^{-10}	3.5×10^{13}	0.1	0.007	2.86	79.2	47	○
比較例1	2.0×10^{-12}	2.2×10^{13}	0.3	0.05	0.66	29.1	51	×
比較例2	1.1×10^{-12}	2.5×10^{12}	0.3	0.01	0.99	43.4	59	×
比較例3	4.8×10^{-10}	8.6×10^{17}	0.1	15.2	6.26	84.8	201	×
比較例4	4.8×10^{-13}	1.7×10^{15}	0.1	13.9	11.5	84.9	225	×

【0037】

表１及び図５に示すように、$\Phi \cdot N_p \cdot L_G \cdot K_C$ を１．１以上とすることで、光利用効率を大きくすること、具体的には光利用効率を５０％以上とすることができ、８．２以下とすることで、照度ムラを１５０％以下にすることができることがわかる。

また、Ｋｃを０．００５以上とすることで、光利用効率を高くすることができ、０．１以下とすることで、導光板からの射出される光の照度むらを小さくすることができることがわかる。

【0038】

次に、導光板に混練又は分散させる微粒子の粒子密度N_pが種々の値の導光板を作成し、それぞれの導光板の光射出面の各位置から射出される光の照度分布を測定した。ここで本実施形態では、粒子密度N_pを除いて他の条件、具体的には、散乱断面積Φ、導光板の光軸方向の半分の長さL_G、補正係数K_C、導光板の形状等は、同じ値とした。従って、本実施形態では、$\Phi \cdot N_p \cdot L_G \cdot K_C$は、粒子密度$N_p$に比例して変化する。

このようにして種々の粒子密度の導光板について、それぞれ光射出面から射出される光の照度分布を測定した結果を図６に示す。図６は、縦軸を照度［ｌｘ］とし、横軸を導光板の一方の光入射面からの距離（導光長）［ｍｍ］とした。

【0039】

さらに、測定した照度分布の導光板の側壁から射出される光の最大照度をI_{Max}とし、最小照度をI_{Min}とし、平均照度をI_{Ave}としたときの照度むら［$(I_{Max}-I_{Min})/I_{Ave}$］×１００［％］を算出した。

図７に、算出した照度むらと粒子密度との関係を示す。図７では、縦軸を照度むら［％］とし、横軸を粒子密度［個／m^3］とした。また、図７には、横軸を同様に粒子密度とし、縦軸を光利用効率［％］とした、光利用効率と粒子密度との関係も併せて示す。

【0040】

図６、図７に示すように、粒子密度を高くする、つまり$\Phi \cdot N_p \cdot L_G \cdot K_C$を大きくすると、光利用効率は高くなるが、照度むらも大きくなる。また、粒子密度を低くする、つまり、$\Phi \cdot N_p \cdot L_G \cdot K_C$を小さくすると、光利用効率は低くなるが、照度むらを小さくなることがわかる。

ここで、$\Phi \cdot N_p \cdot L_G \cdot K_C$を１．１以上８．２以下とすることで、光利用効率を５０％以上とし、かつ、照度むらを１５０％以下とすることができる。照度むらを１５０％以下とすることで、照度むらを目立たなくすることができる。

つまり、$\Phi \cdot N_p \cdot L_G \cdot K_C$を１．１以上８．２以下とすることで、光利用効率を一定以上とし、かつ照度むらも低減することができることがわかる。

【0041】

なお、本実施形態では、図１（Ｂ）及び図２（Ｂ）に示すように、光射出面１８ａを平坦な面としたが、本実施形態の場合も、光射出面が実質的に平坦（つまり、平面）であればよい。例えば、製造誤差または成形後の経時などにより、光射出面１８ａが第１傾斜面

Microsoft Exhibit 1002 - Page 1212
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

１８ｄ及び第２傾斜面１８ｃ側に多少の凹の曲面となった場合も実質的に平坦であれば、同様に用いることができる。

【0042】

ここで、導光板１８は、光入射面となる第１光入射面１８ｄ、第２光入射面１８ｅと、光射出面１８ａと、光反射面となる第１傾斜面１８ｂ、第２傾斜面１８ｃの少なくとも１面の表面粗さＲａを３８０ｎｍより小さくすること、つまりＲａ＜３８０ｎｍとすることが好ましい。

光入射面となる第１光入射面１８ｄ、第２光入射面１８ｅの表面粗さＲａを３８０ｎｍよりも小さくすることで、導光板表面の拡散反射を無視すること、つまり、導光板表面での拡散反射を防止することができ、入射効率を向上させることができる。

また、光射出面１８ａの表面粗さＲａを３８０ｎｍよりも小さくすることで、導光板表面の拡散反射透過を無視すること、つまり導光板表面での拡散反射透過を防止することができ、全反射により奥まで光を伝えることができる。

さらに、光反射面となる第１傾斜面１８ｂ、第２傾斜面１８ｃの表面粗さＲａを３８０ｎｍよりも小さくすることで、拡散反射を無視すること、つまり光反射面での拡散反射を防止でき、全反射成分をより奥まで伝えることができる。

【0043】

ここで、導光板は、光入射面における導光板の厚み（入光部厚み）をＤ１とし、光入射面と反対側の面における導光板の厚み（中心厚み）をＤ２とし、導光板の光の入射方向の長さ（導光長）をＬとしたときに、

Ｄ１＜Ｄ２　かつ、

27／100000＜（Ｄ２－Ｄ１）／（Ｌ／２）＜5／100　　（Ａ）

導光板の重量に対する混入された散乱粒子の重量の割合：Ｎｐａの範囲が

０．０４％Ｗｔ＜Ｎｐａ＜０．２５％Ｗｔ

の関係を満たすことが好ましい。上記関係を満足する形状とすることで出射効率を３０％以上に向上させることができる。

または、導光板は、

Ｄ１＜Ｄ２　かつ、

66／100000＜（Ｄ２－Ｄ１）／（Ｌ／２）＜26／1000　　（Ｂ）

導光板の重量に対する混入された散乱粒子の重量の割合：Ｎｐａの範囲が

０．０４％Ｗｔ＜Ｎｐａ＜０、２５％Ｗｔ

の関係を満たすように改良することも好ましい。上記関係を満足する形状とすることで出射効率を４０％以上に向上させることができる。

さらに、導光板は、

Ｄ１＜Ｄ２　かつ、

1／1000＜（Ｄ２－Ｄ１）／（Ｌ／２）＜26／1000　　（Ｃ）

導光板の重量に対する混入された散乱粒子の重量の割合：Ｎｐａの範囲が

０．０４％Ｗｔ＜Ｎｐａ＜０．２５％Ｗｔ

の関係を満たすように改良することがさらに好ましい。上記関係を満足する形状とすることで、出射効率を５０％以上に向上させることができる。

【0044】

図８に、傾斜面の傾斜角がそれぞれ異なる導光板、つまり（Ｄ２－Ｄ１）／（Ｌ／２）が異なる種々の形状の導光板についてそれぞれ光利用効率を測定した結果を示す。ここで、図８の横軸は、導光板の（Ｄ２－Ｄ１）／（Ｌ／２）であり、縦軸は、光利用効率［％］である。

図８に示した測定結果からも、導光板の形状を27／100000＜（Ｄ２－Ｄ１）／（Ｌ／２）＜5／100とすることで、光利用効率を３０％以上とすることができ、66／100000＜（Ｄ２－Ｄ１）／（Ｌ／２）＜26／1000とすることで、光利用効率を４０％以上とすることができ、1／1000＜（Ｄ２－Ｄ１）／（Ｌ／２）＜26／1000とすることで、光利用効率を５０％以上とすることができることがわかる。

Microsoft Exhibit 1002 - Page 1213
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【0045】
ここで、本実施形態では、光を効率よく反射させるために導光板１８の２つの傾斜面（第１傾斜面１８ｂ及び第２傾斜面１８ｃ）にプリズム列を形成したが、必ずしも形成する必要はなく、微細な凹凸を形成していない平坦な面としてもよい。
【0046】
また、本実施形態では、導光板を、光射出面に対向する面を光射出面に対して一定角度傾斜した傾斜面と形状としたが、本発明は、これに限定されず光入射面における導光板の厚みよりも、光入射面に対向する面における導光板の厚みが厚い形状であれば、どのような形状でもよい。例えば、導光板の光射出面に対向する面（図１及び図２の第１傾斜面１８ｂ及び／または第２傾斜面１８ｃ）を曲面形状としてもよい。また、傾斜面を曲面とする場合は、光射出面側に凸の形状としても、光射出面に凹の形状としてもよい。
【0047】
以下、図９とともに導光板のより好ましい形状の一例を説明する。
図９（Ａ）～図９（Ｄ）は、それぞれ導光板の他の一例を示す概略断面図である。また、図１０（Ａ）は、導光板の他の一例を示す概略断面図であり、図１０（Ｂ）は、図１０（Ａ）に示す導光板の傾斜面同士の接続部周辺を拡大して示す概略断面図である。
図９（Ａ）に示す導光板２０２は、第１傾斜面２０４が、光入射面１８ｄ側の第１傾斜部２０６と、導光板中心側の第２傾斜部２０８とで構成されている。第１傾斜部２０６と第２傾斜部２０８とは、光射出面に対する傾斜角が互いに異なる角度で傾斜し、第１傾斜部２０６の傾斜角よりも第２傾斜部２０８の傾斜角の方が角度が小さい。つまり、第１傾斜面は、導光板中心に向かうに従って傾斜角が緩やかになる傾斜部で形成されている。
また、第２傾斜面２０４’は、第１傾斜面２０４と対称な形状であり、第２光入射面１８ｅ側の第１傾斜部２０６’と導光板中心側で第１傾斜部２０６’よりも傾斜角が緩やかな第２傾斜部２０８’とで構成されている。
このように、傾斜面の断面形状を、傾斜角の異なる複数の直線で構成される形状とし、中心側の傾斜部の傾斜角よりも光入射面側の傾斜部の傾斜角の方が大きくなる形状とすることで、光射出面の光入射面近傍部分から射出される光の輝度が高くなることを防止できる。これにより、より均一な光を光射出面から射出させることができる。
また、図９（Ａ）では、傾斜面を２つの傾斜部で構成したが、傾斜面を構成する傾斜部の数は特に限定されず、導光板の中心に向かうに従って傾斜角が徐々に緩やかになるように配置した任意の数の傾斜部で構成することができる。
例えば、図９（Ｂ）に示すように、導光板２１０の第１傾斜面２１２（第２傾斜面２１２’）を第１光入射面１８ｄ（第２光入射面１８ｅ）側から導光板中心に向かって、第１傾斜部２１４（２１４’）と、第１傾斜部２１４（２１４’）よりも傾斜角が緩やかな第２傾斜部２１６（２１６’）と、第２傾斜部２１６（２１６’）よりも傾斜角が緩やかな第３傾斜部２１８（２１８’）の３つの傾斜部で構成してもよい。
【0048】
次に、図９（Ｃ）に示す導光板２２０は、第１傾斜面２２２の第１光入射面１８ｄ側、つまり、第１光入射面１８ｄとの接続部にＲ形状の曲面部２２２ａを有する。また、第２傾斜面２２２’も同様に第２光入射面１８ｅ側にＲ形状の曲面部２２２ａ’を有する。
このように、導光板の傾斜面の光入射面との接続部に曲面部を設けＲ形状とし、光入射面と傾斜面とを滑らかに接続された形状とすることによっても、光射出面の光入射面近傍部分から射出する光の輝度が高くなることを防止できる。
【0049】
次に、図９（Ｄ）に示す導光板２３０は、第１傾斜面２３２及び第２傾斜面２３２’が１０次多項式で表すことができる非球面形状に形成されている。
このように傾斜面を非球面形状とすることによっても、光射出面の光入射面近傍部分から射出する光の輝度が高くなることを防止できる。
【0050】
さらに、図１０（Ａ）及び図１０（Ｂ）に示すように、導光板６０は、第１傾斜面６０

Microsoft Exhibit 1002 - Page 1214
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

ｂと第２傾斜面６０ｃとの接続部６０ｆ（導光板の傾斜面の中央部）を曲面形状またはＲ形状とし、滑らかに接続させることが好ましい。つまり、導光板の傾斜面は、２等分線に垂直な断面において、２等分線側が曲線（より具体的には、円弧）で、かつ、光入射面側が直線となる形状することが好ましい。

これにより、第１傾斜面６０ｂと第２傾斜面６０ｃとの接続部６０ｆで輝線、暗線等が発生することを防止でき、より均一な光を射出させることができる。

【0051】

ここで、導光板６０の傾斜面６０ｂ，６０ｃ同士の接続部６０ｆ、つまり導光板６０の中央部をＲ形状とする場合は、そのＲ形状の曲率半径をR_1とすると、曲率半径R_1と導光板の光の入射方向の長さＬとの関係が、$3L \leqq R_1 \leqq 500L$を満たすことが好ましい。

また、接続部６０ｆのＲ形状の、光の入射方向における端部から端部までの長さをL_Rとし、光射出面６０ａに平行な面と第１傾斜面６０ｂ（または、第２傾斜面６０ｃ）とでなす角をθとしたとき、$2R_1 \cdot \sin(\theta) \leqq L_R$を満たすことが好ましい。

L_Rを$2R_1 \cdot \sin(\theta)$以上とすることで、中央部の輝度の低下を抑制することができ、光射出面からより均一な光を射出させることができる。

また、L_Rは、０．９８以下とすることが好ましい。これにより、本発明の効果をより好適にえることができる。

さらに、導光板は、$3L \leqq R_1 \leqq 500L$、かつ、$2R_1 \cdot \sin(\theta) \leqq L_R \leqq 0.98L$を満たす形状であることがより好ましい。

【0052】

なお、θは、導光板６０の最大厚みt_{max}と、最小厚みt_{min}及び導光板の光の入射方向の長さＬとを用いて、下記式（Ｄ）として表すことができる。

【数1】

【表1】

$$\theta = \tan^{-1}\left[\frac{t_{max} - t_{min}}{L/2}\right] \qquad (D)$$

【0053】

また、上記の透明樹脂に可塑剤を混入して導光板を作製してもよい。

このように、透明材料と可塑剤とを混合した材料で導光板を作製することで、導光板をフレキシブルにすること、つまり、柔軟性のある導光板とすることができ、導光板を種々の形状に変形させることが可能となる。従って、導光板の表面を種々の曲面に形成することができる。

これにより、例えば、導光板、または、この導光板を用いた面状照明装置を電飾（イルミネーション）関係の表示板として用いる場合に、曲率を持つ壁にも装着することが可能となり、導光板をより多くの種類、より広い使用範囲の電飾やＰＯＰ（ＰＯＰ広告）等に利用することができる。

【0054】

ここで、可塑剤としては、フタル酸エステル、具体的には、フタル酸ジメチル（ＤＭＰ）、フタル酸ジエチル（ＤＥＰ）、フタル酸ジブチル（ＤＢＰ）、フタル酸ジ－２－エチルヘキシル（ＤＯＰ（ＤＥＨＰ））、フタル酸ジノルマルオクチル（ＤｎＯＰ）、フタル酸ジイソノニル（ＤＩＮＰ）、フタル酸ジノニル（ＤＮＰ）、フタル酸ジイソデシル（ＤＩＤＰ）、フタル酸混基エステル（C_6～C_{11}）（６１０Ｐ、７１１Ｐ等）、フタル酸ブチルベンジル（ＢＢＰ）が例示される。また、フタル酸エステル以外にも、アジピン酸ジオクチル（ＤＯＡ）、アジピン酸ジイソノニル（ＤＩＮＡ）、アジピン酸ジノルマルアルキル（$C_{6、8、10}$）（６１０Ａ）、アジピン酸ジアルキル（$C_{7、9}$）（７９Ａ）、アゼライン酸ジオクチル（ＤＯＺ）、セバシン酸ジブチル（ＤＢＳ）、セバシン酸ジオクチル（ＤＯＳ）、リン酸トリクレシル（ＴＣＰ）、アセチルクエン酸トリブチル（ＡＴＢＣ）、エポキシ化大豆油（ＥＳＢＯ）、トリメリット酸トリオクチル（ＴＯＴＭ）、ポリエステル系、塩素化パラフィン等が例示される。

【0055】

Microsoft Exhibit 1002 - Page 1215
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

図１及び図２に示すように、本実施形態のバックライトユニット２では、導光板１８の両方の側面に密着して光混合部２０Ａ及び２０Ｂが設けられている。光混合部２０Ａ及び２０Ｂは、透明な樹脂に、光を散乱する粒子が混入された柱状の光学部品であり、カップリングレンズ４０を介して入射される光をミキシングする機能を有する。光混合部２０Ａ及び２０Ｂの材料には、基本的には、導光板１８と同じ材料を用いることができ、導光板１８と同様に、内部に光を散乱させるための散乱体を含むことができる。光混合部２０Ａ及び２０Ｂの内部に含有させる散乱体の密度等は、導光板１８と同じであっても異なっていても良い。また、光混合部２０Ａ及び２０Ｂは、図２に示されるように、ＬＥＤアレイ２４に近接して配置されるため、耐熱性の高い材料を用いて形成されることが好ましい。

【0056】

次に、偏光分離フィルム１６について説明する。

本実施形態においては、好ましい形態として、導光板１８の光射出側の面である光射出面１８ａの上に偏光分離フィルム１６が導光板１８と一体化して形成されている。偏光分離フィルム１６は、導光板の光射出面から出射する光のうち、所定の偏光成分、例えば、ｐ偏光成分を選択的に透過させ、それ以外の偏光成分、例えば、ｓ偏光成分の殆どを反射させることができる。偏光分離フィルム１６は、反射した光を導光板に再度入射させて、再利用することができるので、光の利用効率を高め、輝度を格段に向上させることができる。

偏光分離フィルム１６は、例えば、透明樹脂に針状粒子を混練して分散させて得られた板材を延伸させて、針状粒子を所定の方向に配向させることによって得られる。

偏光分離フィルム１６は、導光板１８の製造時に圧着又は融着させて一体化させることが好ましい。これにより、導光板１８の光射出面１８ａと偏光分離フィルム１６との間に空気を介在させることなく、互いを密着させることができる。

ここでは、偏光分離フィルム１６を導光板１８と一体で形成したが、これに限定されず、偏光分離フィルム１６と導光板１８とをそれぞれ独立に製造し、導光板１８の光射出側の面に偏光分離フィルム１６を貼り付けて設けても良い。

また、図示例では、偏光分離フィルム１６を導光板１８の光射出面の直上に設けたが、これに限定されず、拡散フィルムの上に設けることもできる。この場合、偏光分離フィルムを拡散フィルムと一体にしてもよい。

【0057】

また、偏光分離フィルム１６としては、公知のものを用いることができる。

例えば、特開平６－３３１８２４号公報に記載されているような、少なくとも１偏波面に対しては、導光板の光射出面に導光板の屈折率よりも高い屈折率を有し、この偏波面に直交する偏波面に対しては導光板の平均屈折率より低い屈折率を有する複屈折性材料を用いることもできる。

また、特開平１１－２８１９７５号公報に記載されているような、延伸フィルムを用いることもできる。ここで、延伸フィルムを用いる場合は、特開平１１－２８１９７５号公報に記載されているように、粘着剤層あるいは接着剤層を介して、導光板の片面に貼付することが好ましい。

また、特開平７－４９４９６号公報に記載されているような、相対的に屈折率の大きな透明性媒質と相対的に屈折率の小さな透明性媒質とを交互に積層してなる多層構造体や、面状透明性支持体の少なくとも片方の面に、好ましくは１０００ｎｍ以下の厚みを有する誘電体膜が少なくとも一層以上成膜されているもの、もしくは屈折率の異なる複数種類の透明複数種類の透明性ポリマーが積層されたものを用いることもできる。

また、特開平７－７２４７５号公報に記載されているような、断面略Ｗ字状の透明支持体に可視光波長と同等以下の厚みを有する誘電薄膜を少なくとも一層以上設けたものからなり、所定の入射方向の近傍の光線についてｐ偏光成分を透過し、ｓ偏光成分の少なくとも一部を反射する偏光分離器を用いることもできる。

また、特開２００４－７８２３４号公報に記載されているような、並んで配列された本質的に直角の２等辺の係数のプリズムの直線的な配列からなる構造化表面を有し、この構

Microsoft Exhibit 1002 - Page 1216
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

造表面と反対の平滑な表面への接面に関してほぼ４５°の角度を形成する垂直な係数の面を有する第１の材料と、本質的に第１の材料と同じ第２の材料と、少なくとも１つの材料の構造化平面上にあり、選択された光学的な厚さの高屈折率材料及び低屈折率材料の交互に重なる層からなる少なくとも１つの光学的な堆積とからなり、第１及び第２の材料は、全て光学的に接合され、単一ユニットを形成し、この単一ユニットにおいて、第１及び第２の材料の屈折率及び上記光学的堆積の複数の層の上記屈折率及び光学的厚さは、偏光された光の選択的な反射を生成するように全て選ばれて、上記光学的な堆積の一部の内部において、混合された偏光の入射光線が、ｓ－偏光成分及びｐ－偏光成分に分離され、上記ｓ－偏光成分は、上記光学的な堆積の他の部分で反射され、その部分で入射光線に平行に反射されるが、入射光と逆の方向に進み、上記ｐ－偏光成分は、入射光線に対して平行に透過する再帰反射偏光子を用いることもできる。

また、特開昭６１－２６２７０５号公報に記載されているような、Ａ型の凸条とＶ型の溝を交互に設け三角波形面を形成した透明な材料の上に偏光フィルタ機能や位相差板機能を有する誘電体多層膜を設けた偏光素子を用いることもできる。

また、米国特許第３６１０７２９号明細書に記載されているような、複屈折性を備える材料を種々の波長の１／４となる厚みの層にして連続的に積層させた偏光フィルムを用いることもできる。

また、米国特許第５８６７３１６号明細書に記載されているような、複屈折性を備える連続相と連続相の内部に少量の分散相とを有するポリマーにより形成された光学フィルムを用いることもできる。

また、特開２００３－２９５１８３号公報に記載されているような、表面プラズモンを利用した金属薄膜を低屈折率透明媒質でサンドイッチした構成の偏光分離膜を用いることもできる。

さらに、入射面に平行なＰ偏光成分のみを透過し、入射面に垂直なＳ偏光成分を反射する表面プラズモンを利用した偏光分離膜の配置に加え、光の偏光方向を変更する、例えば直交する偏光成分の間に光学的な厚さにおいてλ／４の差を生じる僅かな複屈折性を有するλ／４位相フィルムや拡散フィルムなどの偏光方向変更膜を導光板と一体にして構成することにより、輝度をより向上させることができる。

【0058】

また、特開平８－７６１１４号公報に記載されているような、液晶と高分子の複合体を延伸して形成した異方性散乱体を用いた散乱型偏光フィルムを偏光分離フィルム１６の代わりに用いたり、特開平６－２８１８１４号公報に記載されているような、分子螺旋の軸がフィルムを横切って延在するように配向させ、フィルムにおける分子螺旋のピッチが、最大ピッチと最小ピッチとの間の差が少なくとも１００ｎｍとなるように変化されているコレスティック型偏光フィルムを偏光分離フィルム１６として用いてもよい。

また、特開２００１－３４３６１２号公報に記載されているような、直線偏光の振動方向によりヘイズの値が異なるヘイズ異方性層を用いることもできる。この場合は、さらに、導光板の光射出面と反対面に第一位相差板を貼付し、かつ導光板と反射板との間に第２位相差板を設置することが好ましい。

また、特開平９－２７４１０８号公報に記載されているような、透明な高分子フィルムの中にこれと異なる材料からなる微小領域が一様に分散され、高分子フィルムと微小領域とは直交する直線偏光の一方に対する屈折率がほぼ同じで、該直線偏光の他方に対する屈折率が異なる偏光素子を用いることができる。

【0059】

上記実施形態では、偏光分離フィルムを導光板１８の光射出面側に設けて輝度の向上を実現させたが、偏光分離フィルムを設ける代わりに、特開２００１－２０１７４６公報、特開２００１－２２８４７４号公報に記載されているように、導光板の光射出面に偏光分離機能を有する微細凹凸部を形成することでも、光射出面から射出させる光の輝度を向上させることができる。

また、偏光分離フィルム１６の代わりに、特開平９－１３４６０７号公報に記載されて

Microsoft Exhibit 1002 - Page 1217
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

いるように、導光板と反射部材（反射板）との間に、実質的に導光板の屈折率以上の第１の屈折率及び導光板の屈折率よりも小さな第２の屈折率を有し、第１の偏光状態の略全てを、第１の偏光状態に直交する第２の偏光状態から分離する異方性層を配置することでも輝度を向上させることができる。

また、特開２００４－３６３０６２号公報に記載されているように、導光板の傾斜背面に、微細突起からなり、偏光分離機能を有する粗面パターンを形成することでも、輝度を向上させることができる。

また、特表平１０－５０８１５１号公報に記載されているように、光導波路（導光板）に、光導波路の材料と異なる材料が充填された凹部を設け、この２つの材料の一方を屈折率がｎｐである等方性材料とし、他方の材料を屈折率がｎｏとｎｅである異方性材料とする。ここで、屈折率に関しては、ｎｏまたはｎｅがｎｐに等しいかまたは事実上等しくする。これにより、等方性材料と異方性材料間の境界面で偏光を分離させることができ、光源で照射された光の大部分を光導波路より出る前に同じ偏光方向を有する光に変えることができる。このように、特表平１０－５０８１５１号公報に記載されている構成を本発明に適用することによっても輝度を向上させることができる。

また、特開平９－２９２５３０号公報に記載されているように、導光板を導光機能を有する２層以上の層で構成し、第１の層または第２の層の少なくとも一方の層を複屈折性を有する材料とし、第１の層と第２の層との間に界面を設け、界面で光が散乱または屈折または回折した光を導光板の表面から出射させることによっても輝度を向上させることができる。

【0060】

次に、バックライトユニットの反射シート２２について説明する。

反射シート２２は、導光板１８の傾斜面１８ｃ、１８ｄから漏洩する光を反射して、再び導光板１８に入射させるものであり、光の利用効率を向上させることができる。反射シート２２は、導光板１８の傾斜面１８ｃ及び１８ｄをそれぞれ覆うように中央部で折り曲げられて形成される。

反射シート２２は、導光板１８の傾斜面１８ｃ、１８ｄから漏洩する光を反射することができるものであれば、どのような材料で形成されてもよく、例えば、ＰＥＴやＰＰ（ポリプロピレン）等にフィラーを混練後延伸することによりボイドを形成して反射率を高めた樹脂シート、透明もしくは白色の樹脂シート表面にアルミ蒸着などで鏡面を形成したシート、アルミ等の金属箔もしくは金属箔を担持した樹脂シート、あるいは表面に十分な反射性を有する金属薄板により形成することができる。

【0061】

次に、拡散フィルム１４について説明する。

拡散フィルム１４は、図１に示されるように、偏光分離フィルム１６と液晶パネル４との間に配置される。拡散フィルム１４は、フィルム状部材に光拡散性を付与して形成される。フィルム状部材は、例えば、ＰＥＴ（ポリエチレンテレフタレート）、ＰＰ（ポリプロピレン）、ＰＣ（ポリカーボネート）、ＰＭＭＡ（ポリメチルメタクリレート）、ベンジルメタクリレート、ＭＳ樹脂、あるいはＣＯＰ（シクロオレフィンポリマー）のような光学的に透明な樹脂を材料に形成することができる。

拡散フィルム１４の製造方法は特に限定されないが、例えば、フィルム状部材の表面に微細凹凸加工や研磨による表面粗化を施して拡散性を付与したり、表面に光を散乱させるシリカ、酸化チタン、酸化亜鉛等の顔料や、樹脂、ガラス、ジルコニア等のビーズ類をバインダとともに塗工したり、上記顔料やビーズ類を上記透明な樹脂中に混練したりすることで形成することができる。他には、反射率が高く光の吸収が低い材料で、例えば、Ａｇ、Ａｌのような金属を用いて形成することもできる。

本発明において、拡散フィルム１４としては、マットタイプやコーティングタイプの拡散フィルムを用いることができる。

【0062】

拡散フィルム１４は、導光板１８の光射出面から所定の距離だけ離して配置されてもよ

Microsoft Exhibit 1002 - Page 1218
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

く、その距離は導光板１８の光射出面からの光量分布に応じて適宜変更することができる。

このように拡散フィルム１４を導光板１８の光射出面から所定の間隔だけ離すことにより、導光板１８の光射出面から射出する光が、光射出面と拡散フィルム１４の間で更にミキシング（混合）される。これにより、拡散フィルム１４を透過して液晶表示パネル４を照明する光の輝度を、より一層均一化することができる。

拡散フィルム１４を導光板１８の光射出面から所定の間隔だけ離す方法としては、例えば、拡散フィルム１４と導光板１８との間にスペーサを設ける方法などを用いることができる。

【0063】

以上、本発明の第１の実施形態のバックライトユニット２の各構成要素について詳細に説明したが、本発明はこれに限定されるものではない。

例えば、ＬＥＤから射出された光を混合することができるため混合部、さらには、射出された光を平行光とすることができるためボールレンズ、シリンドリカルレンズ等の平行光生成機構を設けることが好ましいが、混合部及び平行光生成機構は、必ずしも設ける必要はない。

また、混合部及び／または平行光生成機構は、光源及び導光板と非接触で設けることが好ましい。混合部及び／または平行光生成機構を光源及び導光板と非接触で配置することで、光源から生じる熱が混合部、平行光生成機構さらには導光板に伝わり、熱により変形することを防止できる。これにより、光射出面から射出される光に輝度むらが生じることをより確実に防止することができる。

【0064】

上記実施の形態では、赤色、緑色及び青色の３色のＬＥＤ３２、３４及び３６を用い、カップリングレンズ４０により各ＬＥＤが発する光を混色し白色光を得たが、本発明はこれに限定されない。光源には、１種類のＬＥＤと蛍光物質（つまり、蛍光体）とを組み合わせ、ＬＥＤが発する光を蛍光物質により白色光に変換するように構成したＬＥＤチップを用いてもよい。例えば、単色のＬＥＤとしてＧａＮ系青色ＬＥＤを用いた場合には、ＹＡＧ（イットリウム・アルミニウム・ガーネット）系蛍光物質を用いれば、白色光を得ることができる。

このような白色光を得ることができる光源を利用すれば、レンズを利用する必要がなくなり部材の数を削減することができる。

また、光源として１種類のＬＥＤを用いた場合でも、光源としてＬＥＤを用いることで、光源から射出される光を後述する導光板のより奥まで届かせることができる。これにより、装置の薄型を維持しつつ、装置を大型化することができる。また、冷陰極管と比較して演色性の高い光を射出させることが可能となる。

【0065】

図１１（Ａ）は、光源に１種類のＬＥＤと蛍光体とで構成されたＬＥＤチップを用いた面状照明装置（バックライトユニット）の一実施形態を示した概略上面図であり、図１１（Ｂ）は、面状照明装置の概略断面図である。

なお、図１１（Ａ）及びＢに示したバックライトユニット１２０は、光源１２２を除いて、他の構成は、図１に示したバックライトユニット２と同様の構成のものである。従って、両者で同一の構成要素には同一の符号を付してその詳細な説明を省略し、以下にバックライトユニット１２０に特有の点を説明する。

光源１２２は、ＬＥＤアレイ１２４とカップリングレンズ１２６とを備え、図１１（Ａ）に示すように、導光板１８の第１光入射面１８ｄ及び第２光入射面１８ｅに対向して配置されている。

ＬＥＤアレイ１２４は、複数のＬＥＤチップ１２８が所定間隔離間して一列でヒートシンク１３０上に配置されている。図１２（Ａ）に、ＬＥＤアレイ１２４の構成の概略斜視図を、図１２（Ｂ）に、ＬＥＤチップ１２８の構成の概略上面図を、図１２（Ｃ）に、多層ＬＥＤアレイ１３２の構成の概略上面図を、図３Ｄに、ヒートシンク２５の一実施形態

Microsoft Exhibit 1002 - Page 1219
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

の概略側面図を示す。

ＬＥＤチップ１２８は、上述したように、１種類のＬＥＤと蛍光物質とを組み合わせた構成であり、ＬＥＤが発する光が蛍光物質により変換され、白色光として射出される。

【0066】

ヒートシンク１３０は、導光板１８の一辺に平行な板状の部材であり、導光板１８に対向して配置されている。ヒートシンク１３０は、導光板１８に対向した面に、複数のＬＥＤチップ１２８を支持している。ヒートシンク１３０は、銅やアルミニウム等の熱伝導性の良い金属で形成されており、ＬＥＤチップ１２８から発生する熱を吸収し、外部に放散させる。

また、ヒートシンク１３０は、本実施形態のように導光板１８の第１光入射面及び第２光入射面に対向した面に垂直な方向における長さが、導光板１８の第１光入射面及び第２光入射面に対向した面の短辺方向における長さよりも長い形状であることが好ましい。これにより、ＬＥＤチップ１２８の冷却効率を高めることができる。

ここで、ヒートシンクは、表面積を広くすることが好ましい。例えば、図１２（Ｄ）に示すように、ヒートシンク１３０を、ＬＥＤチップ１２８を支持するベース部１３０ａと、ベース部１３０ａに連結された複数のフィン１３０ｂとで構成してもよい。

フィン１３０ｂを複数設けることで表面積を広くすることができ、かつ、放熱効果を高くすることができる。これにより、ＬＥＤチップ１２８の冷却効率を高めることができる。

また、ヒートシンクは、空冷方式に限定されず、水冷方式も用いることができる。

なお、本実施形態では、ＬＥＤチップの支持部としてヒートシンクを用いたが、本発明はこれに限定されず、ＬＥＤチップの冷却が必要ない場合は、放熱機能を備えない板状部材を支持部として用いてもよい。

【0067】

ここで、図１２（Ｂ）に示すように、本実施形態のＬＥＤチップ１２８は、ＬＥＤチップ１２８の配列方向の長さよりも、配列方向に直交する方向の長さが短い長方形形状、つまり、導光板１８の厚み方向（光射出面１８ａに垂直な方向）が短辺となる長方形形状を有する。言い換えれば、ＬＥＤチップ１２８は、導光板１８の光射出面１８ａに垂直な方向の長さをａ、配列方向の長さをｂとしたときに、ｂ＞ａとなる形状である。また、ＬＥＤチップ１２８の配置間隔をｐとするとｐ＞ｂである。このように、ＬＥＤチップ１２８の導光板１８の光射出面１８ａに垂直な方向の長さａ、配列方向の長さｂ、ＬＥＤチップ１２８の配置間隔ｐの関係がｐ＞ｂ＞ａを満たすことが好ましい。

ＬＥＤチップ１２８を長方形形状とすることで、大光量の出力を維持しつつ、薄型な光源とすることができる。光源を薄型化することで、面状照明装置を薄型にすることができる。

【0068】

なお、ＬＥＤチップは、ＬＥＤアレイをより薄型にできるため、導光板の厚み方向を短辺とする長方形形状とすることが好ましいが、本発明はこれに限定されず、正方形形状、円形形状、多角形形状、楕円形形状等の種々の形状のＬＥＤチップを用いることができる。

【0069】

また、本実施形態では、ＬＥＤアレイを単層としたが、本発明はこれに限定されず、図１２（Ｃ）に示すように、複数のＬＥＤアレイ１２４を積層させた構成の多層ＬＥＤアレイ１３２を光源として用いることもできる。このようにＬＥＤを積層させる場合でもＬＥＤチップを長方形形状とし、ＬＥＤアレイを薄型にすることで、より多くのＬＥＤアレイを積層させることができる。多層のＬＥＤアレイを積層させる、つまり、ＬＥＤアレイ（ＬＥＤチップ）の充填率を高くすることで、より大光量を出力することができる。また、ＬＥＤアレイのＬＥＤチップと隣接する層のＬＥＤアレイのＬＥＤチップも上述と同様に配置間隔が上記式を満たすことが好ましい。つまり、ＬＥＤアレイは、ＬＥＤチップと隣接する層のＬＥＤアレイのＬＥＤチップとを所定距離離間させて積層させることが好まし

Microsoft Exhibit 1002 - Page 1220
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

い。

【0070】

図３に示すように、ＬＥＤアレイ１２４の各ＬＥＤチップ１２８の光射出側にカップリングレンズ１２６としてボールレンズが配置されている。カップリングレンズ１２６は、各ＬＥＤチップ１２８に対応して配置されている。各ＬＥＤチップ１２８から出射した光は、カップリングレンズ１２６によって平行光にされ、導光板１８の光混合部２０に入射する。

ここでは、カップリングレンズとしてボールレンズを用いたが、これに限らず、ＬＥＤが発する光を平行光にすることができれば種々の部材を用いることができる。カップリングレンズには、例えば、シリンドリカルレンズ、レンチキュラ、かまぼこ型のレンズ、フレネルレンズなどを用いることもできる。

【0071】

また、導光板１８の第１光入射面及び第２光入射面に対向するようにＬＥＤアレイ２４を配置せずに、ライトガイドを用いてＬＥＤアレイ２４の各ＬＥＤが発する光を導光板に導いてもよい。ライトガイドは、光ファイバや、透明樹脂からなる導光路等を用いて構成することができる。

光源としてＬＥＤアレイ２４を用い、そのＬＥＤアレイ２４を導光板１８の側面近傍に配置した場合には、ＬＥＤアレイ２４を構成する各ＬＥＤの発熱により導光板１８が変形したり、溶融する恐れがある。そこで、ＬＥＤアレイ２４を導光板１８の側面から離れた位置に配置し、ライトガイドを用いてＬＥＤチップから射出された光を導光板１８に導くことにより、ＬＥＤの発熱による導光板１８の変形及び溶融を防止することができる。

【0072】

なお、上記実施形態では、ＬＥＤチップとして、ＧａＮ系青色ＬＥＤとＹＡＧ系蛍光物質とを組み合わせた構成を例示したが、本発明はこれに限定されず、種々のＬＥＤと蛍光物質を組み合わせた構成のＬＥＤチップを用いることができる。

例えば、ＬＥＤとしては、赤色ＬＥＤ、緑色ＬＥＤ、紫ＬＥＤ，紫外ＬＥＤ、近紫外ＬＥＤ、赤外ＬＥＤ，近赤外ＬＥＤ等の種々の波長領域の光を発光するＬＥＤを用いることができる。また、蛍光物質としてもＬＥＤチップから発光される光に応じて、任意の蛍光物質を用いることができる。

【0073】

例えば、青色ＬＥＤに赤緑色の蛍光体を組み合わせた光源も用いることができる。具体的には、特開２００５－２２８９９６号公報に記載されているＬＥＤと蛍光体を組み合わせた発光素子も用いることができる。

また、赤外ＬＥＤに赤色、緑色、青色の蛍光体を組み合わせた光源も用いることができる。このような光源としては、特開２０００－３４７６９１号公報に記載されているＬＥＤと蛍光体を組み合わせた発光装置、特開２００２－４３６３３号公報に記載されているＬＥＤと蛍光体を組み合わせた白色発光ダイオード、特開２００５－１２６５７７号公報に記載されているＬＥＤと蛍光体を組み合わせた発光装置も用いることができる。

また、本発明は、蛍光体をＬＥＤの発光面に配置し、白色光を射出させることに限定されず、蛍光体をＬＥＤの発光面に配置する代わりに、導光板に蛍光体を混入することによっても、白色光を光射出面から射出させることができる。

また、蛍光体をＬＥＤの発光面に配置するのに替えて、または加えて、蛍光体を塗布、または混入した光学シートを導光板の光射出面上に配置した構成も用いることができる。上記構成としても白色光を光射出面から射出させることができる。

【0074】

ここで、光源に用いるＬＥＤチップとしては、２つ以上の主要ピーク波長を有する光を射出するＬＥＤチップを用いることが好ましい。

具体的には、青色の波長領域と緑色の波長領域のそれぞれに主要ピークを有する光を射出するＬＥＤチップ、赤色の波長領域と青色の波長領域のそれぞれに主要ピークを有する光を射出するＬＥＤチップ、緑色の波長領域と赤色の波長領域のそれぞれに主要ピークを

Microsoft Exhibit 1002 - Page 1221
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

有する光を射出するＬＥＤチップ、赤色の波長領域と青色の波長領域と緑色の波長領域のそれぞれに主要ピークを有する光を射出するＬＥＤチップ等も用いることができる。

このように、ＬＥＤチップとして、２つ以上の主要ピークの光を射出するＬＥＤチップを用いることで、簡単な装置構成で演色性の高い光を射出させることができる。また、演色性の高い白色光も射出させることができる。

なお、２つ以上の主要ピーク波長を有する光を射出するＬＥＤチップは、上述したＲ，Ｇ，Ｂ、赤外、紫外等の光を射出するＬＥＤと蛍光体とを組み合わせることで作製することができる。また、複数のピーク波長を持つＬＥＤと蛍光物質とを組み合わせて、さまざまな発光色を複数のピーク波長の組合せで射出するＬＥＤチップを作製することもできる。

【0075】

また、光源としては、異なる種類の２つ以上の主要ピーク波長を有する光を射出するＬＥＤチップ、つまり、発光波長の異なる２種類のＬＥＤチップで、光源を構成しても良い。この場合は前記異なる種類のＬＥＤチップの数は等しくても、等しくなくても良く、また、２種類のＬＥＤチップを規則的に又は不規則に混在させて、アレイ状に配置してもよい。つまり、導光板の射出面からの射出光が所望のカラーバランスにすることが好ましい。言い換えれば、所望のカラーバランスの光を射出することができれば、配置関係でＬＥＤチップを配置することができれば、その配置位置は特に限定されない。

さらに、発光波長の異なる２種類のＬＥＤチップで構成されるＬＥＤユニットを用いることも好ましい。つまり、このＬＥＤユニットを繰り返し単位とし、複数のＬＥＤユニットをアレイ状に配置することも好ましい。

一例としては、青色の波長領域と緑色の波長領域のそれぞれに主要ピークを有する光を射出するＬＥＤチップと、赤色の波長領域と青色の波長領域のそれぞれに主要ピークを有する光を射出するＬＥＤチップとを組み合わせたＬＥＤユニットを用いることが好ましい。

このように、異なる種類の、２つ以上の主要ピーク波長を有するＬＥＤチップを組み合わせることで、面状照明装置の光射出面から演色性の高い光を射出させることができる。これにより、例えば、所望のＮＴＳＣ比を満足する光を射出させることができる。また、演色性の高い白色光も射出させることができる。

【0076】

なお、上記実施形態では、光源のＬＥＤチップとして、ＬＥＤと蛍光体とを組み合わせたＬＥＤチップを用いたが、本発明はこれに限定されず、２つ以上の主要ピークを有する光を射出するＬＥＤを用いることも好ましい。つまり、例えば、ＬＥＤ自体が、青色の波長領域と緑色の波長領域のそれぞれに主要ピークを有する光を射出する場合は、蛍光体を設けることなく、ＬＥＤ単体を光源のＬＥＤチップとして用いることも好ましい。

このように、ＬＥＤ自体が２つ以上の主要ピークを有する光を射出する場合も、同様に、異なる種類の、２つ以上の主要ピーク波長を有するＬＥＤを組み合わせた構成することが好ましい。

この場合も上記ＬＥＤチップを組み合わせた場合と同様の効果を得ることができる。

さらに、２つ以上の主要ピーク波長を有するＬＥＤチップと、２つ以上の主要ピークを有する光を射出するＬＥＤを組み合わせて構成した場合も同様の効果を得ることができる。

【0077】

また、光射出面から白色光を射出させる場合は、光源として、擬似白色ＬＥＤチップ若しくは擬似白色ＬＥＤを用いることが好ましい。ここで、擬似白色とは、可視的に白色に近い色のあるいは白色に見える色である。ここで、擬似白色ＬＥＤチップとしては、上述したＧａＮ系青色ＬＥＤとＹＡＧ系蛍光物質とを組み合わせた構成が例示される。

擬似白色ＬＥＤチップまたは擬似白色ＬＥＤとしては、主要ピーク波長が２つの２波長型、つまり２つの主要ピーク波長の光で白色に見える光を射出するＬＥＤチップもしくはＬＥＤと、主要ピーク波長が３つの３波長型、つまり３つの主要ピーク波長の光で白色に

Microsoft Exhibit 1002 - Page 1222
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

見える光を射出するＬＥＤチップもしくはＬＥＤ等がある。

【0078】

また、上記実施形態では、光射出面から白色の光を射出させたが、本発明はこれに限定されず、光源として用いるＬＥＤ、ＬＥＤチップの構成により種々の色の光を射出させることができる。

【0079】

なお、光源としては、演色性を向上させることができる、装置構成を簡単にすることができる点から、異なる２つの主要ピークを有する光を射出するＬＥＤ及び／またはＬＥＤユニットを用いることが好ましいが、光源として単色のＬＥＤを用いてもよい。

このように、光源として、単色のＬＥＤを用いることで、簡単な構成で、光射出面から青色、赤色、緑色等の光を射出する面状照明装置を提供することができる。

また、上記単色のＬＥＤを組み合わせて白色光を射出させてもよいのは上述したとおりである。

また、上述した２つ以上の主要ピークを有する光を射出するＬＥＤチップ及び／または２つ以上の主要ピークを有する光を射出するＬＥＤと、単色ＬＥＤとを組み合わせても構成してもよい。なお、光源を複数のＬＥＤ及び／またはＬＥＤチップで構成する場合は、各ＬＥＤ、ＬＥＤチップの個数、種類の数は、特に限定されず、種々の組み合わせを用いることができる。

また、上記実施形態では、いずれも光源を構成するＬＥＤ、ＬＥＤチップを一定パターンで配置したが、配置感覚、配置順序は、特に限定されない。例えば、一部のみＬＥＤを密に配置してもよく、また、繰り返し単位のＬＥＤ、ＬＥＤチップの組み合わせ、位置に応じて異なる組み合わせとしてもよい。

【0080】

また、上記実施形態では、ＬＥＤアレイのヒートシンクを平板形状とし、ＬＥＤチップの裏面側に光射出面と平行な方向に延在するように配置したが、ヒートシンクを折り曲げた形状、例えばＬ字形状とし、ＬＥＤチップの裏面から導光板の傾斜面側、つまり反射部材の裏面に延在するように配置してもよい。これにより、面状照明装置の光射出面に平行な方向の面積を小さくすることができる。

なお、ヒートシンクを折り曲げた形状とし導光板の傾斜面側に配置する場合のヒートシンクの厚さ及び/または長さは、バックライトユニットの厚みを損ねない程度とすることが好ましい。ヒートシンクを、導光板の最大厚みと最小厚みよりも薄くし、傾斜面の裏面側に配置することで、導光板の傾斜面と筐体との間の空間を有効利用することができ、面状照明装置の厚みを薄くすることができる。

また、ヒートシンクの材料としては、熱伝導性の高い材料、例えば、上述したように、アルミ、銅などの金属、その他種々の材料を用いることができる。

【0081】

また、ヒートシンクは、導光板、反射部材、ＬＥＤアレイ等を外側から支持する筐体と熱伝導的につながりを持つことが好ましい。つまり、ヒートシングと筐体とが熱伝導的につながりを持つことが好ましい。ヒートシンクと筐体とが熱伝導的につながることにより、ＬＥＤチップから発生する熱をバックライトユニット（面状照明装置）全体で放熱させることができる。これにより、効率よく熱を放熱することができる。

ここで、ヒートシンクと筐体とは、直接接触していることに限定されず、熱接続体を介して接触していてもよい。

【0082】

また、上記実施形態では、導光板１８の第１傾斜面１８ｂと第２傾斜面１８ｃにプリズム列を形成した構造としたが、導光板１８の第１傾斜面１８ｂと第２傾斜面１８ｃにプリズム列を形成せずに、導光板１８の光射出面１８ａ上に、プリズム列が形成されたプリズムシートを配置させても同様の効果が得られる。図１３に、導光板１８の光射出面１８ａ上にプリズムシート２６を配置した場合のバックライトユニットの構成を模式的に示した。図示例では、導光板１８と偏光分離フィルム１６とプリズムシート２６とが一体に構成

Microsoft Exhibit 1002 - Page 1223
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

されている。ここでは，導光板１８と偏光分離フィルム１６とプリズムシート２６を一体化させたが、それらを独立の部材として配置することもできる。

プリズムシート２６は、複数のプリズムを平行に配列させることにより形成される透明なシートであり、導光板１８の光射出面から出射する光の集光性を高めて輝度を改善することができる。

導光板１８と偏光分離フィルム１６とプリズムシート２６を一体化させる方法としては、例えば、まず、偏光分離フィルム１６とプリズムシート２６を一体化させたシートを作製する。そして、そのシートを、導光板１８の製造時に導光板１８と融着又は圧着させて一体化させればよい。

偏光分離フィルム１６をプリズムシート２６と一体化させる方法としては、プリズムシート２６と偏光分離フィルム１６を個別に製造して単純に貼り合わせる方法や、偏光分離板材を連続押出機の型ロールに投入し、押し出されたプリズムシートと融着させる方法を利用することができる。しかし、これらの方法に限定されるものではない。

また、第１傾斜面１８ｂ及び第２傾斜面１８ｃにプリズム列が形成された導光板１８を備える、図１に示すバックライトユニットの偏光分離フィルム１６と拡散シート１４との間に、プリズムシートを配置させても良い。

【0083】

図１３に示した例では、プリズムシートを１枚で構成したが、プリズムシートを２枚で構成することもできる。この場合は、２枚のプリズムシートのうちの一方は、そのプリズム列の延在する方向が導光板１８の光入射面（第１光入射面１８ｄと第２光入射面１８ｅ）に平行になるように配置され、他方は、それに対して垂直になるように配置される。つまり、２枚のプリズムシートは、プリズム列の延在する方向が互いに垂直になるように配置される。

また、これらプリズムシートは、そのプリズムの頂角が、偏光分離フィルム１６側に向くように配置されることが好ましい。

【0084】

なお、プリズムシートを２枚配置する場合、プリズムシートの配置の順序は特に限定されない。すなわち、偏光分離フィルム１６の直上に、導光板１８の光入射面に平行な方向に延在するプリズムを有するプリズムシートを配置し、そのプリズムシートの上に、導光板１８の光入射面と垂直な方向に延在するプリズムを有するプリズムシートを配置してもよいし、その逆でもよい。

また、図示例ではプリズムシート２６を用いたが、プリズムシート２６の代わりに、プリズムに類する光学素子を規則的に配置したシートを用いることもできる。例えば、レンチキュラーレンズ、凹レンズ、凸レンズ、ピラミッド型など、レンズ効果を有する光学素子を規則的に配置したシートをプリズムシートの代わりに用いることもできる。

また、プリズムシートを用いず、拡散フィルムを複数枚用いてもよい。拡散フィルムの使用枚数は２枚以上、好ましくは３枚である。

【0085】

さらに、図１４に示すように、導光板１８の第１傾斜面１８ｂ及び第２傾斜面１８ｃに複数の拡散反射体１４０を所定パターンで、具体的には、導光板１８の端部、つまり、第１光入射面１８ｄ側及び第２光入射面１８ｅ側の密度が低く、第１光入射面１８ｄ及び第２光入射面１８ｅから導光板１８の中央に向かうにしたがって次第に密度が高くなるようなパターンで、例えば、印刷により形成してもよい。このような拡散反射体１２０を所定パターンで導光板１８の傾斜面１８ｂに形成することにより、導光板１８の光射出面１８ａにおける輝線の発生やムラを抑制することができる。

また、拡散反射体１４０を導光板１８の第１傾斜面１８ｂ及び第２傾斜面１８ｃに印刷する代わりに、拡散反射体１４０が所定パターンで形成された薄いシートを導光板１８の第１傾斜面１８ｂ及び第２傾斜面１８ｃと反射シート２２との間に配置してもよい。なお、拡散反射体１４０の形状は、矩形、多角形、円形、楕円形などの任意の形状にすることができる。

Microsoft Exhibit 1002 - Page 1224
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

ここで、拡散反射体としては、例えば、光を散乱させるシリカ、酸化チタンもしくは酸化亜鉛等の顔料、または、樹脂、ガラスもしくはジルコニア等のビーズ類などの光を散乱させるための材料をバインダとともに塗工した物や、表面に微細凹凸加工や研磨による表面粗化パターンでもよい。他には反射率が高く光の吸収が低い材料で、例えば、Ａｇ、Ａｌのような金属を用いることもできる。また、拡散反射体として、スクリーン印刷、オフセット印刷等で用いられる、一般的な白インクも用いることができる。一例としては、酸化チタン、酸化亜鉛、硫酸亜鉛、硫酸バリウム等を、アクリル系バインダや、ポリエステル系バインダ、塩化ビニル系バインダ等に分散したインク、酸化チタンにシリカを混合し拡散性を付与したインクを用いることができる。

【0086】

また、本実施形態では、拡散反射体を光入射面から離れるに従って疎から密にしたが、本発明はこれに限定されず、輝線の強さや広がり、必要な出射光の輝度分布等に応じて適宜選択することができ、例えば、傾斜面全面に均一な密度に配置しても、光入射面から離れるに従って密から疎に配置してもよい。また、このような拡散反射体を印刷により形成する代わりに、拡散反射体の配置位置に対応する部分を砂擦り面として荒らしてもよい。

なお、図１４の導光板では、傾斜面に拡散反射体を配置したが、本発明は、これに限定されず、必要に応じて、光入射面以外の任意の面に配置してよい。

【0087】

また、面状照明装置の光射出面側に光射出面から射出される光の輝度むらを低減させる機能を有する透過率調整部材を配置してもよい。

図１５に、透過率調整部材１８２を配置した面状照明装置１８０の概略断面図を示す。

【0088】

面状照明装置１８０は、光源１９０と、拡散フィルム１４と、導光板１８と、反射シート２２と、透過率調整部材１８２と、プリズムシート１８８とを有する。

ここで、拡散フィルム１４と、導光板１８と、反射シート２２は、図１３に示した面状照明装置の拡散フィルム、導光板、反射シートと同じ機能を有するのでその詳しい説明については省略する。

光源１９０は、上述したＬＥＤチップ１２８とヒートシンク１３０とからなるＬＥＤアレイ１２４と同様の構成を有し、本実施形態では、ＬＥＤアレイ１２４がそれぞれ導光板１８の第１光入射面１８ｄ及び第２光入射面１８ｅに対向して配置されている。つまり、それぞれのＬＥＤアレイ１２４と第１光入射面１８ｄ及び第２光入射面１８ｅとの間には、カップリングレンズ及び光混合部が配置されていない。これにより、ＬＥＤアレイ１２４から射出された光は、導光板１８に直接入射する。

また、導光板１８の光射出面１８ａに透過率調整部材１８２、拡散フィルム１４、プリズムシート１８８が順に積層されている。ここで、プリズムシート１８８は、上述したプリズムシート２６と同様の機能形状を有し、そのプリズムの頂角が拡散シート１４と対向するように、つまり、プリズムの底辺が導光板１８の光入射面１８ａと平行となるように配置されている。

【0089】

透過率調整部材１８２は、上述したように、導光板から射出される光の輝度むらを低減させるために用いられ、透明フィルム１８４と、透明フィルム１８４の表面に配置される多数の透過率調整体１８６とを有する。

【0090】

透明フィルム１８４は、フィルム状の形状を有し、ＰＥＴ（ポリエチレンテレフタレート）、ＰＰ（ポリプロピレン）、ＰＣ（ポリカーボネート）、ＰＭＭＡ（ポリメチルメタクリレート）、ベンジルメタクリレートやＭＳ樹脂、その他のアクリル系樹脂、あるいはＣＯＰ（シクロオレフィンポリマー）等の光学的に透明な部材で形成されている。

【0091】

透過率調整体１８６は、所定の透過率を有する種々の大きさのドットであり、四角形や円形、六角形などの形状を有し、所定パターン、例えば、位置に応じてドットの大きさ、

Microsoft Exhibit 1002 - Page 1225
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

ドットの配置数が異なるパターン（網点パターン）で透明フィルム１８４の導光板１８側の表面全面に印刷等によって形成されている。

透過率調整体１８６は、拡散反射体であればよく、例えば、光を散乱させるシリカ、酸化チタン、酸化亜鉛等の顔料もしくは樹脂やガラス、ジルコニア等のビーズ類をバインダとともに塗工した物や、表面に微細凹凸加工や研磨による表面粗化パターンでもよい。他には反射率が高く光の吸収が低い材料で、例えば、Ａｇ、Ａｌのような金属を用いることもできる。

また、透過率調整体１８６として、スクリーン印刷、オフセット印刷等で用いられる、一般的な白インクを用いることができる。一例としては、酸化チタン、酸化亜鉛、硫酸亜鉛、硫酸バリウム等を、アクリル系バインダや、ポリエステル系バインダ、塩化ビニル系バインダ等に分散したインク、酸化チタンにシリカを混合し拡散性を付与したインクを用いることができる。

【0092】

透過率調整部材１８６は、多数の透過率調整体１８６を透明フィルム１８４の導光板ユニット１８側の表面に所定パターンで配置することで、表面上の位置に応じて透過率調整体１８６のパターン密度が変化している。

【0093】

ここで、透過率調整部材１８２の任意の位置（ｘ，ｙ）におけるパターン密度をρ（ｘ，ｙ）とし、透過率調整部材１８２を備えない場合のバックライトユニット１８０の光出射面（液晶表示パネル４側の面）の任意の位置（ｘ，ｙ）から出射される光の相対輝度をＦ（ｘ，ｙ）とする。このとき、透過率調整部材１８２のパターン密度ρ（ｘ，ｙ）と、相対輝度Ｆ（ｘ，ｙ）との関係は、下記式（５）を満足することが好ましい。

$$\rho(x,y)=c\{F(x,y)-F_{min}\}/(F_{max}-F_{min})\cdots(5)$$

式（５）において、F_{max}は、透過率調整部材１８２を備えない場合のバックライトユニット１８０の拡散フィルム１４の光出射面から出射される光の最大輝度であり、F_{min}は、最小輝度である。なお、相対輝度Ｆ（ｘ，ｙ）は、最大輝度F_{max}を基準点（$F_{max}=1$）としている。

ここで、ｃは最大密度であり、０．５≦ｃ≦１とすることが好ましい。

また、上記の式に従って透過率調整体の配置の密度設計をした際に、正面方向以外から観察した角度によっては輝度ムラが視認される場合がある。これを改善するために、算出した密度分布にさらに「均一な密度分布（バイアス密度ρｂ）」を追加することが好ましい。これにより、輝度ムラを低減させ、かつ、輝度ムラの角度依存性も無くすもしくは低減させることができる。

ここで、バイアス密度ρｂは、０．０１～１．５０（１～１５０％）とすることが好ましい。なお、配置密度が１（１００％）を超える場合は、透過率調整体を２重に配置する。つまり、透過率調整体を全面に配置した上に（ρｂ－１）の配置密度の透過率調整体を配置する。

ここで、パターン密度ρ（ｘ，ｙ）とは、任意の位置（ｘ，ｙ）に存在する透過率調整体１８６の単位面積（１ｍｍ^2）あたりの占有率であり、ρ（ｘ，ｙ）＝１のとき透過率調整体１８６は、単位面積内の全面に配置され、ρ（ｘ，ｙ）＝０のとき、単位面積内に全く配置されない。

【0094】

透過率調整体部材１８２の透過率調整体１８６を上記式（５）のパターン密度ρ（ｘ，ｙ）を満たすように配置することで、バックライトユニット１８０の光出射面から出射される光の平均輝度の低下を抑え、かつ輝度むらを低減することができる。このように、透過率調整部材１８２を用いて輝度むらを低減させることで、拡散フィルム１４は、光の拡散をそれほど十分に行う必要がなくなる。その結果、拡散フィルム１４をより薄くすることができ、また、プリズムシートの使用を止めることができ、あるいは、プリズムシートの使用枚数を減らすことができ、より軽量で、安価なバックライトユニットを提供することができる。

Microsoft Exhibit 1002 - Page 1226
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【0095】
以下、具体的実施例とともに透過率調整部材を備える面状照明装置について、より詳細に説明する。
本実施例では、図１５に示すバックライトユニットと同様の構成のバックライトユニットを作製した。すなわち、本実施例のバックライトユニット１８０は、光源１９０と、拡散フィルム１４と、導光板１８と、反射フィルム２２と、透過率調整部材１８２と、プリズムシート１８８とで構成される。
【0096】
本実施例では、導光板１８は、第１光入射面１８ｄ及び第２光入射面１８ｅの厚みを２ｍｍとし、導光板１８の中央部の厚みつまり導光板１８の最大厚みが４ｍｍ、第１光入射面１８ｄから第２光入射面までの距離が３００ｍｍ、導光板１８の奥行き方向の長さ、つまり、導光板１８の第１光入射面１８ｄに平行でかつ光射出面１８ａに平行な方向の長さが５００ｍｍとした形状とした。
また、導光板１８は、透明樹脂として屈折率が１．４９５のアクリル樹脂を、散乱粒子として屈折率が１．４４のシリコーン粒子を用いたものとした。散乱粒子は、粒子径が２０００ｎｍである。この散乱粒子を透明樹脂に、散乱版面積Φが２．０６×$10^{-12}$$m^2$となり、粒子密度が２２００００個／$mm^3$となるように混錬分散させて形成される。
また、光源１９０（ＬＥＤアレイ１２４）と導光板１８との間隙を０．１ｍｍとした。
【0097】
図１５に示すバックライトユニット１８０において、上記式（５）を満足する透過率調整体１８６のパターン密度ρ（ｘ，ｙ）を算出するために、透過率調整部材１８２を備えないこと以外は、同じ構成及び形状のバックライトユニットを用い、透過率調整部材を備えない場合のバックライトユニットの光出射面から出射される光の相対輝度Ｆ（ｘ，ｙ）を測定した。
【0098】
ここで、相対輝度Ｆ（ｘ，ｙ）は、次のようにして測定した。
まず、上記バックライトユニット１８０をＸＹステージに固定し、バックライトユニット１８０の光出射面に垂直になるように輝度計を固定する。そして輝度計によってバックライトユニット１８０の光出射面の位置における輝度を測定して導光板１８の光出射面の特定位置に関する輝度の情報を得る。
その後、ＸＹステージを移動させることにより、バックライトユニット１８０の光出射面上の位置と輝度の関係を求めて、算出した輝度の最大輝度をF_{max}とし、最小輝度をF_{min}とする。この最大輝度F_{max}を１とし、最大輝度F_{max}に対する各位置における輝度の比率を、その位置（ｘ，ｙ）における相対輝度Ｆ（ｘ，ｙ）とした。このようにして、測定した測定結果を図１６に示す。ここで図１６のグラフを縦軸は相対輝度を示し、横軸は、導光板の中央部からの距離を示す。
【0099】
次に、測定した最大輝度F_{max}と、最小輝度F_{min}から上記式１を用いて相対輝度Ｆ（ｘ，ｙ）に対応するパターン密度ρ（ｘ，ｙ）を算出する。ここで、本実施例では、最大密度ｃをｃ＝０．７５とした場合の相対輝度Ｆ（ｘ，ｙ）とパターン密度ρ（ｘ，ｙ）との関係を算出した。相対輝度Ｆ（ｘ，ｙ）とパターン密度ρ（ｘ，ｙ）との関係は、比例関係となり、相対輝度Ｆ（ｘ，ｙ）が最小輝度F_{min}のときにパターン密度ρ（ｘ，ｙ）は０、最大輝度F_{max}のときにパターン密度ρ（ｘ，ｙ）に最大密度ｃ＝０．７５となる。
【0100】
次に、算出した相対輝度Ｆ（ｘ，ｙ）とパターン密度ρ（ｘ，ｙ）との関係に基づいて、図１５に示した本実施形態のバックライトユニットの相対輝度Ｆ（ｘ，ｙ）に対応するパターン密度ρ（ｘ，ｙ）の分布を算出する。図１７に、最大密度ｃをｃ＝０．７５とした場合について算出したパターン密度ρ（ｘ，ｙ）の分布を示す。図１７において、縦軸は、パターン密度ρ（ｘ，ｙ）を示し、横軸は、導光板の中心（中央部）からの距離を示す。

Microsoft Exhibit 1002 - Page 1227
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【0101】
次に、算出した最大密度ｃをｃ＝０．７５とした場合に式（５）を満足するパターン密度ρ（ｘ，ｙ）の分布に基づいて、透過率調整体１８６が配置された透過率調整部材１８２を作成した。
ここで、本実施形態では、パターン密度ρ（ｘ，ｙ）の分布を幅方向の０．５ｍｍ毎に算出し、算出したパターン密度ρ（ｘ，ｙ）に応じて、幅方向の大きさが０～１ｍｍの透過率調整体１８６を適宜配置することで透過率調整部材１８２を作成した。
ここで、本実施形態では、透過率調整体を全面に配置した場合、つまりパターン密度ρ（ｘ，ｙ）が１のとき、波長５５０ｎｍでの透過率が３３％である白色インクにより作成した透過率調整体１８２を配置した。
【0102】
このようにして作成した透過率調整部材１８２をバックライトユニット１８０に配置した場合に、バックライトユニット１８０の光射出面から出射される光の相対輝度を測定した。測定方法は上述の相対輝度Ｆ（ｘ，ｙ）を測定した測定方法と同様の方法で測定した。測定結果を図１８に示す。ここで、図１８において、縦軸は、相対輝度を示し、横軸は、導光板の中心（中央部）からの距離を示す。また、比較のために透過率調整部材１８２を備えないこと以外は同じ構成のバックライトユニットの光出射面から出射された光の垂直輝度を併せて示す。
【0103】
図１８に示すように、透過率調整部材１８２を配置することで、透過率調整部材１８２を配置しない場合に比べて輝度むらを低減させることができる。
【0104】
ここで、上述したように、最大密度ｃは、０．５≦ｃ≦１とすることが好ましい。最大密度ｃを０．５以上とすることで、平均輝度の低減も抑えることができ、高輝度で均一な光を出射させることができる。
また、透過率調整体１８６は、パターン密度ρ（ｘ，ｙ）＝１、つまり透過率調整体１８６を全面に配置した場合の透過率が１０％以上５０％以下であることが好ましく、２０％以上４０％以下とすることがより好ましい。
透過率を１０％以上とすることで、輝度むらを好適に低減させることができ、５０％以下とすることで、平均輝度を低下させることなく、輝度むらを低減させることができる。
さらに、透過率を２０％以上４０％以下とすることで、上記効果をより好適に得ることができる。
【0105】
また、透過率調整体の形状は四角形状、三角形、六角形、円形、楕円形等、どのような形状でもよい。
また、バックライトユニットに、本実施例のような線状光源と１軸延伸形状の導光板とを用いた場合は、透過率調整体の形状を、線状光源の軸と平行な細長い帯形状としてもよい。
【0106】
ここで、上記実施形態では、透過率調整体が配置される光学部材として透明フィルムを用いたが、本発明は、これに限定されず、拡散フィルムやプリズムシートに透過率調整体を配置してもよい。例えば、透明フィルムの代わりに、図１５に示す拡散フィルム１４又はプリズムシート１８８に透過率調整体を形成してもよい。これにより部品点数を減らすことが可能となり、製造コストを低減することができる。
【0107】
また、透過率調整部材１８２の透過率調整体１８６は、透過率調整部材１８２に入射する光に応じてパターン密度分布が調整されるが、透過率調整体１８６のパターン密度分布は、透過率調整体１８６の大きさを変化させることによって調整されても、一定形状の透過率調整体１８６の配置間隔を変化させることによって調整されてもよい。
パターン密度に応じた透過率調整体１８６の配置方法としては、ＦＭスクリーニング方

Microsoft Exhibit 1002 - Page 1228
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

式、ＡＭコア方式等種々の方式を用いることができ、これらのうち、ＦＭスクリーニング方式を用いることが好ましい。ＦＭスクリーニング方式を用いることにより、透過率調整体１８６を微細で均一なドットとして分散集合させて配置することができ、バックライトユニットの光射出面から、透過率調整体１８６の配置パターンを視認しにくくすることができる。つまり、バックライトユニットの光射出面から透過率調整体１８６の配置パターンが投影され、むらのある光が射出されることを防止でき、より均一な光を射出することができる。また、ドット寸法が小さくなりすぎ、透過率調整体１８６の形成が困難になることも防止できる。

【0108】

透過率調整体１８６は、最大寸法を５００μｍ以下、例えば、矩形形状の場合は一辺の長さを５００μｍ以下、楕円形状の場合は、長径を５００μｍ以下とすることが好ましく、２００μｍ以下とすることがより好ましい。透過率調整体１８６の最大寸法を５００μｍ以下とすることで、透過率調整体１８６の形状が目視されにくくなり、最大寸法を２００μｍ以下とすることで、透過率調整体１８６の形状が目視できなくなり、実際に液晶表示装置として使用する際に、透過率調整体１８６の形状がバックライトユニットの光射出面に投影されて輝度むらとなることがなく、効率よく輝度むらを低減することができる。

また、透過率調整体１８６は、最大寸法を１００μｍ以下とすることがさらに好ましい。最大寸法を１００μｍ以下とすることで、寸法がより確実に肉眼の判別能以下とすることができ、実際に液晶表示装置として使用する際に、透過率調整体１８６の形状がバックライトユニットの光射出面に投影されて輝度むらとなることがなく、より確実に、かつ、効率よく輝度むらを低減することができる。

【0109】

また、透過率調整体を透明フィルムの表面に印刷する方法としては、スクリーン印刷、オフセット印刷、グラビア印刷、インクジェット印刷等の種々の印刷方法を用いることができる。オフセット印刷は生産性に優れるという利点を有し、スクリーン印刷は、インク厚を厚くすることができ、インク濃度を高くしなくても、パターン部分の透過率を低くすることができるという利点を有する。また、インクジェット印刷は、立体物に印刷することが可能であり、導光板の表面に透過率調整体を形成する方法として最適である。

また、透過率調整体を透明フィルムの表面に印刷する際に、透明フィルムの網点パターンの配置領域外にアライメントマークを印刷してもよい。透明フィルムにアライメントマークを形成することで、製造時の導光板と透過率調整部材とのアライメントを容易にとることができる。

【0110】

本実施形態では、透過率調整部材を導光板と拡散フィルムとの間に設けたが、配置位置はこれに限定されず、拡散フィルムとプリズムシートとの間に配置してもよい。

また、透過率調整部材を、透明フィルムに透過率調整体を配置することで設けたが、本発明はこれに限定されず、拡散フィルム、プリズムシート、または導光板の表面に透過率調整体を配置したものを透過率調整部材としてもよい。具体的には、拡散フィルムの導光板側の面（光の入射面）、及び、拡散フィルムの導光板側とは反対側の面（光の出射面）の少なくとも一方に透過率調整体を配置してもよい。また、プリズムシートの導光板側の面（光の入射面）、及び、プリズムシートの導光板側とは反対側の面（光の出射面）の少なくとも一方に透過率調整体を配置してもよい。さらに、導光板の光射出面に直接透過率調整体を配置してもよい。

このように、透過率調整体を拡散フィルム、プリズムシートまたは導光板の表面に設けることで、透明フィルムを使用することなく透過率調整部材を形成することができ、層構成をより簡単にすることができる。

また、透過率調整体を直接導光板の光射出面に配置することで、上記効果に加えて、面状照明装置の組み立て時に、アライメントをとることなく、導光板から射出される光の輝度むらに対して透過率調整体を正確な位置に配置することができる。

【0111】

Microsoft Exhibit 1002 - Page 1229
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

また、複数箇所つまり複数の光学部材、例えば、導光板の表面及び拡散フィルム裏面等に透過率調整体を配置し、複数の透過率調整部材を形成することが好ましい。このように透過率調整体を複数の光学部材に配置することで、各位置での透過率調整体の配置パターンと入射する光との位置ずれの許容量を広げることができ、輝度むら及び色むらのない均一な光を射出することができる。ここで、複数箇所に透過率調整体を配置する場合、透過率調整体の配置パターンは、同一の配置パターンとしても、異なる配置パターンとしてもよい。

【0112】

また、上記実施形態では、好適な態様として、透過率調整部材の透過率調整体を上記式（５）のパターン密度ρ（ｘ，ｙ）を満たすように配置したが、本発明はこれに限定されず、輝度むらの発生を抑制するための種々のパターン密度で透過率調整体を配置させることができる。例えば、透過率調整部材として、線状光源の軸に垂直な方向に密度の分布を有するように透過率調整体が配置された公知の透過率調整部材とすることもできる。

【0113】

さらに、透明フィルムの表面上に白インクを任意の色のインク（白色以外のインク）に混練し、分散した色度調整フィルムを導光板の光射出面上に配置することが好ましい。ここで、白インクと任意の色のインクとの混合比は、白インク１００に対して任意の色のインクを１未満である。

色度調整フィルムを配置することで、射出される光の色を微調整することができ、演色性や色再現性を向上させることができる。これにより、光源として、演色性の低い光源を用いた場合でも演色性を向上させることができる。また、射出される光の色を微調整することができる。

【0114】

以下、具体的実施例とともにより詳細に説明する。

本実施例では、色温度９１５０ＫのＬＥＤ素子、色温度８５００ＫのＬＥＤ素子の３つの光源を用いて、色度調整フィルムを配置していない場合と、下記表２及び表３に示した種々のインク割合の色度調整フィルムを配置し場合に射出される光の色度を測定した。

【0115】

【表2】

No	白インキ	violet	trichromatic magenta	magenta	trichromatic cyan
S0	500	0.0	0.0	0.0	0.0
S1	500	1.5	0.0	0.0	0.0
S2	500	3.0	0.0	0.0	0.0
S3	500	0.0	1.5	0.0	0.0
S4	500	0.0	3.0	0.0	0.0
S5	500	0.0	0.0	1.5	0.0
S6	500	0.0	0.0	3.0	0.0
S7	500	0.0	0.0	0.0	1.5
S8	500	0.0	0.0	0.0	3.0
S9	260	1.5	0.0	0.0	1.0
S10	520	1.5	0.0	0.0	1.0
S11	1040	1.5	0.0	0.0	1.0
S12	1166	1.0	0.0	0.0	2.4
S13	875	1.0	0.0	0.0	2.3
S14	438	1.0	0.0	0.0	2.3
S15	1750	1.0	0.0	0.0	2.3

【0116】

【表3】

No	高濃度白 4707M	藍 4746M	マゼンタ FIL135TC
A0	500	0.0	0.0
A14	900	1.5	1.5

【0117】

測定結果を図１９及び図２０に示す。

ここで、図１９は、色温度９１５０ＫのＬＥＤ素子から射出され、表２及び表３に示し

Microsoft Exhibit 1002 - Page 1230
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

た各種色度調整フィルムを透過した光をそれぞれ測定した結果を示すグラフであり、図２０は、色温度８５００ＫのＬＥＤ素子から射出され、表２及び表３に示した各種色度調整フィルムを透過した光をそれぞれ測定した結果を示すグラフである。

【0118】

図１９及び図２０に示すように、各種色度調整フィルムを配置することで射出される光の色温度を調整することができる。つまり、図１９及び図２０中の矢印でそれぞれ示すように、射出される光を元の光源色から、Ｒ（レッド）方向、Ｙ（イエロー）方向、Ｍ（マゼンダ）方向等の種々の色方向へシフトさせることができる。

これにより、演色性や色温度再現域を向上させることができる。また、青色ＬＥＤに蛍光体を配置して白色光を射出させる場合でも、色度調整フィルムを配置することで、赤色の色再現性を向上させることができる。

【0119】

ここで、色度調整フィルムの配置位置は特に限定されず、導光板の光射出面と各種光学部材との間、各種光学部材同士の間等に配置してもよく、光源と導光板との間に配置してもよい。

また、色度調整フィルムを配置することに替えて、拡散フィルム、プリズムシート、導光板表面等に上述の白インキに各種インクを所定量混練したインクを塗布してもよい。

【0120】

また、上記実施形態では、図１に示されるように、光射出側面１８ａが平坦に構成され、その反対側の面が傾斜面で形成されている導光板を用いたが、本発明のバックライトユニットに用いられる導光板は、このような形状に限定されない。

以下、本発明のバックライトユニットに使用できる導光板の他の構成例について説明する。

【0121】

図２１（Ａ）及びＢには、本発明のバックライトユニットに用いることができる導光板の他の構成例を示した。図２１（Ａ）は、導光板２８と、光混合部２０と、光源１２を示す概略平面図であり、図２１（Ｂ）は、導光板２８を示す概略断面図である。なお、図２１（Ａ）及びＢにおいて、光源１２及び光混合部２０（２０Ａ及び２０Ｂ）は、図１に示される光源及び光混合部と同じ機能を有するので、その詳しい説明については省略する。

【0122】

導光板２８は、図１に示した導光板１８を上下反転させたような構造を有し、その光射出面が、一対の平坦な第１傾斜面２８ａ及び第２傾斜面２８ｂで構成され、その反対側の面が平坦面２８ｃで構成される。導光板２８の第１傾斜面２８ａ及び第２傾斜面２８ｂは、中央部から端部に向かうに従って厚みが薄くなるように、平坦面２８ｃに対して傾斜している。かかる構造の導光板２８では、第１光入射面２８ｄ及び第２光入射面２８ｅから入射した光は、第１傾斜面２８ａ及び第２傾斜面２８ｂから出射する。

かかる形状を有する導光板２８も、上述した導光板１８と同様に、散乱体を含む透明樹脂を用いて形成され、導光板に含まれる散乱粒子の散乱断面積をΦ、光が入射する方向の導光板の半分の長さをL_G、導光板に含まれる散乱粒子の密度（単位体積あたりの粒子数）をN_P、補正係数をK_Cとした場合に、$\Phi \cdot N_P \cdot L_G \cdot K_C$の値が１．１以上であり、かつ８．２以下であり、$K_C$の値が０．００５以上０．１以下であるという関係を満たしている。これにより、均一で輝度むらが少ない照明光を一対の傾斜面である第１傾斜面２８ａ及び第２傾斜面２８ｂから出射することができる。

【0123】

また、図１に示す形状の導光板１８を用いたバックライトユニット２では、反射シート２２の形状を、導光板１８の光射出側と反対側に位置する第１傾斜面１８ｂ及び第２傾斜面１８ｃに応じて、導光板１８の中央部から両端面（第１光入射面１８ｄ及び第２光入射面１８ｅ）に向かって傾斜させて構成したが、図２１（Ａ）及び図１９Ｂに示すような形状を有する導光板２８をバックライトユニットに用いる場合は、反射シート２２は、導光板２８の平坦面２８ｃを覆うように平坦に形成される。

Microsoft Exhibit 1002 - Page 1231
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

なお、図２１（Ａ）及び図２１（Ｂ）に示す導光板２８は、第１傾斜面２８ａ及び第２傾斜面２８ｂにプリズム列は形成されていないが、それら第１傾斜面２８ａ及び第２傾斜面２８ｂにプリズム列を形成することも可能である。また、導光板２８の光射出面と反対側の面である平坦面２８ｃにプリズム列を形成することもできる。

また、図２１（Ａ）及び図２１（Ｂ）に示される形状の導光板２８をバックライトユニットに用いる場合、導光板の光射出側、すなわち、導光板２８の第１傾斜面２８ｂ及び第２傾斜面２８ｃ上に偏光分離フィルムが配置される。偏光分離フィルムは、第１傾斜面２８ｂ及び第２傾斜面２８ｃに密着して形成されてもよいし、例えば、偏光分離フィルムを透明な樹脂製の平坦な板に貼り付けて偏光分離板を作製し、偏光分離板を第１傾斜面２８ｂ及び第２傾斜面２８ｃから所定間隔離して配置してもよい。

【0124】

また、図２２（Ａ）及び図２２（Ｂ）には、本発明のバックライトユニットに用いることができる導光板の更に他の構成例を示した。図２２（Ａ）は、導光板３８と、光混合部２０と、光源１２を示す概略平面図であり、図２２（Ｂ）は、導光板３８を示す概略断面図である。なお、図２２（Ａ）及び図２２（Ｂ）において、光源１２及び光混合部２０（２０Ａ及び２０Ｂ）は、図１に示される光源及び光混合部と同じ機能を有するので、その詳しい説明については省略する。

【0125】

図２２（Ａ）及び図２２（Ｂ）に示す導光板３８は、光が出射する側の光射出面と、その反対側の面が同じ形状で形成されている。導光板３８の光射出面は、矩形状の外形を有し、一対の平坦な第１傾斜面３８ａ及び第２傾斜面３８ｂによって構成され、その反対側の面も同様に、一対の平坦な第３傾斜面３８ｃ及び第４傾斜面３８ｄによって構成されている。すなわち、導光板３８は、光射出側とその反対側を、中央部から両端部に向かって緩やかに傾斜する一対の傾斜面で構成している。第１傾斜面３８ａと第２傾斜面３８ｂは所定の角度で互いに傾斜し、同様に、第３傾斜面３８ｃと第４傾斜面３８ｄも所定の角度で互いに傾斜している。第１傾斜面３８ａに対する第２傾斜面３８ｂの角度と、第３傾斜面３８ｃに対する第４傾斜面３８ｄの角度は同じである。導光板３８は、両端部で板厚が最も薄く、両端部から中央に向かうに従って板厚が厚くなり中央部で最も厚くなっている。

【0126】

図２２に示す導光板３８では、側面から入射した光は導光板２０内部を通過し、第１傾斜面３８ａ及び第２傾斜面３８ｂから出射する。このとき、第３傾斜面３８ｃ及び第４傾斜面３８ｄから一部の光が漏出する場合もあるが、漏出した光は導光板３８の背面を覆うようにして配置される反射シート（図示せず）によって反射され再び導光板の内部に入射する。

【0127】

図２３は、第１の実施形態に用いることができる面状照明装置（バックライトユニット）１４１の他の一例の概略構成を示す概略断面図である。なお、本実施形態において、図１及び図２に示したバックライトユニット１０と同様の構成のものには、同一の符号を付し、その詳細な説明は省略し、異なる部分について重点的に説明する。

バックライトユニット１４１は、光源１４２と、導光板１４４とを有する。また、図示は省略したが、図１及び図２に示したバックライトユニット１０と同様に、バックライトユニット１４１の導光板１４４の光射出面側には、拡散フィルムと、プリズムシートとが配置され、導光板１４４の傾斜面側（光射出面とは反対の面側）には、反射フィルム２２が配置されている。

【0128】

光源１４２は、図１２（Ａ）及びＢに示したＬＥＤアレイ１２４と同様のものである。

導光板１４４は、略矩形形状の平坦な光射出面１４４ａと、光射出面１４４ａの反対側に位置し、光射出面１４４ａの一辺に平行で、光射出面１４４ａを２等分する２等分線Ｘに対して互いに対称で、光射出面１４４ａに対して所定の角度で傾斜する２つの傾斜面（

Microsoft Exhibit 1002 - Page 1232
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

第１傾斜面１４４ｂと第２傾斜面１４４ｃ）と、２つのＬＥＤアレイ１２４に対向し、それらＬＥＤアレイ１２４からの光が入射される２つの光入射面（第１光入射面１４４ｄと第２光入射面１４４ｅ）とを有している。第１傾斜面１４４ｂ及び第２傾斜面１４４ｃは、２等分線Ｘを境にして、光射出面１４４ａに対し傾斜している。導光板１４４は、第１光入射面１４４ｄ及び第２光入射面１４４ｅから中央に向かうに従って厚さが厚くなっており、中央部が最も厚く、両端部が最も薄くなっている。導光板１４４は、第１光入射面１４４ｄ側の一部及び第２光入射面１４４ｅ側の一部が、導光板１４４の他の部分（以下、母材１４６とする）とは異なる材料の低屈折率部材１４８で構成される。

【0129】

低屈折率部材１４８は、母材１４６と共に光入射面１４４ｃを形成し、光入射面１４４ｃとなる面以外は、母材１４６と接している。つまり低屈折率部材１４８の光射出面１４４ａ側、第１傾斜面１４４ｂ側、第２傾斜面１４４ｃ側及び中央部側の面は、母材１４６に覆われている。低屈折率部材１４８は、断面形状が中央部側に凸のかまぼこ形となる形状である。

このような導光板も、押出成形法や射出成形法を用いて製造することができる。また、母材１４６と低屈折率部材１４８とを別々に製造し、母材１４６に低屈折率部材１４８を埋め込む、または接着させて設けてもよい。

ここで、低屈折率部材１４８の屈折率をＮｉとし、母材１４６の屈折率をＮｍとすると、母材１４６と低屈折率部材１４８とは、Ｎｍ＞Ｎｉの関係を満たしている。

【0130】

母材の屈折率よりも屈折率が低い低屈折率部材を光入射面を含む一部に設け、光源から射出された光を低屈折率部材に入射させることで、光源から射出され光入射面に入射する光のフレネルロスを低減し、入射効率を向上させることができる。

また、低屈折率部材１４８は、入射された光を平行光にし、かつミキシングする機能、つまり、カップリングレンズ及び混合部の機能を有する。本実施形態のバックライトユニットは、低屈折率部材を設けることで、カップリングレンズ及び混合部を設けることなく、光源から射出された光をより遠い位置まで到達させることができ、かつ、均一な輝度のむらのない照明光を射出させることができる。

【0131】

ここで、導光板の光射出面は、略全面を低屈折率部材で形成することが好ましい。光射出面の略全面を低屈折率部材とすることで、光源から射出され導光板に入射する光を低屈折率部材に入射させることができ、入射効率をより向上させることができる。

【0132】

ここで、図２３では、低屈折率部材１４８を導光板１４４の中央部に向かって凸のかまぼこ形状としたが、本発明はこれに限定されない。

図２４（Ａ）～図２４（Ｃ）は、本発明のバックライトユニットに用いることができる導光板及び光源の他の例の概略断面図を示すものである。ここで、図２４（Ａ）～図２４（Ｃ）に示す導光板の断面形状は、いずれの位置においても同一の形状を有する。

図２４（Ａ）は、断面形状が正方形となる低屈折率部材１５２を有する導光板１５１を示すのもである。図２４（Ｂ）は、断面形状が台形、具体的には、光入射面となる面１５４ａと光入射面の反対側の面１５４ｂとが平行で光入射面となる面１５４ａよりも導光板１５３の中央部側の面１５４ｂの方が短い台形となる低屈折率部材１５４を有する導光板１５３を示すものである。図２４（Ｃ）は、断面形状が三角形、具体的には、光入射面となる面が底面となり導光板１５５の中央部側に頂点を有する三角形となる低屈折率部材１５６を有する導光板１５５を示すものである。

低屈折率部材を上記のような形状としても、入射効率を向上させることができる。

また、低屈折率部材の形状は、上記例にも限定されず、例えば、断面形状が半円形、双曲線形、放物線となる形状等、種々の形状とすることができる。

【0133】

以上、本発明の第１の実施形態に用いることができるバックライトユニットの他の一例

Microsoft Exhibit 1002 - Page 1233
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

の各構成要件について詳細に説明したが、本発明はこれに限定されるものではない。

図２５に、本発明の第１の実施形態に用いることができるバックライトユニットのさらに他の一例の概略断面図を示す。ここで、バックライトユニット１６０は、導光板１４４の光入射面１４４ｃ近傍に反射部材１６２を設けたことを除いて基本的に図２３に示したバックライトユニット１４１と同じ構成のものである。従って、両者で同一の構成要素には同一の符号を付して、その詳細な説明を省略し、以下に、バックライトユニット１６０に特有の点を重点的に説明する。

【0134】

反射部材１６２は、導光板１４４の光入射面近傍の光射出面１４４ａ及び第１傾斜面１４４ｂ及び第２傾斜面１４４ｃから漏洩する光を反射して、再び導光板に入射させるものであり、導光板１４４の第１光入射面１４４ｄ側の光射出面１４４ａの一部、第２光入射面１４４ｅ側の光出射面１４４ａの一部、第１光入射面１４４ｄ側の第１傾斜面１４４ｂの一部及び第２光入射面１４４ｅ側の第２傾斜面１４４ｃの一部の４ヶ所に、塗布、蒸着または接着等により設けられている。

反射部材１６２は、導光板１４４の光入射面近傍の光射出面１４４ａ及び傾斜面１４４ｂから漏洩する光を反射することができるものであれば、どのような材料で形成されてもよく、例えば、ＰＥＴやＰＰ（ポリプロピレン）等にフィラーを混練後延伸することによりボイドを形成して反射率を高めた樹脂シート、透明もしくは白色の樹脂シート表面にアルミ蒸着などで鏡面を形成したシート、アルミ等の金属箔もしくは金属箔を担持した樹脂シート、あるいは表面に十分な反射性を有する金属薄板により形成することができる。

【0135】

反射部材１６２を、第１光入射面１４４ｄ近傍及び第２光入射面１４４ｅ近傍の光射出面１４４ａ、第１傾斜面１４４ｂ及び第２傾斜面１４４ｃに設けることで、光入射面１４４ｃ近傍の、光源１４２との距離が短いため射出されやすい光の漏洩を防止でき、光入射面近傍で射出されていた光をより遠い位置まで到達させることができる。これにより、導光板に入射した光を効率よく利用することができる。

【0136】

また、光の入射効率を向上させることができるため、本実施形態のように導光板の光入射面近傍に低屈折率部材を設けることが好ましいが、本発明はこれに限定されず、低屈折率部材を設けることなく、反射部材のみを設けても光の利用効率を高くすることができる。

【0137】

ここで、本実施形態では、光射出面と傾斜面の両面に反射部材を設けたが、傾斜面に反射シートを配置する場合は、反射シートが反射部材となるので、光入射面側の一部の光射出面のみに反射部材を設ければよい。

【0138】

ここで、上述の第１の実施形態では、いずれも一枚の導光板で説明したが、本発明はこれに限定されず、複数の導光板を用いて一面の光射出面を形成するようにしてもよい。

図２６に、複数の導光板を用いた面状照明装置の一例を示す。なお、図２６では、導光板の配置を明確に示すため、導光板１８、１８'、１８''と光源１２のみを示す。

【0139】

複数の導光板は、各導光板のそれぞれの光射出面が同一平面となり、かつ、それぞれの光入射面が同一平面となる位置に配置されている。具体的には、導光板１８とそれに隣接する導光板１８'とが、導光板１８の光射出面１８ａと隣接する導光板１８'の光射出面１８ａ'が同一平面となり、かつ、導光板１８の第１光入射面１８ｄと隣接する導光板１８'の第１光射出面１８'ｄとが同一平面となる位置に配置されている。なお、導光板１８と隣接する導光板１８'とは、密着していることが好ましい。また、導光板１８'と導光板１８''とも同様に、それぞれの光射出面１８'ａと光射出面１８''ａが同一平面となり、かつ、第１光入射面１８'ｄと第１光入射面１８'ｄとが同一平面となる位置に配置されている。また、導光板のそれぞれの第２光入射面同士、第１傾斜面同士、第２傾斜面同士も同

Microsoft Exhibit 1002 - Page 1234
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

一平面を形成するように配置されている。

光源１２は、導光板１８、１８'、１８''の各第１光入射面、第２光入射面に対向する位置に配置されている。これにより、導光板１８、１８'、１８''の各第１光入射面、第２光入射面には、共通の光源１２から出射された光が入射する。

【0140】

このように複数の導光板を並列に配置して１つの光射出面を形成することで、より大面積の面状照明装置とすることができる。これにより、より大型の液晶表示装置の面状照明装置としても用いることができる。

また、図２６には図示してないが、拡散フィルム、プリズムシートも、光源と同様に、複数の導光板により形成された光射出面を１つの拡散フィルム、プリズムシートで覆うようにすることが好ましい。

【0141】

また、上記実施形態では、いずれも光射出面を平面としたが、本発明はこれに限定されない。

図２７（Ａ）～図２７（Ｃ）は、面状照明装置の他の実施例を示す図であり、図２７（Ａ）は、面状照明装置３００の概略斜視図であり、図２７（Ｂ）は、面状照明装置３００の側面図であり、図２７（Ｃ）は、面状照明装置３００を長手方向の断面を示す概略断面図である。

面状照明装置３００は、光源３０２と、導光板３０４と、拡散フィルム３０６と、アクリルパイプ３０８と、反射フィルム３１０とを有する。

【0142】

２つの光源３０２は、図２７（Ｃ）に示すように、それらの間に導光板３０４が挟まれるように配置される。光源３０２は、複数のＬＥＤ３０２ａを有し、ＬＥＤ３０２ａは、図２７（Ｂ）に示すように、導光板３０４の光入射面の形状に沿ってリング状に配置されている。ここで、ＬＥＤ３０２ａとしては、上述した種々のＬＥＤを用いることができる。

導光板３０４は、図２７（Ｂ）に示すように、光源３０２から射出された光の入射方向に垂直な断面において、光射出面が円形に形成され、外周が光射出面となる中空の円筒形状を有する。また、導光板３０４は、図２７（Ｃ）に示すように、円筒の上面及び下面に相当する光入射面（円筒形状の軸方向における端部）から中央に向かうに従って厚みが厚くなっており、中央部の厚みが最も厚く、両端部の厚みが最も薄くなっている。つまり、光源３０２から射出された光の入射方向に平行な方向における導光板３０４の断面形状は、上述した導光板１８等と同様の形状、つまり、光の入射方向において、光入射面から離れるに従って厚みが厚くなる形状である。

【0143】

拡散フィルム３０６は、導光板３０４の光射出面上に配置されている。つまり、円筒形状の導光板３０４の外周面を覆うように円筒状に配置されている。

アクリルパイプ３０８は、中空の円筒形状であり、拡散フィルム３０６の外周に配置されている。また、アクリルパイプ３０８は、透明樹脂で形成されている。

反射フィルム３１０は、導光板３０４の傾斜面側、つまり、円筒形状の導光板３０４の内面側に配置されている。

つまり、面状照明装置３００は、内側から円筒形状の反射フィルム３１０、導光板３０４、拡散フィルム３０６、アクリルパイプ３０８の順で積層されている。

ここで、面状照明装置３００は、外形形状が円筒形状であることを除いて、各種構成は、上述した面状照明装置と同様であるので、形状、材質等の詳細な説明は、省略する。

【0144】

面状照明装置３００も、光源３０２から導光板３０４に入射した光が、内部の散乱粒子により拡散され、直接もしくは反射フィルム３１０に反射して、光射出面から射出され、拡散フィルム３０６、アクリルパイプ３０８を透過して射出される。

面状照明装置３００は、円筒の外周面が光射出面あり、外周面の全面から光が射出され

Microsoft Exhibit 1002 - Page 1235
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

る。これにより、３６０度の全方位に光を射出することができ、蛍光灯と同様に用いることができる。

このように、本発明の面状照明装置は、照明装置として用いられている棒状の蛍光灯と同様の棒状とすることもでき、蛍光灯と同様の用途に用いることもできる。

なお、本実施形態では、導光板の光射出面に拡散フィルムのみを配置したが、上述した面状照明装置と同様の各種光学部材を配置することで、上述と同様の効果を得ることができる。

【0145】

また、面状照明装置の形状は円筒形状に限定されない。

図２８は、面状照明装置のさらに他の実施例を示す図であり、図２８（Ａ）は、面状照明装置３２０の概略側面図であり、図２８（Ｂ）は、面状照明装置３２０を長手方向の断面を示す概略断面図である。

図２８（Ａ）及び図２８（Ｂ）に示すように、面状照明装置３２０は、光源３２２と、導光板３２４と、反射フィルム３２６とを有する。また、図示は省略したが、導光板３２４の外周面には、面状照明装置３００と同様に、拡散フィルム及びアクリルパイプが配置されている。

面状照明装置３２０は、光源３２２から射出された光の入射方向に垂直な断面が、円形の面状照明装置３００を半分した半円筒形状に形成されている。つまり、光源３２２、導光板３２４及び反射フィルム３２６が半円筒形状に形成されている。

このようなを半円筒形状の面状照明装置も好適に用いることができる。例えば、蛍光灯と同様に室内照明として天井に配置する場合は、半円筒形状とすることで、天井側に光を照射することなく、室内を明るくすることができる。これにより、効率よく室内を照明することができる。

【0146】

図２７に示した面状照明装置３００では、円筒形状の導光板を直管の棒状としたが、円筒形状の導光板を、折り曲げ曲管として、面状照明装置をリング状にしてもよい。

図２９、図３０及び図３１は、それぞれ面状照明装置をリング状にした形状の一例を示す概略正面図である。

図２９に示す面状照明装置３３０は、８つの光源３３２と、４つの導光板３３４とを有する。

導光板３３２は、外周面が光射出面となる円筒形状であり、端面から中央部に向かうに従ってその厚みが厚くなる形状である。また、導光板３３４は、端面から端面までの円筒の中心線が９０度の円弧となる曲管である。

この導光板３３２は、端面が隣接する導光板３３２の端面と向かい合うように配置され、連結された４つの導光板３３２が、１つのリング形状となる。

また、導光板３３４の端面には、ぞれぞれ光源３３２が配置されている。

【0147】

このように導光板３３２を曲管形状とし複数連結して配置することで、リング状の面状照明装置とすることができる。

【0148】

また、面状照明装置３３０では、４つの導光板により、リング形状の面状照明装置としたが、これに限定されず、例えば、図３０に示すように、１つの導光板を円筒形状の中心線が円形となる形状することで、１つの導光板３４４とその端面に配置する２つの光源３４２とを有する面状照明装置３４０でリング状の面状証明装置とすることもできる。

また、導光板の円筒形状の中心線の円弧の角度を設定することで、任意の数の導光板でリング状にすることができる。

また、面状照明装置は、棒状、リング状に限定されず、種々の形状とすることができる。

【0149】

さらに、導光板を円筒形状とする場合には、図３１（Ａ）に示すように、面状照明装置

Microsoft Exhibit 1002 - Page 1236
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

３５０の円筒形状の導光板３５４の一部に溝３５４ａを形成することが好ましい。つまり、図３１（Ｂ）に示すように、光源３４２から射出された光の入射方向に垂直な断面において、導光板３５４の一部に溝３５４ａすることが好ましい。

導光板３５４に溝３５４ａを形成することで、導光板３５４の内面側に、反射フィルム３４６を簡単に配置することができる。

【0150】

また、本発明の面状照明装置の他の一例について説明する。

図３２（Ａ）は、本発明に係る他の一例の面状照明装置４００に用いられる導光板１８と光源４１２の概略平面図であり、図３２（Ｂ）は、図３２（Ａ）に示す導光板１８と光源４１２の概略断面図である。

なお、図３２に示す面状照明装置４００は、光源４１２の構成を除いて、他の構成は基本的に面状照明装置１０と同様の構成であるので、以下、本実施形態に特徴的な部分である光源４１２について説明する。また、図示は省略したが、面状照明装置４００にも反射シート、拡散フィルム、プリズムシート等が配置されている。

【0151】

以下、光源４１２について説明する。

２つの光源４１２は、図３２（Ｂ）に示されるように、そられの間に導光板１８が挟まれるように配置されている。光源４１２は、図３３に示すように、列状（ライン状）の配置された複数の擬似白色ＬＥＤチップ４４０と、擬似白色ＬＥＤチップ４４０に対応して配置された複数の補助用ＬＥＤユニット４４２と、擬似白色ＬＥＤチップ４４０と補助用ＬＥＤユニット４４２とを支持するヒートシンク１３０とを有する。

【0152】

擬似白色ＬＥＤチップ４４０は、ＬＥＤに蛍光物質を塗布、付着させた、または、ＬＥＤチップの光射出面側に蛍光体層を配置したものである。擬似白色ＬＥＤチップ４４０は、ＬＥＤが発する光を、蛍光物質を透過させて白色光を射出させる。

一例として、ＬＥＤとしてＧａＮ系青色ＬＥＤを用い、蛍光物質としてＹＡＧ（イットリウム・アルミニウム・ガーネット）系蛍光物質を用いた構成がある。また、他の一例としては、ＬＥＤとして、紫外線ＬＥＤを用い、蛍光物質として、赤色としてＢａＭｇＥｕＭｎ系蛍光物質，緑色としてＺｎｓ系やＳｒＡｌＥｕ系蛍光物質，青色としてＳｒＢａＭｇ系蛍光物質を用いた構成がある。ここで、本実施形態で用いた赤色の蛍光物質及び青色の蛍光物質は，その化学構成によって吸収および励起波長が変化する。

また、上述したように複数の擬似白色ＬＥＤチップ４４０は、列状に配置されている。

【0153】

補助用ＬＥＤユニット４４２は、赤色ＬＥＤ４４２ａ及び青色ＬＥＤ４２ｂを有し、擬似白色ＬＥＤチップ４４０と隣接する擬似白色ＬＥＤとの間に配置されている。

本実施形態では、赤色ＬＥＤ４４２ａは、中心波長６３０ｎｍの光を射出するＬＥＤであり、青色ＬＥＤ４４２ｂは、中心波長４８０ｎｍの光を射出するＬＥＤである。

なお、本実施例では、赤色ＬＥＤと、青色ＬＥＤを用いたが、緑色等の単色の光を発光するＬＥＤを用いることもできる。

なお、補助用ＬＥＤユニットは、擬似白色ＬＥＤチップとは異なる発光波長の光を発光するＬＥＤを１種類または複数種組み合わせた構成を用いることができる。

【0154】

ヒートシンク１３０は、上述したバックライトユニット１２０のヒートシンク１３０と同様の構成であるので、説明は省略する。

なお、本実施形態では、ヒートシンク１３０を用いたが、板状の支持体を用いてもよい。

なお、補助用ＬＥＤユニット４４２は、ヒートシンク１３０に直接固定しても、ヒートシンク１３０以外の周辺の部材に固定してもよい。

【0155】

このように、面状照明装置４００の光源４１２として、擬似白色ＬＥＤチップ４４０と

Microsoft Exhibit 1002 - Page 1237
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

、擬似白色ＬＥＤチップ４４０とは異なる発光波長の光を発光するＬＥＤを１種類または複数種組み合わせた補助用ＬＥＤユニット４４２とを組み合わせることで、光源の演色性を向上させることができる。

また、擬似白色ＬＥＤチップと補助用ＬＥＤユニットとを別々にすることで、補助用ＬＥＤユニットから射出される光の利用効率を高くすることができる。

また、擬似白色ＬＥＤチップと補助用ＬＥＤユニットを別々に設けた構成としても光源から入射する光は導光板で混色される。このため、擬似白色ＬＥＤと補助用ＬＥＤユニットを別々に配置しても、色むらのない光を光射出面から射出させることができる。

【0156】

ここで、本実施形態では、光源の補助用ＬＥＤユニットを赤色ＬＥＤと青色ＬＥＤで構成したが、本発明はこれに限定されず、図３４（Ａ）に示すように、補助用ＬＥＤ５２を、赤色ＬＥＤ４５２ａと、緑色ＬＥＤ４５２ｂと、青色ＬＥＤ４５２ｃとで構成してもよい。また、図３４（Ａ）では、補助用ＬＥＤユニット４５２を、擬似白色ＬＥＤ４５０の間に、赤色ＬＥＤ４５２ａと、緑色ＬＥＤ４５２ｂと、青色ＬＥＤ４５２ｃとを三角形の頂点となる位置に配置したが、その配置方法は特に限定されない。

図３４（Ｂ）は、補助用ＬＥＤユニット４５２を、赤色ＬＥＤ４５２ａと、緑色ＬＥＤ４５２ｂと青色ＬＥＤ４５２ｃで構成した場合の他の配置例である。図３４（Ｂ）に示すように、擬似白色ＬＥＤチップ４５０の間に、赤色ＬＥＤ４５２ａと、緑色ＬＥＤ４５２ｂと、青色ＬＥＤ４５２ｃとを直線状に配置した構成としてもよい。

【0157】

また、補助用ＬＥＤユニットの組み合わせも特に限定されず、ＲＧＢまたは任意の色を射出するＬＥＤを任意の組み合わせを用いることができる。

さらに、上述の補助用ＬＥＤは、異なる２種類以上のＬＥＤを組み合わせたが、補助用ＬＥＤを単色、つまり一種類のＬＥＤ、例えば、図３４（Ｃ）に示すように、補助用ＬＥＤユニットを赤色ＬＥＤ４６２のみとすることもできる。

また、上記実施形態では、いずれも補助ＬＥＤユニットを擬似白色ＬＥＤと隣接する擬似白色ＬＥＤとの間に配置したが、これに限定されず、擬似白色ＬＥＤの近傍であればよく、例えば、図３４（Ａ）中上下方向、つまり、複数の擬似白色ＬＥＤの延在方向に垂直な方向の擬似白色ＬＥＤの近傍に補助用ＬＥＤユニットを配置してもよい。

【0158】

ここで、面状照明装置は、導光板の光射出面から射出される光の平均演色評価数をＲａとし、赤、黄、青の演色評価数をそれぞれR_9、R_{11}、R_{12}とし、擬似白色ＬＥＤのみを列状に配置した光源を配置した面状照明装置の導光板の光射出面から射出される光の平均演色評価数をＲａ’とし、赤、黄、青の演色評価数をそれぞれR_9'、R_{11}'、R_{12}'としたとき下記式（６）式（７）を満たすことが好ましい。

【0159】

【数2】

$$R_a' \geqq R_a \tag{6}$$

$$\begin{cases} 0.75 \leqq K(R) \leqq 2.0,\ K(R) = \dfrac{R_9'}{R_9} \\ 0.75 \leqq K(G) \leqq 2.0,\ K(G) = \dfrac{R_{11}'}{R_{11}} \\ 0.75 \leqq K(B) \leqq 2.0,\ K(B) = \dfrac{R_{12}'}{R_{12}} \end{cases} \tag{7}$$

【0160】

ここで、平均演色評価数Ｒａ、Ｒａ’は、以下の方法で算出する。

まず、基準光の相対分光分布を測定する。ここで、本発明においては、相関色温度６５００ＫのＣＩＥ昼光（D_{65}）を基準光として定義する。

Microsoft Exhibit 1002 - Page 1238
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

基準光の相対分光分布をD_{65}（λ）、演色評価数算出用の試験色の反射スペクトルをT_i（λ）とすると、基準光の三刺激値は、下記式（８）、式（９）のように表される。

【0161】

【数3】

$$\begin{cases} X_{0i} = k\int_{\lambda} D_{65}(\lambda)T_i(\lambda)\bar{x}(\lambda)d\lambda = k\sum_{j=380}^{780} D_{65j}T_{ij}\bar{x}_j \\ Y_{0i} = k\int_{\lambda} D_{65}(\lambda)T_i(\lambda)\bar{y}(\lambda)d\lambda = k\sum_{j=380}^{780} D_{65j}T_{ij}\bar{y}_i \quad (j=1, 2, \cdots, 8) \\ Z_{0i} = k\int_{\lambda} D_{65}(\lambda)T_i(\lambda)\bar{z}(\lambda)d\lambda = k\sum_{j=380}^{780} D_{65j}T_{ij}\bar{z}_i \end{cases} \quad (8)$$

$$k = \frac{100}{\int_{\lambda} D_{65}(\lambda)\bar{y}(\lambda)d\lambda} = \frac{100}{\sum_{j=380}^{780} D_{65j}\bar{y}_i} \quad (9)$$

ここで、D_{65}光源を基準光として用いる場合、Ｘｎ＝９５．０４５，Ｙｎ＝１００，Ｚｎ＝１０８．８９２となる。

【0162】

次に、使用する光源から射出される光の相対分光分布を測定する。

測定した相対分光分布をＰ（λ）とすると、使用する光源の三刺激値は下記式（１０）、式（１１）のように表される。

【数4】

$$\begin{cases} X_i = k\int_{\lambda} P(\lambda)T_i(\lambda)\bar{x}(\lambda)d\lambda = k\sum_{j=380}^{780} P_jT_{ij}\bar{x}_j \\ Y_i = k\int_{\lambda} P(\lambda)T_i(\lambda)\bar{y}(\lambda)d\lambda = k\sum_{j=380}^{780} P_jT_{ij}\bar{y}_j \quad (j=1, 2, \cdots, 8) \\ Z_i = k\int_{\lambda} P(\lambda)T_i(\lambda)\bar{z}(\lambda)d\lambda = k\sum_{j=380}^{780} P_jT_{ij}\bar{z}_j \end{cases} \quad (10)$$

$$k = \frac{100}{\int_{\lambda} P(\lambda)\bar{y}(\lambda)d\lambda} = \frac{100}{\sum_{j=380}^{780} P_j\bar{y}_i} \quad (11)$$

【0163】

得られた三刺激値をL* a* b*へ変換すると、下記式（１２）のように表される。

【数5】

$$\begin{cases} L_i^* = 116\left(\frac{Y_i}{Y_n}\right)^{\frac{1}{3}} - 16 \\ a_i^* = 500\left[\left(\frac{X_i}{X_n}\right)^{\frac{1}{3}} - \left(\frac{Y_i}{Y_n}\right)^{\frac{1}{3}}\right] \quad (i=1, 2, \cdots, 8) \\ b_i^* = 200\left[\left(\frac{Y_i}{Y_n}\right)^{\frac{1}{3}} - \left(\frac{X_i}{X_n}\right)^{\frac{1}{3}}\right] \end{cases} \quad (12)$$

Microsoft Exhibit 1002 - Page 1239
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【0164】
さらに、得られたL*a*b*から、基準光（D_{65}）を用いた際の光と光源を用いた光の式差ｄＥｉは、下記式（１３）のように定義される。

【数6】

$$\begin{cases} \Delta E_i = \sqrt{(\Delta a_i)^2 + (\Delta b_i)^2 + (\Delta L_i)^2} \\ \Delta a_i = \left| a_{0i}^* - a_i^* \right| \\ \Delta b_i = \left| b_{0i}^* - b_i^* \right| \\ \Delta L_i = \left| L_{0i}^* - L_i^* \right| \end{cases} \quad (i=1, 2, \cdots, 8) \qquad (13)$$

【0165】
得られた各試験色についての基準光とＬＥＤ光源との色差ｄＥｉより各試験色に対する演色評価数と、平均演色評価数は、下記式（１４）のように表される。

【数7】

$$\begin{cases} R_i = 100 - 4.6 \times \Delta E_i \quad (i=1, 2, \cdots, 8) \\ R_a = \dfrac{1}{8} \sum_{i=1}^{8} R_i \end{cases} \qquad (14)$$

【0166】
以上のようにして、補助用ＬＥＤユニットは用いずに擬似白色ＬＥＤのみを配置した光源としたことを除いて他の部分は面状照明装置４００と同一の構成の面状照明装置の光射出面から射出される光の平均演色評価数Ｒａ’と面状照明装置４００の光射出面から射出される光の平均演色評価数Ｒａとを算出する。

【0167】
このように、補助用ＬＥＤユニットは用いずに擬似白色ＬＥＤのみを配置した光源としたことを除いて他の部分は面状照明装置４００と同一の構成の面状照明装置の光射出面から射出される光の平均演色評価数Ｒａ’と、赤、黄、青の演色評価数R_9’、R_{11}’、R_{12}’を測定し、算出し．面状照明装置４００の光射出面から射出される光の平均演色評価数Ｒａと、赤、黄、青の演色評価数R_9、R_{11}、R_{12}を測定し、算出する。さらに、測定した値に基づいて、Ｋ（Ｒ）＝（R_9’／R_9）、Ｋ（Ｇ）＝（R_{11}’／R_{11}）、Ｋ（Ｂ）＝（R_{12}’／R_{12}）を算出する。
このようにして算出した、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）及びＲａ’／Ｒａに基づいて演色性を評価する。
このように、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）及びＲａ’／Ｒａに基づいて演色性を評価することで、光源から射出される光の演色性を正確に評価することができ、かつ擬似白色ＬＥＤとの対比を簡単に行うことができる。また、本評価方法を用いて光源を設計することで、所望の演色性を有する面状照明装置を作成することが可能となる。
また、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）及びＲａ’／Ｒａが上記式（６）及び式（７）を満足するか否かを基準として評価することにより、演色性をより正確に判断することができる。

【0168】
面状照明装置４００の導光板の光射出面から射出される光の演色評価数及び平均演色評価数と、光源を擬似白色ＬＥＤのみで構成する以外は、同一の構成の面状照明装置の導光板の光射出面から射出される光のそれぞれの演色評価数及び平均演色評価数との関係が上記式（６）式（７）を満たすことで、演色性をより向上させることができる。

【0169】
また、補助用ＬＥＤユニットとしては、異なる色の光を発光する、つまり、発光する光の中心波長が５０ｎｍ以上離れているＬＥＤを２種以上組み合わせることが好ましい。
また、擬似白色ＬＥＤの光の強度αと、補助用ＬＥＤの光の強度βとの関係が、０．０５≦（β／α）＜０．５を満たすことが好ましい。αとβとの関係が上記範囲を満たすことで、本発明の効果をより好適に得ることができる。

Microsoft Exhibit 1002 - Page 1240
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

なお、補助用ＬＥＤユニットとして、中心波長の異なる２種以上のＬＥＤを組み合わせる場合は、補助用ＬＥＤユニットのそれぞれの種類のＬＥＤの光の強度β_i（ｉ＝１，２，３，・・・）と、擬似白色ＬＥＤの光強度αとも、０．０５≦（β_i／α）＜０．５を満たしていることが好ましい。

【0170】

さらに、擬似白色ＬＥＤチップの光の強度αと、補助用ＬＥＤの光の強度βとの関係は、０．１≦（β／α）≦０．３とすることがより好ましい。αとβとの関係が０．１≦（β／α）≦０．３を満たすことで、色むらの発生をより確実に防止でき、かつ好適に演色性を向上させることができる。

また、本実施形態では、擬似白色ＬＥＤチップに対して補助用ＬＥＤを小さくしたが、擬似白色ＬＥＤチップの大きさと補助用ＬＥＤユニットの大きさとの関係は特に限定されず、例えば、擬似白色ＬＥＤチップと補助用ＬＥＤとを同じ大きさとしてもよい。

【0171】

また、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）及びＲａ’／Ｒａに基づいて演色性を評価し、擬似白色ＬＥＤチップと補助用ＬＥＤユニットの組み合わせ、その割合、また、補助用ＬＥＤユニットを構成するＬＥＤの組み合わせ等を調整し、上記式（６）及び式（７）を満たす擬似白色ＬＥＤチップ及び補助用ＬＥＤユニット、つまり、光源を決定し、その決定した光源を用いて、つまり、決定した組み合わせに基づいて、面状照明装置を製造する。

このようにして、面状照明装置を製造することにより、演色性の高い面状照明装置を製造することができる。

【0172】

また、補助用ＬＥＤユニットを用いずに、擬似白色ＬＥＤチップのみを配置した光源としたことを除いて他の部分は面状照明装置４００と同一の構成の面状照明装置の光射出面から射出される光の平均演色評価数Ｒａ’と、赤、黄、青の演色評価数R_9’、R_{11}’、R_{12}’とを予め算出しておき、面状照明装置の平均演色評価数Ｒａと、赤、黄、青の演色評価数R_9、R_{11}、R_{12}としたとき、上記式（６）及び式（７）を満たすように補助用ＬＥＤユニットの組み合わせ、その割合を決定する面状照明装置の設計方法としても用いることができる。

【0173】

また、補助用ＬＥＤユニットは用いずに擬似白色ＬＥＤのみを配置した光源としたことを除いて他の部分は面状照明装置４００と同一の構成の面状照明装置の光射出面から射出される光の平均演色評価数Ｒａ’と、赤、黄、青の演色評価数R_9’、R_{11}’、R_{12}’とを予め算出しておき、製造された面状照明装置の平均演色評価数Ｒａと、赤、黄、青の演色評価数R_9、R_{11}、R_{12}を測定し、上記式（６）及び式（７）を満たしているか否かで、面状照明装置の演色性を検査する面状照明装置の検査方法としても用いることができる。

【0174】

以下、擬似発光ＬＥＤチップと補助用ＬＥＤユニットとの関係について測定した結果とともにより詳細に説明する。

本実施例では、擬似白色ＬＥＤチップとして、青色ＬＥＤとＹＡＧ（イットリウム・アルミニウム・ガーネット）系を蛍光物質とを組み合わせたＬｕｍｉｌｅｄｓ社製Ｌｕｘｅｏｎ　Ｆｌａｓｈを用いた。

また、補助用ＬＥＤユニットの赤色ＬＥＤとしては、中心波長が６３０ｎｍまたは６５０ｎｍの光を発光するＬＥＤを、緑色ＬＥＤとしては、中心波長が５２０ｎｍの光を発光するＬＥＤを、青色ＬＥＤとしては、中心波長が４７０ｎｍまたは４８０ｎｍの光を発光するＬＥＤを実施例に応じて各種組み合わせた。また、補助用ＬＥＤユニットのＬＥＤには、スペクトル半値角が約３０度のＬＥＤを用いた。

図３５に、擬似白色ＬＥＤチップと、中心波長６３０ｎｍの光を発光する赤色ＬＥＤ、中心波長５２０ｎｍの光を発光する緑色ＬＥＤ、中心波長４７０ｎｍの光を発光する青色ＬＥＤの分光特性を示す。ここで、図３５のグラフの縦軸は相対強度［ａ．ｕ．］であり

Microsoft Exhibit 1002 - Page 1241
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

、横軸は、波長［ｎｍ］である。

上記擬似白色ＬＥＤ及び補助用ＬＥＤユニットのＬＥＤを各種組み合わせた結果を下記表４及び表５に示す。

ここで、表４、表５中Ｎｏ１は、擬似白色ＬＥＤのみを光源として用いた実施例であり、Ｎｏ２～Ｎｏ１４が、種々のＬＥＤを組み合わせた補助用ＬＥＤユニットと擬似白色ＬＥＤとを光源として用いた本発明の実施例である。

表４には、光源として用いた擬似白色ＬＥＤチップ、補助用ＬＥＤユニットのＬＥＤの中心波長と配置割合、また測定した演色評価数R_1～R_8及び算出した平均演色評価数Ｒａを示す。ここで、表４の補助用ＬＥＤの欄の上段は、ＬＥＤの中心波長、下段は、擬似発光ＬＥＤに対する割合を示す。

表５には、測定した結果から算出した、平均演色評価数Ｒａ、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）および判定結果を示す。

また、表５において、判定は、光源として用いた擬似白色ＬＥＤのみを用いた場合よりも、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）が１つでも高くなった場合は△を、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）の少なくとも１つとＲａが高くなった場合は○を、Ｒａ、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）のすべてが高くなった場合を◎、Ｒａ、Ｋ（Ｒ）、Ｋ（Ｇ）、Ｋ（Ｂ）のすべてが平均的に高くなった場合を◎◎とした。

【0175】

【表4】

No	擬似白色	補助用LED①	補助用LED②	補助用LED③	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_a
1	B+YAG	—	—	—	81.1	71.4	62.6	60.1	73	63.1	77.4	79.6	71
2	B+YAG 1	630nm 0.1	—	—	90.3	76.2	65.9	57.1	66.2	56.2	72.6	85.6	71.3
3	B+YAG 1	650nm 0.1	—	—	86.4	74.6	64.5	58.7	69.7	59.5	74.9	84.3	71.6
4	B+YAG 1	—	520nm 0.1	—	69.2	60.5	54.6	54.7	76.6	81.3	89.1	74.3	70.1
5	B+YAG 1	—	—	470nm 0.1	82.1	77.7	69.7	71	73.8	55.1	66.7	70.6	70.8
6	B+YAG 1	—	—	480nm 0.1	80.6	75.1	67.9	69.2	77.1	62.4	73.2	73.9	72.4
7	B+YAG 1	630nm 0.1	—	470nm 0.1	95.1	84.7	73.6	66.7	66.8	49.9	63.8	75.3	72
8	B+YAG 1	650nm 0.1	—	470nm 0.1	89	82.1	71.9	69	70.4	52.3	65.2	74	71.7
9	B+YAG 1	630nm 0.1	—	480nm 0.1	93.1	81.8	72	65.8	70	56.7	70.3	80.6	73.8
10	B+YAG 1	630nm 0.1	520nm 0.1	—	79.5	67.8	59.9	54.6	72.6	74	88.4	88.4	73.1
11	B+YAG 1	650nm 0.1	520nm 0.1	—	75.1	64.7	57.4	54.7	74.8	77.3	89.9	82.9	72.1
12	B+YAG 1	—	520nm 0.1	470nm 0.1	71.7	65.9	60.7	66.7	86	75.5	78.8	70	71.9
13	B+YAG 1	630nm 0.1	520nm 0.1	470nm 0.1	84.1	74.9	66.8	66.3	79.8	69.7	79	81.5	75.3
14	B+YAG 1	650nm 0.1	520nm 0.1	470nm 0.1	78.4	70.9	63.9	66.6	83	72.4	79.4	77.2	74

【0176】

Microsoft Exhibit 1002 - Page 1242
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【表5】

No	R_a	K(R)	K(G)	K(B)	判定
1	71	—	—	—	—
2	71.3	1.69	0.94	0.97	○
3	71.6	1.47	0.97	0.99	○
4	70.1	0.84	0.97	1.6	△
5	70.8	0.92	1.1	0.73	△
6	72.4	0.93	1.1	1.08	○
7	72	1.6	1.02	0.72	△
8	71.7	1.38	1.06	0.93	△
9	73.8	1.61	1.03	1.06	◎
10	73.1	1.52	0.96	1.56	○
11	72.1	1.31	0.97	1.58	○
12	71.9	0.77	1.12	0.39	○
13	75.3	1.45	1.19	1.36	◎◎
14	74	1.23	1.1	1.38	◎

【0177】

表４に示すように、Ｒａ，Ｋ（Ｒ），Ｋ（Ｇ），Ｋ（Ｂ）が、上記式（６）を満たす光源を用いた場合、つまり、Ｎｏ２，３，６，９，１０，１１，１２、１３，１４は、演色性を高くすることができることが分かる。

特に、表４及び表５のＮｏ１３の実施例、つまり、擬似白色ＬＥＤを１に対して、補助用ＬＥＤユニットとして赤色ＬＥＤ（中心波長６３０ｎｍ）を０．１、緑色ＬＥＤ（中心波長５２０ｎｍ）を０．１、青色ＬＥＤ（中心波長４７０ｎｍ）を０．１の割合で配置した場合は、全ての色に対する演色性を高くすることができることがわかる。

【0178】

図３６に、補助用ＬＥＤユニットとして、中心波長６３０ｎｍの光を発光する赤色ＬＥＤと、中心波長４８０ｎｍの光を発光する青色ＬＥＤとを組み合わせた光源（表４，表５中Ｎｏ９）から射出される光の分光特性と、補助用ＬＥＤユニットとして、中心波長６３０ｎｍの光を発光する赤色ＬＥＤと、中心波長５２０ｎｍの光を発光する緑色ＬＥＤと、中心波長４８０ｎｍの光を発光する青色ＬＥＤとを組み合わせた光源（表４，表５中Ｎｏ１３）から射出される光の分光特性を示す。また、比較のため、擬似白色ＬＥＤのみで構成される光源から射出される光の分光特性も併せて示す。

ここで、図３６のグラフの縦軸は相対強度［ａ．ｕ．］であり、横軸は、波長［ｎｍ］である。

図３６のグラフに示すように、射出される光の相対強度の点からも、Ｎｏ９、Ｎｏ１３の組み合わせの光源を用いた面状照明装置は、擬似白色ＬＥＤのみのＮｏ１の面状照明装置よりも赤色領域、青色領域の波長の射出量が大きくなっていることがわかる。

【0179】

なお、上記実施形態では、簡単かつ安価な構成で演色性の高い光、特に演色性の高い白色光を射出できるため、主要ＬＥＤチップとして擬似白色ＬＥＤチップを用いたが、擬似白色ＬＥＤも同様に用いることができる。また、本発明はこれに限定されず、２つ以上の主要ピーク波長を有する光を射出するＬＥＤチップであれば、種々のＬＥＤチップまたはＬＥＤを用いることができる。つまり、主要ＬＥＤチップとしては、例えば、上記実施形態のように青色の波長領域と緑色の波長領域に主要ピークを有する光を射出するＬＥＤチップに限定されず、赤色の波長領域と青色の波長領域に主要ピークを有する光を射出する

Microsoft Exhibit 1002 - Page 1243
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

ＬＥＤチップ、緑色の波長領域と赤色の波長領域に主要ピークを有する光を射出するＬＥＤチップ、赤色の波長領域と青色の波長領域と緑色の波長領域のそれぞれに主要ピークを有する光を射出するＬＥＤチップ等も用いることができる。

【0180】

このように、光源を構成するＬＥＤユニットを、主要ＬＥＤチップ（もしくは主要ＬＥＤ）と補助用ＬＥＤ（もしくは補助用ＬＥＤユニット）とで構成することで、より演色性の高い光を射出させることができる。

【0181】

以上、本発明に係る面状照明装置について詳細に説明したが、本発明は、以上の実施形態に限定されるものではなく、本発明の要旨を逸脱しない範囲において、各種の改良や変更を行ってもよい。

【0182】

また、導光板の形状は、薄型化、大型化等の各種効果を得ることができるため、図１及び図２に示した導光板１８の形状とすることが好ましいが、これに限定されず、種々の形状の導光板を用いることができる。

このように導光板の形状は特に限定されないが、導光板は、光入射面から離れるに従って厚さが厚くなる形状とすることが好ましく、図１及び図２に示したように、導光板の両端にそれぞれ光入射面を有し、光入射面から離れるに従って厚みが厚くなる形状とすることが好ましい。導光板を入射面から離れるに従って厚さが厚くなる形状とすることで、光源から入射した光をより遠くまで到達することができ、導光板の薄型化を維持しつつ、光射出面を大型化することができる。これにより、面状照明装置を薄型化かつ大型化することできる。

【0183】

光入射面から離れるに従って厚さが厚くなる導光板の形状の他の一例としては、図２に示した導光板を半分に切断した形状、つまり、光入射面が１面のみとなり、光入射面から離れるに従って、導光板の厚みが厚くなる形状としてもよい。また、導光板の側面のいずれの面にも光源を配置し、４方の側面を光入射面とし、４つの光入射面から中央に向かうに従って、厚みが厚くなる形状、つまり、光射出面と反対側の面が四角錐形状となる形状としてもよい。

【0184】

導光板を上記のような形状とした場合も、散乱粒子を含有させることが好ましく、さらに、光の入射する方向において導光板の光入射面から光射出面に直交する方向の厚み（導光板の厚み）が最大となる位置までの長さをL_Gとし、上述の$\Phi \cdot N_p \cdot L_G \cdot K_C$が１．１以上８．２以下を満たすことが好ましい。導光板に散乱粒子を含有させることで、導光板に入射した光を効率よく拡散させ、光射出面から照度むら及び／または輝度むらの低減された光を射出させることができ、さらに、上記範囲を満たすことで照度むら及び／または輝度むらがより低減され、かつ光利用効率を高い光を光射出面から射出させることができる。

【図面の簡単な説明】

【0185】

【図1】（Ａ）は、本発明の第１の実施形態に係る面状照明装置を備える液晶表示装置の概略を示す斜視図であり、（Ｂ）は、（Ａ）に示す液晶表示装置の概略断面図である。

【図2】（Ａ）は、本発明に係る面状照明装置に用いられる導光板と光源の概略平面図であり、（Ｂ）は、（Ａ）に示す導光板と光源の概略断面図である。

【図3】赤色、緑色及び青色の３種類の発光ダイオードを用いて構成される複数のＲＧＢ－ＬＥＤの配置の様子を模式的に示す図である。

【図4】ＲＧＢ－ＬＥＤとカップリングレンズの模式図である。

【図5】$\Phi \cdot N_p \cdot L_G \cdot K_C$と光利用効率との関係を測定した結果を示す図である。

【図6】粒子密度が異なるそれぞれの導光体から射出される光の照度をそれぞれ測定した結果を示す図である。

Microsoft Exhibit 1002 - Page 1244
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【図7】光利用効率及び照度むらと粒子密度との関係を示す図である。
【図8】導光板の形状と光利用効率との関係を測定した結果を示す図である。
【図9】（Ａ）～（Ｄ）は、それぞれ導光板の他の一例を示す概略断面図である。
【図10】（Ａ）は、導光板の他の一例を示す概略断面図であり、（Ｂ）は、（Ａ）に示した導光板の一部を拡大して示す概略断面図である。
【図11】（Ａ）は、本発明に係る面状照明装置に用いられる導光板と光源の概略平面図であり、（Ｂ）は、その概略断面図である。
【図12】（Ａ）は、本発明に用いられるＬＥＤアレイの構成の一実施例を示す概略斜視図であり、（Ｂ）は、（Ａ）に示すＬＥＤアレイのＬＥＤチップの概略正面図であり、（Ｃ）は、（Ａ）のＬＥＤアレイを用いる多層ＬＥＤアレイの構成を示す概略正面図であり、（Ｄ）は、ヒートシンクの一実施形態を示す概略側面図である。
【図13】図１に示される導光板の光射出面上にプリズムシートを配置した場合のバックライトユニットの概略構成図である。
【図14】傾斜面に拡散反射体を印刷した導光板を備える面状照明装置の概略上面図である。
【図15】透過率調整部材を有する面状照明装置の一例を示す概略断面図である。
【図16】透過率調整部材を備えないバックライトユニットの光出射面から出射される光の相対輝度のグラフである。
【図17】図１６に基づいて算出した相対輝度に基づいて最大密度ｃを０．７５とした場合に本発明を満足する透過率調整部材のパターン密度の分布を算出した算出結果を示すグラフである。
【図18】図１７で算出した最大密度ｃを０．７５とした場合の透過率調整部材を配置した面状照明装置の光出射面から出射する光の相対輝度を示すグラフである。
【図19】他の光源から射出され色度調整フィルムを透過した光を測定した結果を示すグラフである。
【図20】他の光源から射出され色度調整フィルムを透過した光を測定した結果を示すグラフである。
【図21】（Ａ）は、本発明のバックライトユニットに用いることができる導光板の他の構成例の概略平面図であり、（Ｂ）は、その概略断面図である。
【図22】（Ａ）は、本発明のバックライトユニットに用いることができる導光板の更に他の構成例の概略平面図であり、（Ｂ）は、その概略断面図である。
【図23】本発明の第１の実施形態の面状照明装置の他の例を示す概略断面図である。
【図24】（Ａ）～（Ｃ）は、それぞれ本発明の第１の実施形態の面状照明装置に用いる導光板の他の例を示す概略断面図である。
【図25】本発明の第１の実施形態の面状照明装置の他の一例の構成を示す概略断面図である。
【図26】複数の導光板を用いた面状照明装置の概略構成図である。
【図27】（Ａ）は、面状照明装置の他の実施例を示す概略斜視図であり、（Ｂ）は、（Ａ）に示す面状照明装置の概略側面図であり、（Ｃ）は、（Ａ）に示す面状照明装置の長手方向における概略断面図である。
【図28】（Ａ）は、面状照明装置のさらに他の実施例を示す概略側面図であり、（Ｂ）は、（Ａ）に示す面状照明装置の長手方向における概略断面図である。
【図29】リング状の面状照明装置の一例を示す概略正面図である。
【図30】リング状の面状照明装置の他の一例を示す概略正面図である。
【図31】（Ａ）は、リング状の面状照明装置の他の一例を示す概略正面図であり、（Ｂ）は、（Ａ）に示す面状照明装置の断面図である。
【図32】（Ａ）は、本発明の他の面状照明装置に用いられる導光板と光源の概略を示す平面図であり、（Ｂ）は、その概略断面図である。
【図33】図３２に示した光源の構成を示す概略正面図である。
【図34】（Ａ）～（Ｃ）は、それぞれ、図３２に示した面状照明装置に用いることができ

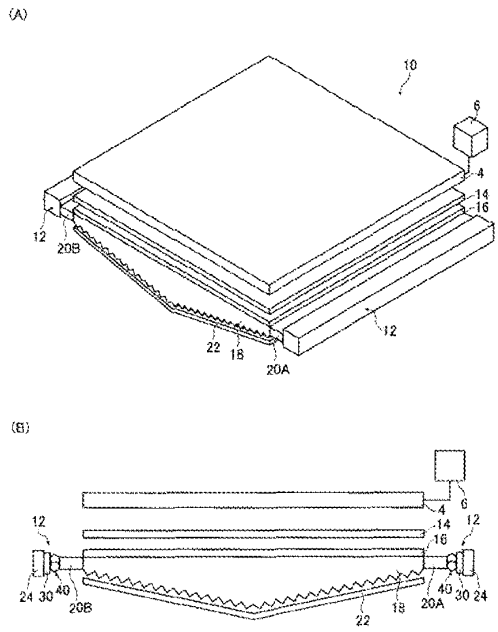
Microsoft Exhibit 1002 - Page 1245
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

る光源の他の一例をしめす概略正面図である。
【図35】擬似白色ＬＥＤ及び補助用ＬＥＤユニットの各ＬＥＤから射出される光の分光特性を示すグラフである。
【図36】光源から射出される光の分光特性を測定した結果を示すグラフである。
【符号の説明】
【0186】
２、１２０、１４１、１８０　　バックライトユニット
４　　液晶表示パネル
６　　駆動ユニット
１０　　液晶表示装置
１２、１２２、１４２、１９０　　光源
１４　　拡散フィルム
１６　　偏光分離フィルム
１８、２８、３８、１４４、１５１、１５３、１５５　　導光板
１８ａ　　光射出面
１８ｂ　　第１傾斜面
１８ｃ　　第２傾斜面
１８ｄ　　第１光入射面
１８ｅ　　第２光入射面
２０Ａ、２０Ｂ　　光混合部
２２　　反射シート
２４　　ＬＥＤアレイ
２６、１８８　　プリズムシート
２８ａ　　第１傾斜面
２８ｂ　　第２傾斜面
２８ｃ　　平坦面
２８ｄ　　第１光入射面
３８ａ　　第１傾斜面
３８ｂ　　第２傾斜面
３８ｃ　　第３傾斜面
３８ｄ　　第４傾斜面
８２　　光源
８４　　ＬＥＤアレイ
８６　　ＬＥＤ
８８、１２６　　カップリングレンズ
９０　　導光部材
９０ａ　　光射出面
９２　　光ファイバ
９４　　ケース
１００　　バックライトユニット
１０２　　反射シート
１０４、１０６　　プリズムシート
１０８　　拡散シート
１２４　　ＬＥＤアレイ
１２８　　ＬＥＤチップ
１３０　　ヒートシンク
１３２　　多層ＬＥＤアレイ
１４０　　拡散反射体
１４６　　母材
１４８、１５２、１５４、１５６　　低屈折率部材

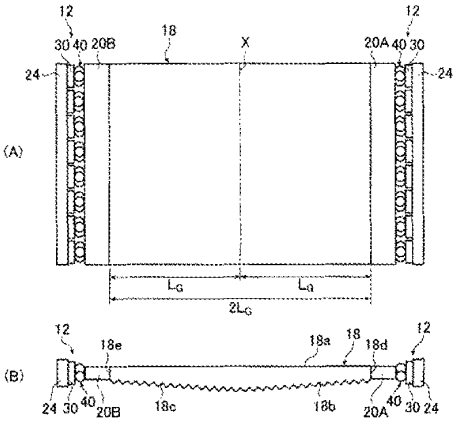
Microsoft Exhibit 1002 - Page 1246
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

１６２　反射部材
１８２　透過率調整部材
１８４　透明フィルム
１８６　透過率調整体

【図1】

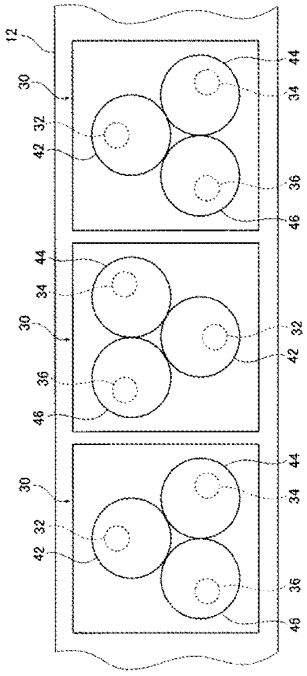


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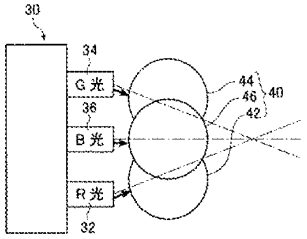


Microsoft Exhibit 1002 - Page 1247
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

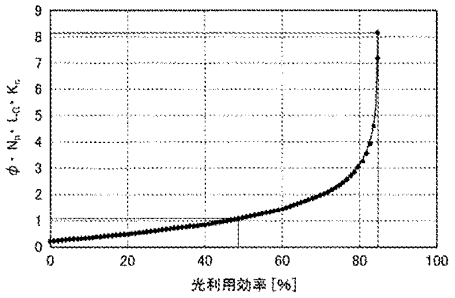
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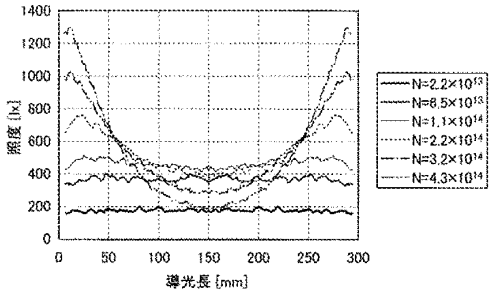
【図4】



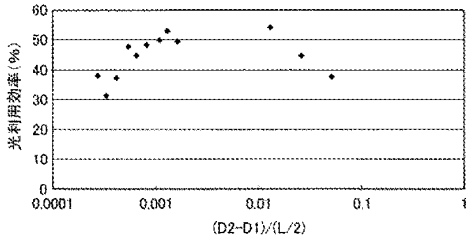
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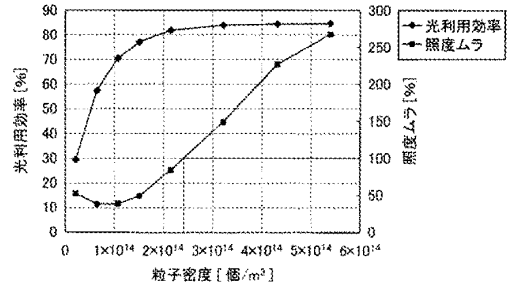
【図6】



【図8】

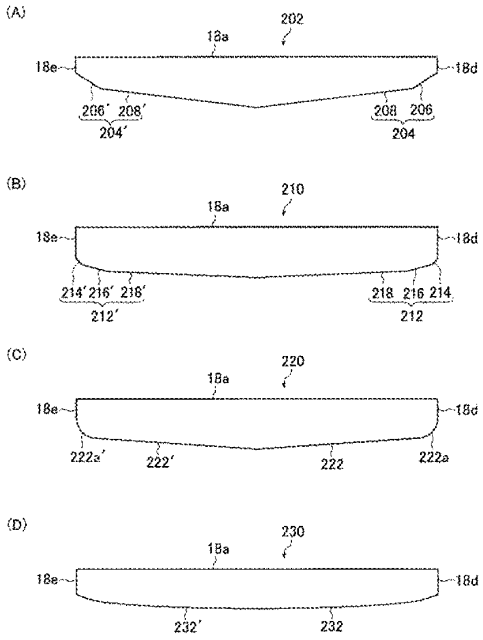


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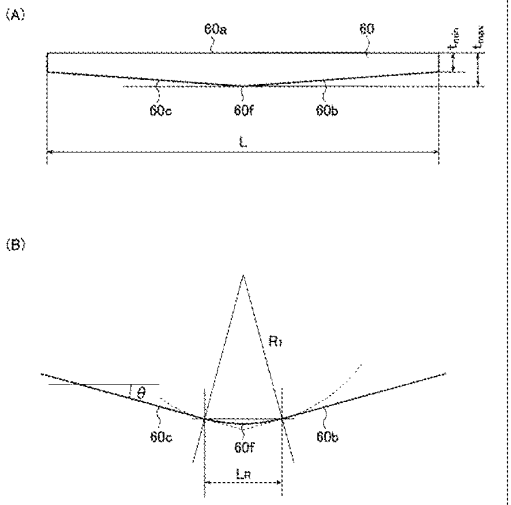


Microsoft Exhibit 1002 - Page 1248
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

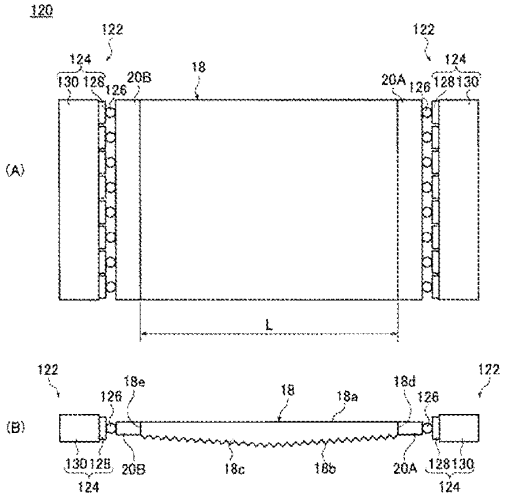
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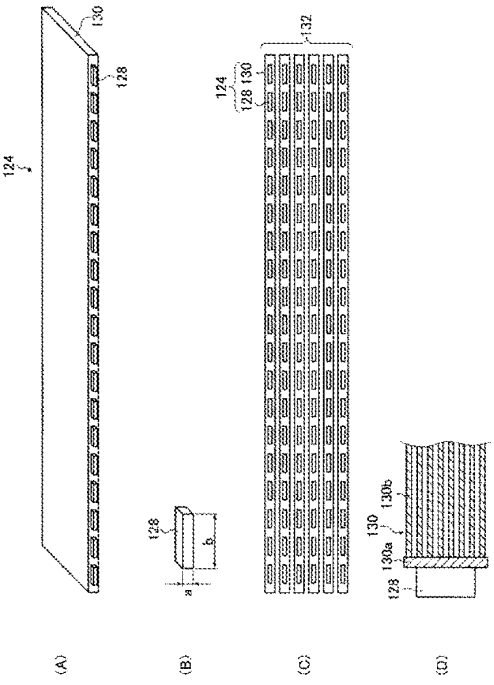
【図１０】



【図１１】

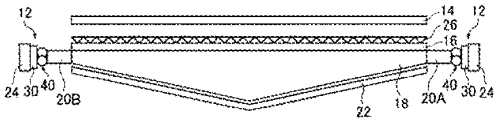


【図１２】

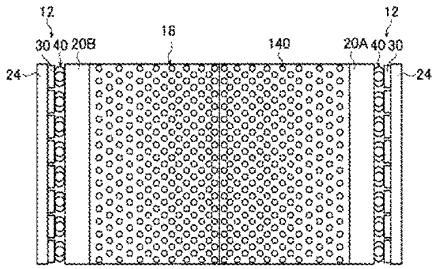


Microsoft Exhibit 1002 - Page 1249
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

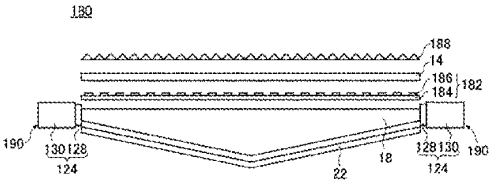
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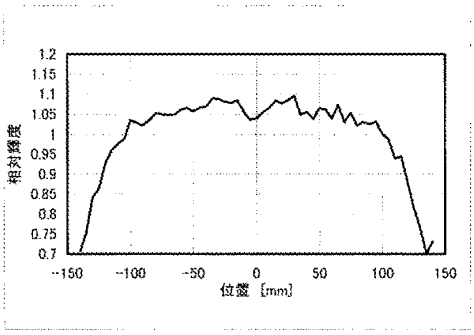
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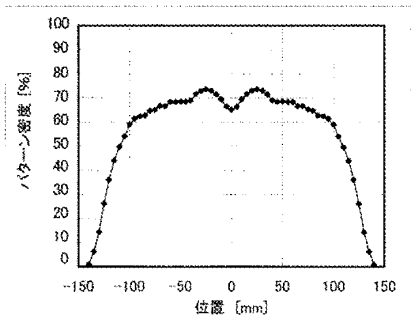
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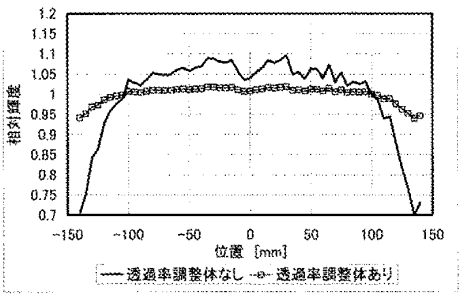
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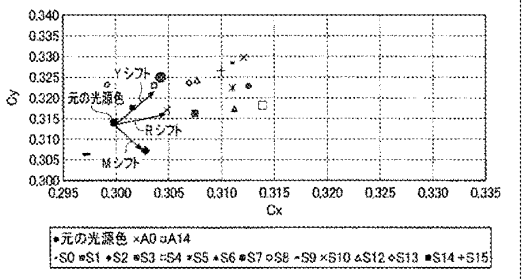
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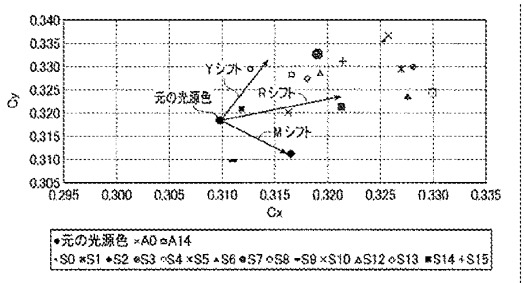
【図18】



【図19】

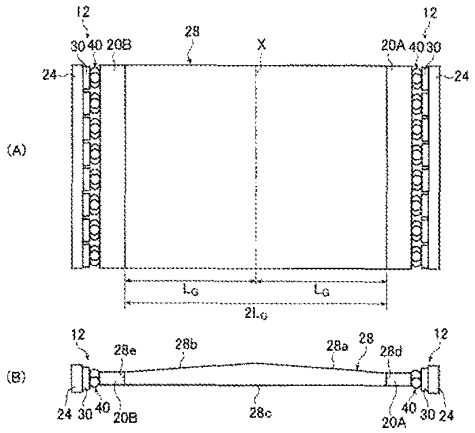


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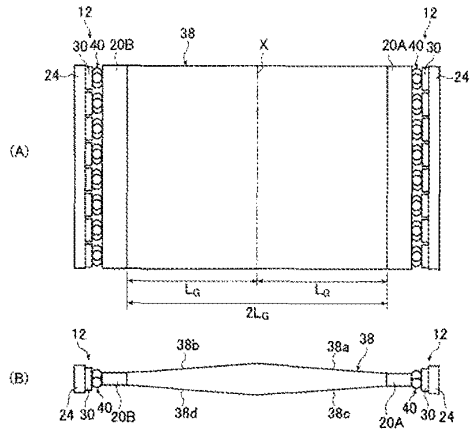


Microsoft Exhibit 1002 - Page 1250
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

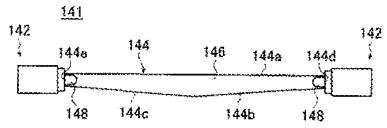
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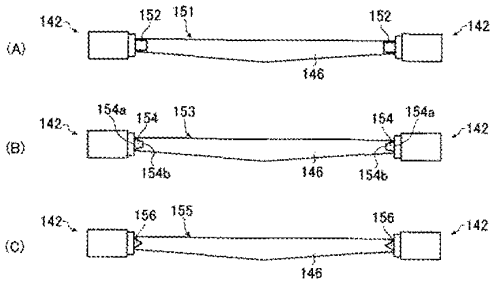
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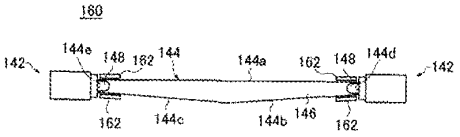
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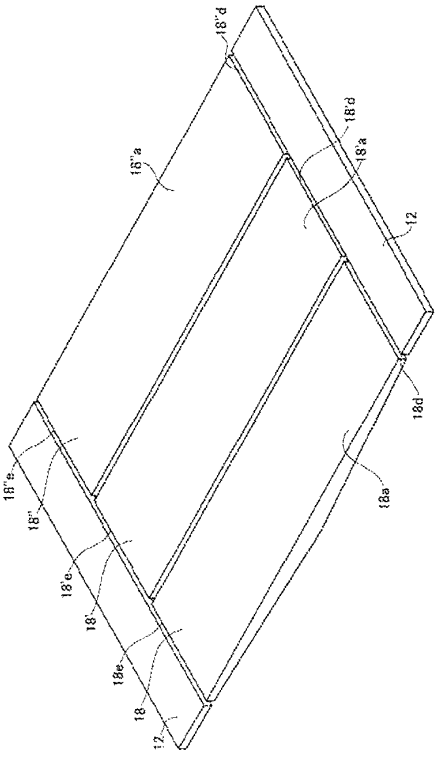
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【図25】

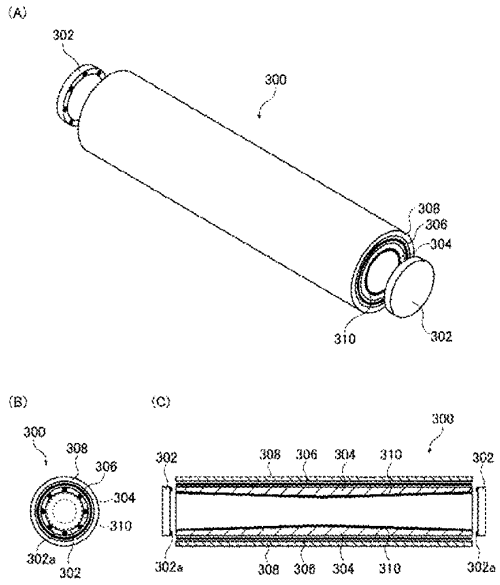


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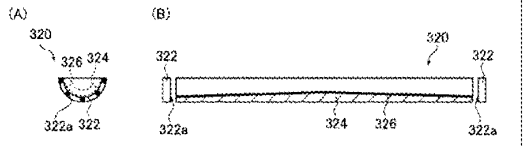


Microsoft Exhibit 1002 - Page 1251
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

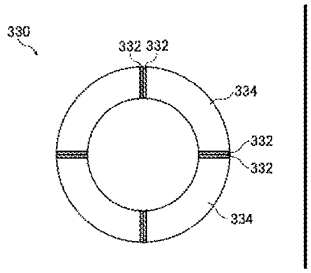
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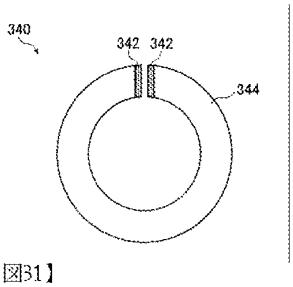
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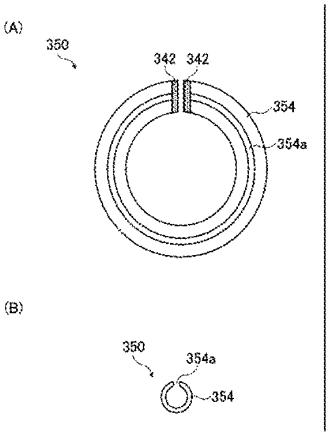
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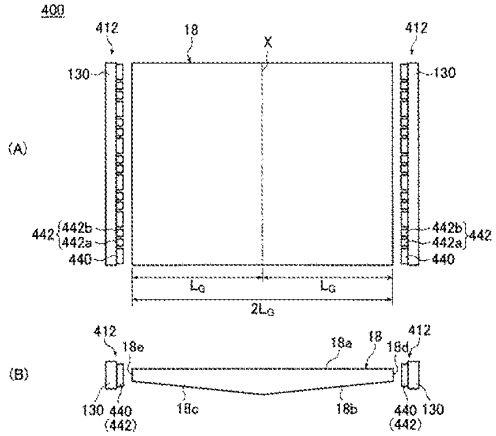
【図30】



【図31】

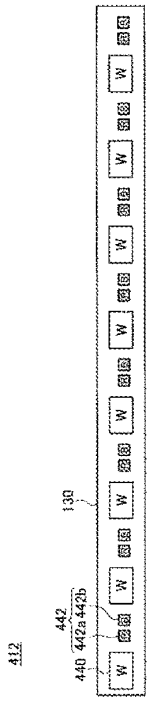


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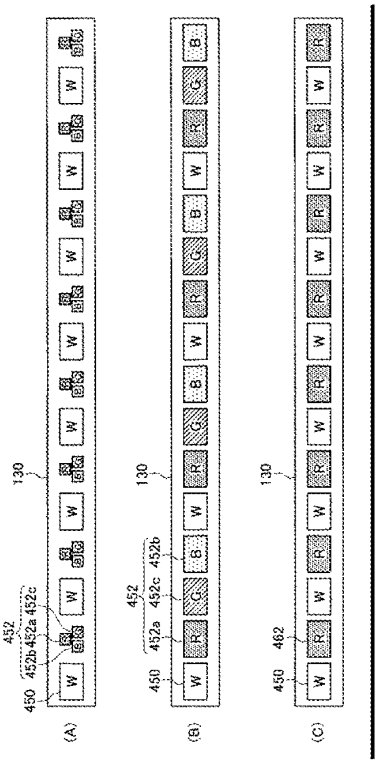


Microsoft Exhibit 1002 - Page 1252
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

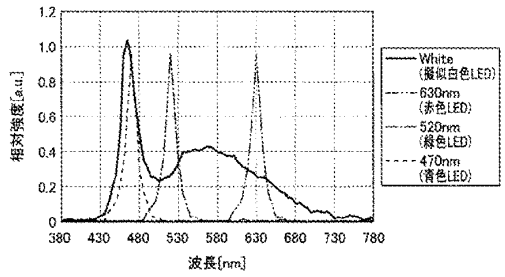
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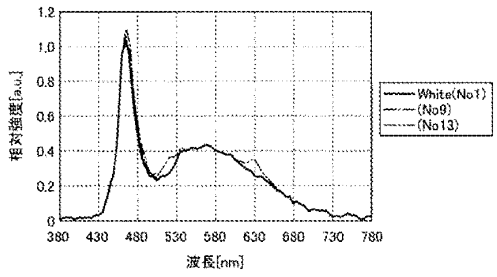
【図34】



【図35】



【図36】



Microsoft Exhibit 1002 - Page 1253
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

(51)Int.Cl.	F I	テーマコード（参考）
	Ｇ０２Ｆ　1/13357	
	Ｇ０２Ｂ　6/00　３３１	

Ｆターム(参考) 2H191 FA71Z FA85Z LA11 LA21 LA27 LA40
3K243 MA01

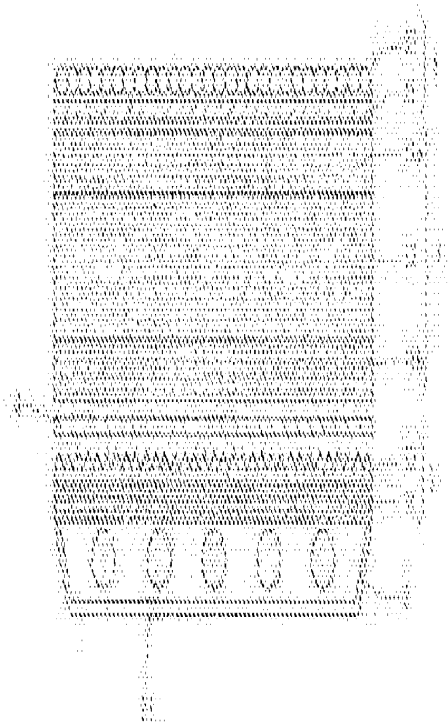
Microsoft Exhibit 1002 - Page 1254
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Abstract of JP2010160527 (A)

Translate this text into

Select language

PROBLEM TO BE SOLVED: To materialize a display with a wide viewing angle and high color reproducibility in a liquid crystal display. ;SOLUTION: The first light diffusion layer 3 has a light diffusion plate 31 and a prism sheet 32, and a luminous intensity distribution characteristic thereof is such that a luminance value in the 70 [deg.] direction with respect to the normal line on a plane of light incidence of the liquid crystal cell is equal to or less than 20% of the luminance value in the normal direction and that emitted light from the first light diffusion layer 3 contains non-parallel light. The second light diffusion layer 5 includes a second polarizing plate 51 and a glare-proof layer 52. The glare-proof layer 52 includes a base film formed by curing a curable resin composition and 10-40 pts.mass of a filler with respect to 100 pts.mass of solids of the curable resin composition. A light diffusion characteristic of the glare-proof layer 52 is such that a light emission angle of laser light emitted from the glare-proof layer 52 having relative intensity of 0.005% for intensity of laser light with a wavelength of 549 nm incident from the normal direction on the rear surface of the glare-proof layer 52 is 40[deg.] or larger with respect to the normal direction on the rear surface of the glare-proof layer 52. ;COPYRIGHT: (C)2010,JPO&INPIT



(19)日本国特許庁(JP)　(12)公開特許公報(A)　(11)特許出願公開番号
特開2010-160527
(P2010-160527A)
(43)公開日　平成22年7月22日(2010.7.22)

(51)Int.Cl.			F I		テーマコード（参考）
G02F	1/1335	(2006.01)	G02F	1/1335	2H191
G02F	1/13357	(2006.01)	G02F	1/13357	

審査請求 未請求　請求項の数 8　OL　（全 23 頁）

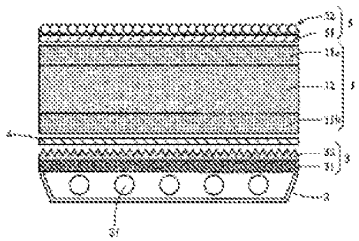
(21)出願番号　特願2010-100428(P2010-100428)
(22)出願日　平成22年4月24日(2010.4.24)
(62)分割の表示　特願2009-89712(P2009-89712)の分割
原出願日　平成21年4月2日(2009.4.2)
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(54)【発明の名称】液晶表示装置

(57)【要約】
【課題】液晶表示装置において広視野角で色再現性の高い表示を実現する。
【解決手段】第１光拡散層３は、光拡散板３１とプリズムシート３２とを有し、その配光特性を、バックライト装置２を光源としたとき、液晶セルの光入射面の法線に対して７０°方向の輝度値が、法線方向の輝度値に対して２０％以下で、且つ、第１光拡散層３からの出射光は非平行光を含むようにする。第２光拡散層５は、第２偏光板５１と防眩層５２とから構成し、防眩層５２は、硬化性樹脂組成物を硬化させてなる基材フィルムと、硬化性樹脂組成物の固形分１００質量部に対して１０～４０質量部のフィラーとを含み、防眩層５２の光拡散特性を、防眩層５２の背面の法線方向から入射する波長５４９ｎｍのレーザ光の強度に対して相対強度が０．０００８％となる、防眩層５２から出射するレーザ光の、防眩層５２の背面の法線方向に対しての光出射角度が４０°以上であるようにする。
【選択図】図１



Microsoft Exhibit 1002 - Page 1256
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【特許請求の範囲】
【請求項1】
一対の基板の間に液晶層が設けられてなる液晶セルと、液晶セルの背面側に設けられたバックライト装置と、バックライト装置と液晶セルとの間に配置された第１光拡散層と、第１光拡散層と液晶セルとの間に配置された第１偏光板と、液晶セルの前面側に配置された第２光拡散層とを備え、
前記第１光拡散層は、光拡散機能と光偏向機能との両機能又はいずれか一方の機能を有し、前記第１光拡散層からの出射光は、（ｉ）前記バックライト装置を光源としたとき、ＶＡ方式液晶セルの光入射面の法線に対して７０°方向の輝度値が該法線方向の輝度値に対して２０％以下である配光特性を有し、且つ、（ｉｉ）非平行光を含み、
前記第２光拡散層は、第２偏光板と、第２偏光板の前面側に設けられた防眩層とから構成され、該防眩層は、硬化性樹脂組成物を硬化させてなる基材フィルムと、該硬化性樹脂組成物の固形分１００質量部に対して１０質量部～４０質量部のフィラーとを含み、該防眩層の光拡散特性は、該防眩層の背面の法線方向から入射する波長５４９ｎｍのレーザ光の強度に対して相対強度が０．０００８％となる、該防眩層から出射するレーザ光の、該防眩層の背面の法線方向に対しての光出射角度が４０°以上であることを特徴とする液晶表示装置。
【請求項2】
前記第１光拡散層が、光拡散機能と光偏向機能との両機能を有することを特徴とする請求項１記載の液晶表示装置。
【請求項3】
前記第１光拡散層は、前記光拡散機能を奏する光拡散板と、前記光偏向機能を奏する光偏向構造板とを有し、前記光拡散板の前面側に前記光偏向構造板が設けられた構成であることを特徴とする請求項２記載の液晶表示装置。
【請求項4】
前記液晶セルが、ＴＮ方式液晶、ＩＰＳ方式液晶、及び、ＶＡ方式液晶のいずれかであることを特徴とする請求項１～３のいずれか記載の液晶表示装置。
【請求項5】
前記液晶セルの背面側及び／又は前面側に位相差板がさらに配置されたことを特徴とする請求項１～４のいずれか記載の液晶表示装置。
【請求項6】
位相差板を具備しない請求項１～４のいずれか記載の液晶表示装置。
【請求項7】
前記液晶セルがＴＮ方式液晶であり、且つ、位相差板を具備しない請求項１～３のいずれか記載の液晶表示装置。
【請求項8】
前記硬化性樹脂組成物が紫外線硬化性樹脂組成物である請求項１～７のいずれか記載の液晶表示装置。

【発明の詳細な説明】
【技術分野】
【0001】
本発明は液晶表示装置に関し、より詳細には、視野角特性に優れた液晶表示装置に関するものである。
【背景技術】
【0002】
近年、液晶表示装置は、携帯電話機やＰＤＡ（Personal Digital Assistant）等の携帯用小型電子機器から、パーソナルコンピュータやテレビなどの大型電気機器に至るまで広く使用されており、その用途は益々拡大している。
【0003】
液晶表示装置は，ＣＲＴやＰＤＰ（プラズマディスプレイパネル）などの自発光型の表

Microsoft Exhibit 1002 - Page 1257
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

示装置とは異なり、表示素子自体は発光しない。このため、透過型の液晶表示装置では、液晶表示素子の背面側にバックライト装置が設けられており、このバックライト装置からの照明光の透過光量を液晶表示素子が画素ごとに制御することによって画像の表示が行われる。

【0004】

液晶表示装置には、ＴＮ（Twisted Nematic）方式、ＳＴＮ（Super Twisted Nematic）方式、ＶＡ（Vertical Alignmen）方式、ＩＰＳ（In-plane Switching）方式などのさまざまな方式があるが、これらの方式には、液晶分子が位相差値を持つことによる光漏れや、偏光板における斜視時の軸角度のずれなどに起因して、それぞれに視野角の狭い方向（方位角）が存在する。

【0005】

そこで、視野角を拡大する方法として、位相差板による、液晶セルや偏光板への光学補償という方法が広く採用されている（例えば、特許文献１及び特許文献２を参照）。

【図面の簡単な説明】

【0018】

【図1】本発明に係る液晶表示装置の一例を示す概説図である。

【図2】第１光拡散層の一例を示す概説図である。

【図3】第１光拡散層の他の例を示す概説図である。

【図4】第１光拡散層について、液晶セルの光入射面の法線に対して７０°方向の輝度値を測定する方法の一例である。

【図5】非平行光の定義を説明する図である。

【図6】第２光拡散層の構成例を示す概説図である。

【図7】第２光拡散層におけるレーザ光の入射方向と出射方向とを模式的に表した図である。

【図8】防眩層から出射するレーザ光の相対強度を光出射角度に対してプロットしたグラフの一例である。この例では、光出射角度が２０°、４０°、４６°および６０°であるとき、防眩層から出射するレーザ光の相対強度は、それぞれ０．０１％、０．００１％、０．０００８％および０．０００３％である。

【図9】本発明に係る液晶表示装置の他の例を示す概説図である。

【産業上の利用可能性】

【0062】

本発明の液晶表示装置では、広視野角、高表示品位および優れた色再現性が得られる。また、位相差板を用いなくても視野角の拡大が図れ、部品点数を減らすことができる。

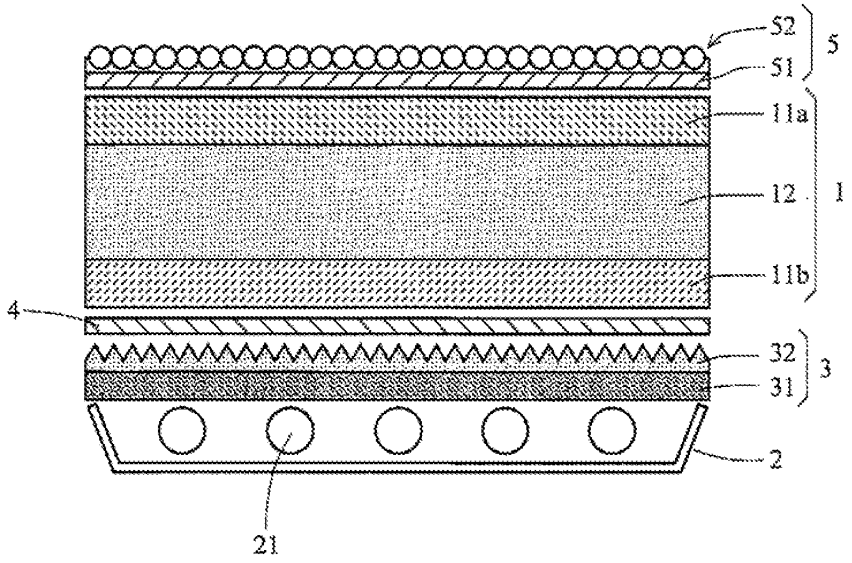
【符号の説明】

【0063】

１	液晶セル
２	バックライト装置
３	第１光拡散層
４	第１偏光板
５	第２光拡散層
６	位相差板
３１	光拡散板
３２	プリズムシート（光偏向構造板）
５１	第２偏光板
５２	防眩層
５２２	フィラー

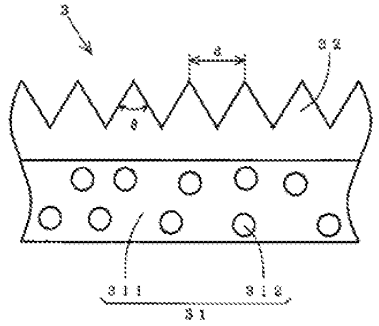
Microsoft Exhibit 1002 - Page 1258
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【図１】

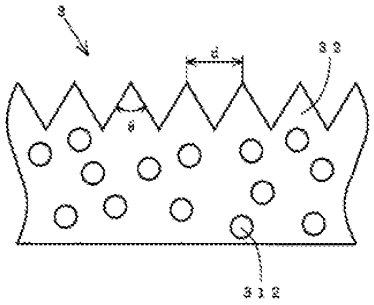


Microsoft Exhibit 1002 - Page 1259
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【図2】

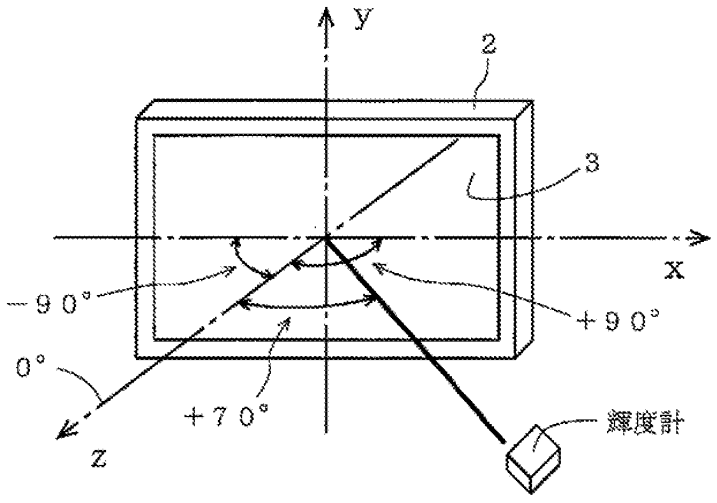


【図３】



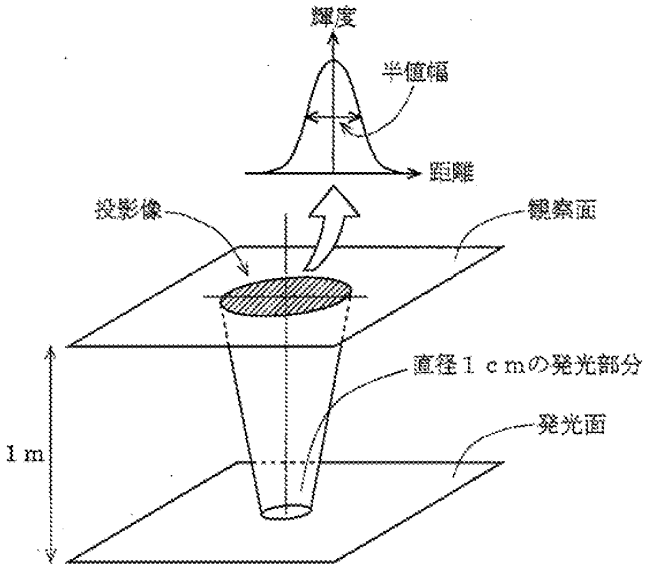
Microsoft Exhibit 1002 - Page 1261
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【図４】

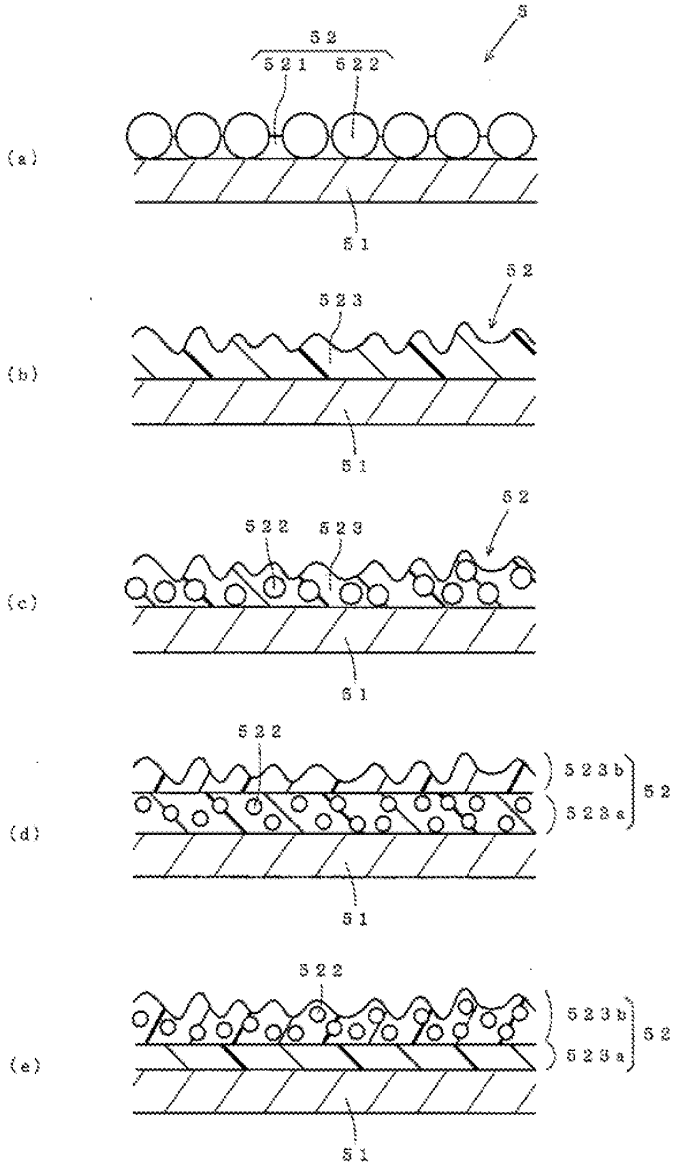


Microsoft Exhibit 1002 - Page 1262
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【図５】

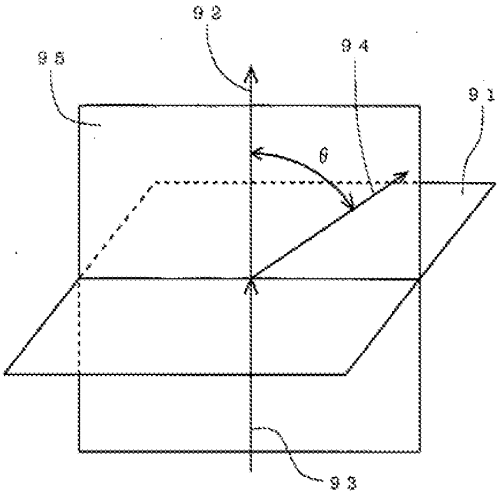


【図6】



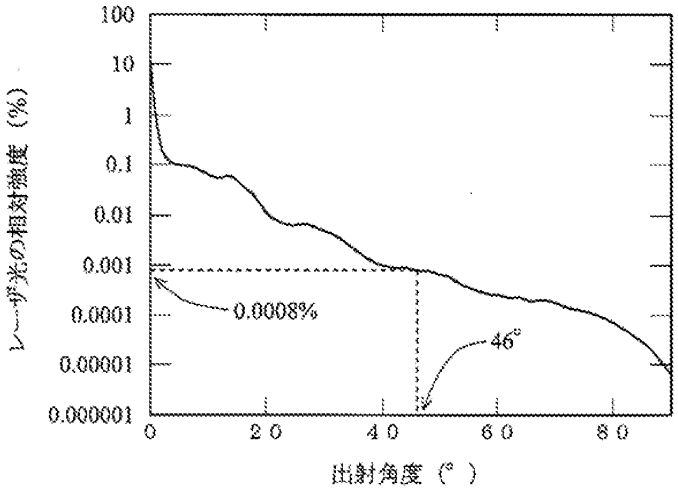
Microsoft Exhibit 1002 - Page 1264
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【図7】



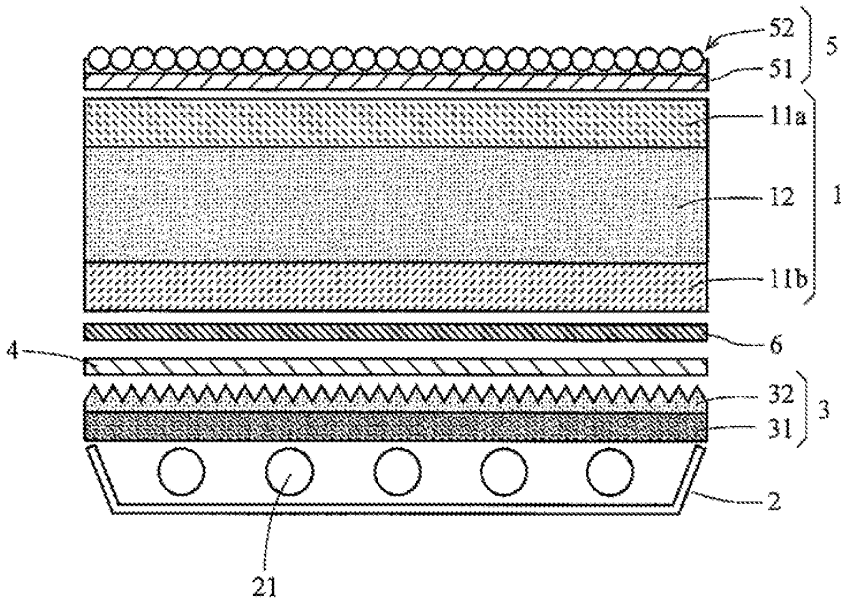
Microsoft Exhibit 1002 - Page 1265
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【図８】



Microsoft Exhibit 1002 - Page 1266
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【図９】



Microsoft Exhibit 1002 - Page 1267
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Ｆターム(参考) 2H191 FA22X FA22Z FA40X FA42X FA42Z FA45X FA46X FA46Z FA54Z FA60Z
FA82Z FB02 FB04 FB05 FB22 FB23 FC09 FC22 FD15 FD16
FD35 GA22 HA06 HA11 HA13 HA15 LA21 LA25 PA03 PA06
PA22 PA62 PA65 PA82

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JP,2012-060607,A

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DRAWINGS

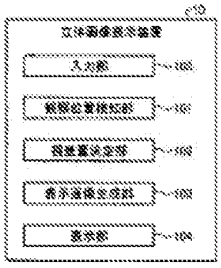
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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[Field of the Invention]
[0001]
The embodiment of the present invention is related with the display technique of a stereoscopic picture.
[Background of the Invention]
[0002]
In recent years, in a movie, an observer is made to carry glasses and the system which shows 3-dimensional scenography is spreading by showing the image (parallax image) which looks respectively to a right and left eye from the position. As display technique of the stereoscopic picture of a naked eye system, To the display surface side of FPD (flat-panel display), by for example, the thing for which the sub pixel which arranges parallax barriers, such as a pinhole, a slit, and a lens array, and is visible according to an observation position is switched, The technology of making the parallax information according to an observer's observation position or the position of an observer's right and left eye recognizing visually is known.
[0003]
If azimuth difference is large, it will jump out to the front largely, or it will withdraw into the back, and will be perceived, and all will be perceived as a plane picture, if there is no azimuth difference.
[0004]
There is technology of making it a side surface be in sight with motion parallax at, with movement of an observer's observation position as technology which displays the high three-dimensional image of presence.
[Citation list]
[Patent literature]
[0005]
[Patent document 1] Japanese Published Patent Application No. 2006-174434 (JP2006-174434A)
[Patent document 2] Japanese Patent No. 3892808 gazette
[Patent document 3] Japanese Patent No. 3944188 gazette
[Description of the Invention]
[Problem to be solved by the invention]
[0006]
In the display technique of such a stereoscopic picture, to display a high quality stereoscopic picture is desired irrespective of a user's observation position.
[Means for solving problem]
[0007]
The primary detecting element where a stereoscopic picture display device detects an observer's observation position to a display part and the aforementioned display part according to the embodiment, The observation position detected in the parallax amount of the inputted video signal is provided with the deciding part determined to the value which decreased, so that distance was [that the angle from the aforementioned display part transverse plane is large, or] near, and the generation part which generates the multiaspect image which should be displayed on the aforementioned display part based on the determined parallax amount.
[Brief Description of the Drawings]
[0008]



Representative drawing

Representative drawing | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |

Microsoft Exhibit 1002 - Page 1269
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

[Drawing 1]The configuration diagram of the stereoscopic picture display device of embodiment 1.
[Drawing 2]Structural drawing of a display part.
[Drawing 3]The figure of the displaying condition of the stereoscopic picture by a stereoscopic picture display device.
[Drawing 4]The figure of the displaying condition of the stereoscopic picture by a stereoscopic picture display device.
[Drawing 5]The figure of the displaying condition of the stereoscopic picture by a glasses-type stereoscopic picture display device.
[Drawing 6]The symbol description figure of an observation position detection part.
[Drawing 7]The explanatory view of the phenomenon in which a display surface is recognized narrowly.
[Drawing 8]It is a graph of the relation of the width of appearance as an observing angle.
[Drawing 9]The explanatory view of viewing area width becoming narrow.
[Drawing 10]The graph of the relation between an observing angle and a viewing area angle.
[Drawing 11]The explanatory view of distance of sight becoming short.
[Drawing 12]The graph of the relation between an observing angle and viewing area width.
[Drawing 13]The graph of the relation between an observing angle and crosstalk quantity.
[Drawing 14]It jumps out with the observing angle of embodiment 1, and is a graph of the relation of the amount of depth.
[Drawing 15]The related figure of each parameter.
[Drawing 16]The flow chart of stereoscopic picture display processing of embodiment 1.
[Drawing 17]The configuration diagram of the stereoscopic picture display device of embodiment 2.
[Drawing 18]It jumps out with the observing angle of embodiment 2, and is a graph of the relation of the amount of depth.
[Drawing 19]The figure of a plane display area and a three dimensional image display area.
[Drawing 20]The flow chart of stereoscopic picture display processing of embodiment 2.
[Drawing 21]It jumps out with the observing angle of the modification 1, and is a graph of the relation of the amount of depth.
[Drawing 22]The flow chart of stereoscopic picture display processing of the modification 1.
[Drawing 23]It jumps out with the observing angle of the modification 2, and is a graph of the relation of the amount of depth.
[Drawing 24]The flow chart of stereoscopic picture display processing of the modification 2.
[Description of Embodiments]
[0009]
Hereinafter, it describes using Drawings about this embodiment. In the embodiment shown below, a actual embodiment has a different portion, and is positional relationship with relative direction of four directions etc., and the size ratio on the convenience of a description and Drawings has a different portion from the direction on the basis of gravitational direction.
[0010]
In the embodiment shown below, the array of the lenticular lens extended perpendicularly is used as a naked eye system. By set of a beam of light, it is natural, and the stereoscopic picture display device which displays a three dimensional image with the display type called the integral imaging system (it is hereafter called II system for short) with which flipping (jump of an image) was inhibited is mentioned as an example, and is described. However, this embodiment is applicable to a glasses-type stereoscopic picture display device besides the stereoscopic picture display device of other naked eye systems instead of what is limited to II system.
[0011]
(Embodiment 1)
The stereoscopic picture display device 10 of this embodiment is mainly provided with the input part 105, the observation position detection part 101, the parallax amount deciding part 102, the display image generating part 103, and the display part 104, as shown in Fig.1. The stereoscopic picture display device 10 of this embodiment inputs the three dimensional image of a displaying object from an external image generating device and picture reproducer, and displays it on the display part 104 in real time.
[0012]
The input part 105 inputs a multiaspect image and a three dimensional image signal from image generating devices, such as a camera, or inputs a three dimensional image signal via decoders, such as picture reproducer.
[0013]
The observation position detection part 101 detects an observer's observation position to the display part 104. According to this embodiment, the acceleration sensor for measuring the angle to the gravitational direction of the stereoscopic picture display device 10 is provided, and an observer's observing angle to the display part 104 is detected as an observation position from the output of an acceleration sensor.
[0014]
The observation position detection part 101 is not limited to this, and equips the stereoscopic picture display device 10 with the head tracking sensor for presuming the direction of the face and the head which have been recognized using a captured image with a camera, The observation position detection part 101 may constitute the observation position detection part 101 from an output from this head tracking sensor so that an observer's observing angle to the transverse plane of the display part 104 may be detected as the aforementioned observation position. The distance sensors for measuring the distance of an observer and the display part 104 to the stereoscopic picture display device 10 may be provided, and the observation position detection part 101 may be constituted so that the distance of the observer from the display part 104 may be detected as an observation position with the output from distance sensors

Microsoft Exhibit 1002 - Page 1270
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

[0015]
In order to generate the element image array generated in order that the display image generating part 103 may display the parallax amount deciding part 102 on the display part 104. The parallax amount of the parallax information of the three dimensional image signal input by the input part 105 is determined to the value which decreased continuously, so that the observing angle theta from the transverse plane of the display part 104 as an observation position is large. In addition, the parallax amount deciding part 102 may be constituted so that distance is near and the above-mentioned parallax amount may be determined from the transverse plane of the display part 104 as an observation position to the value which decreased. The details of the parallax amount deciding part 102 are mentioned below.
[0016]
Here, the element image refers to a set of the parallax image displayed in the sub pixel unit corresponding to the exit pupil (opening 116) mentioned below, and an element image array says the element image group displayed on the display part 104.
[0017]
The display image generating part 103 generates the element image array (multiaspect image) which consists of an element image based on the parallax amount determined by the parallax amount deciding part 102, and displays the generated element image array on the display part 104.
[0018]
The display part 104 is a device which displays the multiaspect image generated by the display image generating part 103. Fig.2 is a perspective view showing roughly an example of the structure of the display part 104 of this embodiment. In Fig.2, it describes as n= 18 viewpoints. The display part 104 is provided with the following so that it may be illustrated by Fig.2.
Display device array 114.
The opening control part 115 arranged at a front face of the display device array 114 concerned.
As the display device array 114, LCD (Liquid Crystal Display) can be used, for example.
[0019]
The opening control part 115 is a beam-of-light controlling element which turns a beam of light to a prescribed direction and to which restrict the beam of light to transmit, and it makes it emit. As the opening control part 115 of this embodiment, as shown in Fig.2, the lenticular sheet is used. A lenticular sheet is an array plate of the lens segment which controls incidence and an exit light line and turns a beam of light to a prescribed direction. As the opening control part 115, array plates, such as a slit which provided the light transmission area as appropriate, can also be used. These light transmission areas and a lens segment have the function to emit selectively only the beam of light which goes in the specific direction among in the beam of light emitted towards the front from the display device array 114. Below, a lens segment and a light transmission area are collectively called an opening.
[0020]
The opening control part 115 uses for the vertical direction of the screen in the display device array 114 the lenticular sheet which is an array plate of the lens which has a bus bar, for example. Each opening 116 and 116 of a lens segment and -- are arranged corresponding to a pixel. The opening control part 115 can also use LCD as a light shutter which can change the position and form of a light transmission area not only with the array plate which accumulated the lenticular segment mentioned above and the light transmission area but with time.
[0021]
Here, at general FPD, one pixel comprises a sub pixel of each RGB color. One display device shall correspond to one sub pixel. In the example of Fig.2, the display device (the sub pixels 140 and 140, --) by which the aspect ratio was set to 3:1 so that a pixel might become a square at the display device array 114 is arranged by matrix form. Each sub pixel bears R (red), G (green), or B (blue), respectively. About a line writing direction, a set of the image displayed on the pixel group with which only the number of azimuth difference compared each sub pixel to the line writing direction, i.e., the parallax image displayed in the sub pixel unit corresponding to an exit pupil (opening 116), is called an element image. A sub pixel is not limited to R, G, and B.
[0022]
About the line direction, the element image comprises a group of six sub pixels on a par with a line direction in the example of Fig.2. That is, 18 pixels is displayed on a line writing direction, and the one element image 141 (a frame is attached and shown within Fig.2) is displayed on a line direction at 6 pixels. At Fig.2, the three dimentional display which gives 18 azimuth difference horizontally becomes possible, and an element image, i.e., the pixel for three dimentional displays, becomes a square because a line direction shall be 6 pixels further. The position of the pixel in the horizontal direction in one effective pixel corresponds with the opening control part 115, and has the angle of a beam of light and correlation which are ejected. The address showing a beam direction is called an azimuth difference address. An azimuth difference address corresponds to the position of the pixel in the horizontal direction in 1 effective pixel. An azimuth difference address is enlarged towards the right of a screen.
[0023]
The openings 116 and 116 in the opening control part 115 and -- are provided corresponding to the position of an element image. In the example of Fig.2, the width (lens pitch) Ps of the opening 116 and the width of one element image are coincided.
[0024]
In the above composition, a plurality of images acquired from decoders, such as image generating devices, such as a camera, and picture reproducer, etc. with several azimuth difference which is different from the same object, respectively are supplied to the input part 105. A plurality of images are interleaved for every pixel to which a position corresponds, respectively, and are supplied as image data of 1. Not only this but a plurality of image data

Microsoft Exhibit 1002 - Page 1271
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

can be supplied, respectively. The display image generating part 103 distributes the pixel from which a position corresponds and azimuth difference differs about a plurality of images supplied, for example to the turn according to azimuth difference. The display image generating part 103 constitutes an element image by distribution, and supplies it to the display device array 114 of the display part 104.

[0025]

Here, the opening 116 of the opening control part 115 is the exit pupil provided so that it might correspond with the element image 141 (the opening 116 may be henceforth called an exit pupil). For this reason, the beam of light from the pixel of the azimuth difference according to the direction of [from an observer's viewpoint in the element image 141] arrives at an observer's viewpoint selectively. The observer can observe a three-dimensional image because the beam of light from the pixel of azimuth difference which is different in an observer's both eyes, respectively reaches.

[0026]

The display device array 114 which sees from an observer and is arranged at the backside of a lenticular sheet displays the parallax image group from which how to look delicate according to an angle is different with the opening 116 mentioned above and the element image in which a plurality of pixels were arranged, i.e., a multiaspect image. As for the beam of light by this multiaspect image, an injection direction becomes settled through which opening 116 of the opening control part 115, and a stereoscopic picture is reproduced.

[0027]

Fig.3 expresses typically the relation of the viewing area width 12 and the azimuth difference address which are the ranges in which the stereoscopic picture in the section of the stereoscopic picture display device 10, a sub pixel, and a certain observation distance (distance of sight) is observed in the stereoscopic picture display device 10 of this embodiment. The element image which is a set of a sub pixel has limited width, and it has width also with the limited viewing area width 12 by which the parallax image displayed on the sub pixel is observed. The number of sub pixels assigned to one exit pupil which is opening 116 of the opening control part 115 in the example concerning Fig.3, i.e., the number of viewpoints, is 2. In order to be able to carry out the corporal vision of the observer in a limited distance, the width of the opening 116, i.e., the lens pitch Ps, is narrowly set up from the pixel width of two sub pixels assigned to the exit pupil (opening 116).

[0028]

In the example shown in Fig.4, the number of sub pixels assigned to one exit pupil (opening 116), i.e., the number of viewpoints, is 4. Also in the example of Fig.4, the lens pitch Ps of the opening 116 is narrowly set up from the pixel width of four sub pixels assigned to the exit pupil (opening 116). On the contrary, when making the lens pitch Ps equal to the pixel width of four sub pixels, a viewing area can be extended by limited distance of sight by sometimes arranging five sub pixels behind [four] all the openings 116, and enlarging the average value of the width of a sub pixel from the pixel width of four sub pixels for a while to them.

[0029]

When this embodiment is applied to a glasses-type stereoscopic picture display device, As shown in Fig.5, polarization or the direction of circular light switches and displays the parallax image which should be shown as the right and left eye of two sheets in time on the 2-way which intersects perpendicularly each other, By coinciding the polarization or the direction of circular light of the polarizing plate provided by the right and left of the glasses of the polarization or the direction of circular light of a parallax image displayed, and the observer 11 in the polarization or the direction of circular light of the parallax image of a left eye and a right eye, respectively, a binocular disparity is given and a corporal vision is realized.

[0030]

Next, it describes about the relation of a display of the observation position and stereoscopic picture to an observer's display part 104. Fig.6 is the figure which describes the function of the observation position detection part 101. When the angle of the stereoscopic picture display device 10 is leaned, the position of the observer 11 on the basis of the stereoscopic picture display device 10 changes. The observation position to the transverse plane of the observer's 11 display part 104 is indirectly acquired by an acceleration sensor's detecting the gravitational direction of the stereoscopic picture display device 10, and inputting the output into the observation position detection part 101. As shown in Fig.6, although an observer's observation position has the distance direction (Z-direction) of the XY direction and display surface which are directions parallel to the display surface of the display part 104, it acquires at least X directions. Here, with X-direction, it is a direction vertical to the extension direction of the opening control part 115 (lenticular sheet).

[0031]

Fig.7 is a key map for describing that a display surface is recognized narrowly, when the display part 104 leaned and observes a plane and a rectangular stereoscopic picture display device. Fig.8 is a graph which shows the relation between the observing angle theta from a transverse plane, and the width (or height) of appearance. When the observer 11 leans the stereoscopic picture display device 10 to right and left from a transverse plane, as it is shown in Fig.7, when the width of appearance becomes narrow and the observer 11 leans the stereoscopic picture display device 10 90 degree, it becomes impossible to recognize the display surface of the display part 104 visually. If the observer 11 leans the stereoscopic picture display device 10 up and down from a transverse plane, the height of appearance will become narrow, and when it leans 90 degree, it becomes impossible to recognize the display surface of the display part 104 visually. That is, the width of appearance becomes small and it becomes difficult to recognize it visually, so that the observer 11 leans the stereoscopic picture display device 10 and the observing angle theta enlarges, as shown in Fig.8.

[0032]

In the stereoscopic picture display device 10 of this embodiment, Fig.9 is the figure for

Microsoft Exhibit 1002 - Page 1272
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

describing that a viewing area becomes narrow also by the same viewing area width VW, when an angle is accomplished and observed from a transverse plane. In the number of pixels with which pixel width was assigned to pp and even an exit pupil, if distance from the display surface of g and the display part 104 to an observation position is made into the distance of sight L, the viewing area width VW will be computed [distance / to N, an exit pupil, and a pixel] by (1) formula.

[0033]

VW=(ppxN) xL/g ... (1)

[0034]

Even if it switches N pixels which the distance of sight L from the display surface of the display part 104 to an observation position assigns to an exit pupil in a fixed case, the viewing area width VW becomes fixed. In other words, the viewing area angle phi shown in Fig.9 becomes narrow as it separates from the transverse plane of the display part 104. Fig.10 is an explanatory view showing the relation for which the viewing area angle phi depends on the observing angle theta. Even if the viewing area width VW is maintained, the viewing area angle phi becomes narrow, and it becomes difficult for both eyes to go into a viewing area as are shown in Fig.10 and the observing angle theta enlarges.

[0035]

Fig.11 is the figure showing that the distance of sight L becomes short, when the observer 11 holds the stereoscopic picture display device 10 and leans the stereoscopic picture display device 10 only the observing angle theta. (1) Since the distance of sight L and the viewing area width VW are in proportionality as shown in a formula, the relation between the observing angle theta from the transverse plane of the display part 104, and the viewing area width VW, it comes to be shown in Fig.12, if the observing angle theta enlarges, the viewing area width VW will become narrow, and when both eyes stop going into a viewing area, it becomes impossible to recognize a right three dimensional image visually.

[0036]

Like this embodiment, when a lenticular sheet is used for the opening control part 115 as a beam-of-light controller in the display part 104, If the observing angle theta from the transverse plane of the display part 104 of an observation position enlarges as shown in Fig.13, crosstalk quantity will increase by a curvature of field, and spatial separating of a parallax image will become insufficient. Crosstalk quantity is a ratio over the parallax image which should appear essentially which parallax images other than the parallax image concerned mix here.

[0037]

thus, the observing angle theta increases from the display surface transverse plane of the display part 104 -- it is alike, and it follows, and the width or the height of a display surface of appearance decreases, (referring to the Fig.8) and the viewing area angle phi become narrow, or (referring to the Fig.10) and crosstalk quantity increase (refer to Fig.13). When the observer 11 holds the stereoscopic picture display device 10 by hand, the viewing area width VW also becomes narrow with reduction of the distance of sight L (refer to Fig.12) As a result, reverse ** which the row of azimuth difference is reversed, and unevenness of a three dimensional image is reversed, and is recognized visually by it becoming impossible to express the elutriation depth of a three dimensional image, and recognizing visually the parallax image which should be emitted from the exit pupil (opening 116) which adjoined, Abnormal images, such as a superimposed multiplex image to carry out, are generated by a plurality of parallax images, and the image quality of a three dimensional image is deteriorated.

[0038]

For this reason, when the observing angle theta from the display surface transverse plane of the display part 104 increases as an observer's observation position in this embodiment, It judges with the restrictions and image quality degradation to expression of elutriation depth which were mentioned above occurring, elutriation depth expression of a three dimensional image is inhibited, and the quality of a display of a three dimensional image is maintained. Namely, the parallax amount deciding part 102 is, in order to jump out as the observing angle theta which the observation position detection part 101 detected increases, and to decrease the amount of depth. As shown in Fig.14, the parallax amount is continuously determined to the small value with the increase in the observing angle theta, in order to use an image with few parallax amounts as picture information used in order that the display image generating part 103 may generate an element image array.

[0039]

more specifically, the parallax amount deciding part 102 makes a parallax amount small with the increase in the observing angle theta by determining the acquisition interval (viewpoint interval) of a multiaspect image in a narrow distance continuously, and, thereby, the observing angle theta increases -- it is alike, follows and jumps out and is decreasing the amount of depth.

[0040]

When the amount of elutriation depth expressions observed at the front of the display part 104 is set to 1 in the example shown in Fig.14, according to increase of the observing angle theta, with the linear function shown by a dotted line, Or determination which decreases a parallax amount continuously with a nonlinear function like the cos function shown with a curve is performed, and it jumps out, and stops depth.

[0041]

By the parallax amount deciding part 102, there are the following techniques as the determination technique of the value of the acquisition interval of the multiaspect image decreased with increase of the observing angle theta. Fig.15 is the figure for describing the determination technique of the value of the acquisition interval of the multiaspect image decreased with increase of the observing angle theta.

[0042]

Microsoft Exhibit 1002 - Page 1273
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

P and the width of the opening 116, i.e., a lens pitch, for N and an element image pitch Ps, [the number of azimuth difference] The distance [mm] between pp, the opening control part 115 (lenticular sheet), and a pixel for a horizontal sub pixel pitch [mm] g, In the distance [mm] from the display surface of the display part 104, if L and viewing area optimization distance are set to L0 and Lv and beam-of-light interval @Pi [mm] are set to Pi (L) for observation distance, pp, Pi (L), g, L, P, Ps, and L0 will be computed by (2) and (3) formulas.

[0043]

pp:Pi(L) =g:L ... (2)

P: Ps=(L0+g):L0 ... (3)

[0044]

Here, in pp=0.05, in using Pi(400) =62 (interocular distance) by Lv=400, it sets up g like (4) types.

[0045]

0.05: 62=g:400 and g= 0.32 ... (4)

[0046]

P and Ps are set up to fit (5) types with L0=500, in order to make viewing area width (VW (500)) into the maximum.

[0047]

P: Ps=1: (500+0.32) / 500 =1:1.00064 ... (5)

[0048]

At this time, the viewing area width VW (L0) and the observing angle theta are computed by (6) and (7) formulas. Here, VW (L0) right end and (VW (L0) left end) are coordinates of the both ends of the viewing area width VW (L0).

[0049]

VW(L0) =PxL0/g ... (6)

theta= {atan(VW (L0) right end /L0)-atan (VW (L0) left end /L0)} /2 ... (7)

[0050]

If the observing angle theta increases as shown in an upper type, the viewing area width VW will become narrow. On the other hand, the viewing area angle phi required for observation will be computed by (8) formulas, if interocular distance is set to 62.

[0051]

Phi=atan(62/Lv)/2 ... (8)

[0052]

(8) As shown in a formula, the viewing area angle phi is dependent on interocular distance and observation distance. In order to be interlocked with the value of (theta-phi) and to lessen the amount of elutriation depth from these formulas, for example, the acquisition interval of a multiaspect image may be determined to a narrow value, or the parallax amount deciding part 102 may be constituted so that it may become a three dimensional image by theta>phi and may become a plane picture by theta<=phi.

[0053]

Next, it describes using the flow chart of Fig.16 about stereoscopic picture display processing of this embodiment constituted as mentioned above.

[0054]

First, the input part 105 inputs a three dimensional image signal from image generating devices, such as a camera, or inputs a three dimensional image signal via decoders, such as picture reproducer (Step S11). And the observation position detection part 101 detects the observing angle theta from the transverse plane of an observer's display part 104 with an acceleration sensor etc. (Step S12).

[0055]

Next, the parallax amount deciding part 102 determines the acquisition interval (viewpoint interval) of a multiaspect image according to the observing angle theta detected at Step S12 (Step S13). Specifically, the parallax amount deciding part 102 determines the viewpoint interval of a small value, so that the observing angle theta increases in accordance with the graph of Fig.14, and the technique of Fig.15.

[0056]

And the display image generating part 103 arranges a parallax image to a parallax image arrangement table at intervals of the viewpoint determined at Step S13, generates an element image array (Step S17), and displays an element image array on the display part 104 (Step S18).

[0057]

Here, a parallax image arrangement table is the multiaspect image displayed on the display surface of the display part 104, i.e., the arrangement table showing how each parallax image is arranged in each element image of an element image array, and is explained by the Patent document 3 in full detail about the details.

[0058]

Thus, by making a parallax amount small continuously with the increase in the observing angle theta in this embodiment, it can be made to agree that there is no sense of incongruity in change of the width of the appearance which changes continuously, the viewing area angle phi, the viewing area width VW, and crosstalk quantity, as shown in Fig.8, and 10, 12 and 13, and a stereoscopic picture can be displayed high-definition. That is, when an observation position separates largely from the transverse plane of the display part 104, without barring ideal grant of motion parallax, by stopping the amount of elutriation depth, an abnormal image can be prevented and the display of a high-definition stereoscopic picture can be realized. Even if a parallax amount decreases, it is because it can continue providing a cubic effect in the wide range from the ability of motion parallax to be provided separately.

[0059]

Although the stereoscopic picture display device which inputs the three dimensional image of a displaying object from an external image generating device and picture reproducer, and it

Microsoft Exhibit 1002 - Page 1274
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

displays on the display part 104 in real time was mentioned as the example in this embodiment and described by it, This embodiment is also applicable to the stereoscopic picture display device which reads the three dimensional image accumulated in storage media, such as not the thing limited to this but a hard disk drive apparatus (HDD), and a volatile or nonvolatile memory, and it displays on the display part 104.

[0060]

(Embodiment 2)

At embodiment 1, with the increase in the observing angle theta, the parallax amount was continuously made small, but by this embodiment 2, when the observing angle theta increases and a threshold value is exceeded, a display image is steeply switched to a plane picture. Although the three dimensional image signal was input from an external image generating device, picture reproducer, etc. and was displayed on the display part 104 in embodiment 1, the multiaspect image and single view image which were preliminarily memorized by the image storage section 1705 are displayed on the display part 104 in this embodiment 2.

[0061]

However, this embodiment may be applied to the stereoscopic picture display device which inputs a three dimensional image signal from an external image generating device, picture reproducer, etc., and it displays on the display part 104.

[0062]

The stereoscopic picture display device 1700 concerning embodiment 2 is mainly provided with the image storage section 1705, the observation position detection part 101, the parallax amount deciding part 1702, the display image generating part 1703, and the display part 104, as shown in Fig.17. Here, the function and composition of the observation position detection part 101 and the display part 104 are the same as that of embodiment 1.

[0063]

The image storage sections 1705 are storage media, such as HDD which memorizes preliminarily the three dimensional image signal which consists of a multiaspect image or a single view image, and a memory.

[0064]

The parallax amount deciding part 1702 is determined in the image which decreased the parallax amount, when it judges whether the observing angle theta detected by the observation position detection part 101 exceeded the predetermined threshold value and a threshold value is exceeded. Specifically, the parallax amount deciding part 1702 determines choosing a plane picture, when a parallax amount is not changed when the observing angle theta is below a threshold value but the observing angle theta exceeds a threshold value, as shown in Fig.18. When it applies to the equipment which inputs the three dimensional image of a displaying object from image generating devices and picture reproducers, such as a camera, and displays the stereoscopic picture display device 1700 on the display part 104 in real time, When the observing angle theta exceeds a predetermined threshold value, a parallax amount may be constituted so that the acquisition interval (viewpoint interval) of 0, i.e., a multiaspect image, may be determined to 0.

[0065]

Thus, a three dimensional image equivalent to a transverse plane to forward which will be in the state where both eyes do not go into a viewing area, or crosstalk quantity exceeds an acceptable value is maintained by providing a threshold value. The example of division of a region and the display area of a three dimensional image which indicates by a plane is shown in Fig.19 as an example.

[0066]

Here, in order to set when the observing angle theta exceeds a threshold value and it switches to a plane picture, and to fill the object of abnormal image prevention, the three dimensional image of a displaying object and the existence of relation do not ask the plane picture to switch. For example, it may constitute so that colorless images, such as a plane picture unrelated to the three dimensional image of a displaying object and a black display (non-display), may be chosen.

[0067]

Although it returns to Fig.17, and the display image generating part 1703 generates an element image array and displays the generated element image array on the display part 104 like embodiment 1, When the observing angle theta exceeds a threshold value, the plane picture determined by the parallax amount deciding part 1702 is chosen from the image storage section 1705, and an element image array is generated.

[0068]

Next, it describes using the flow chart of Fig.20 about stereoscopic picture display processing of this embodiment constituted as mentioned above.

[0069]

First, the observation position detection part 101 detects the observing angle theta from the transverse plane of an observer's display part 104 with an acceleration sensor etc. (Step S22).

[0070]

Next, it is judged whether the observing angle theta as which the parallax amount deciding part 1702 was detected at Step S22 exceeded the threshold value (Step S23). And when the observing angle theta is below a threshold value, a change of (Step S23:No) and a parallax amount is not made. When the observing angle theta exceeds a threshold value, it determines that (Step S23:Yes) and the parallax amount deciding part 1702 choose a plane picture (Step S24).

[0071]

And the plane picture determined at Step S24 is acquired from the image storage section 1705, and the display image generating part 1703 arranges to a parallax image arrangement table, generates an element image array (Step S27), and displays an element image array on the display part 104 (Step S28).

Microsoft Exhibit 1002 - Page 1275
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

[0072]
Thus, since a display image is steeply switched to a plane picture and it displays on the display part 104 when the observing angle theta increases and a threshold value is exceeded in this embodiment, When an observation position separates largely from a transverse plane, without barring ideal grant of motion parallax, by stopping the amount of elutriation depth, an abnormal image can be prevented and the display of a high-definition stereoscopic picture can be realized. Since motion parallax can be separately provided even if it is a plane picture if azimuth difference is only lost, although there are few degrees, they can continue providing a cubic effect.
[0073]
(Modification 1)
A stereoscopic picture display can also be performed combining embodiment 1 and embodiment 2. In the modification 1, as shown in Fig.21, when the observing angle theta which the parallax amount deciding part 102 detected by the observation position detection part 101 is below a threshold value, When a parallax amount is not changed but the observing angle theta exceeds a threshold value, the value which decreased the parallax amount continuously, i.e., the viewpoint interval of a multiaspect image, is determined like embodiment 1 to the value which becomes small continuously.
[0074]
About stereoscopic picture display processing of this modification 1, it describes using the flow chart of Fig.22. The input of a three dimensional image signal and processing of detection of the observing angle theta are the same as that of (Steps S41 and S42) and embodiment 1.
[0075]
Next, it is judged whether the observing angle theta as which the parallax amount deciding part 102 was detected at Step S42 exceeded the threshold value (Step S43). And when the observing angle theta is below a threshold value, a change of (Step S43:No) and a parallax amount is not made. When the observing angle theta exceeds a threshold value, according to the observing angle theta detected at (Step S43:Yes) and Step S42, the acquisition interval (viewpoint interval) of a multiaspect image is determined (Step S44). Specifically, the parallax amount deciding part 102 determines the viewpoint interval of a small value, so that the observing angle theta increases according to the graph of Fig.21.
[0076]
And the display image generating part 103 arranges a parallax image to a parallax image arrangement table at intervals of the viewpoint determined at Step S44, generates an element image array (Step S47), and displays an element image array on the display part 104 (Step S48).
[0077]
(Modification 2)
In the modification 2, as shown in Fig.23, the parallax amount deciding part 102 makes small continuously the value which decreased the parallax amount continuously, i.e., the viewpoint interval of a multiaspect image, like embodiment 1, when the observing angle theta is below a threshold value. On the other hand, when the observing angle theta exceeds a threshold value, the parallax amount deciding part 102 chooses a plane picture.
[0078]
About stereoscopic picture display processing of this modification 2, it describes using the flow chart of Fig.24. The input of a three dimensional image signal and processing of detection of the observing angle theta are the same as that of (Steps S31 and S32) and embodiment 1.
[0079]
Next, it is judged whether the observing angle theta as which the parallax amount deciding part 102 was detected at Step S32 exceeded the threshold value (Step S33). And when the observing angle theta is below a threshold value, according to the observing angle theta detected at (Step S33:No) and Step S32, the acquisition interval (viewpoint interval) of a multiaspect image is determined (Step S35). Specifically, the parallax amount deciding part 102 determines the viewpoint interval of a small value, so that the observing angle theta increases according to the graph of Fig.23. On the other hand, when the observing angle theta exceeds a threshold value, (Step S33:Yes) and the parallax amount deciding part 102 determine choosing 0, i.e., a plane picture, for the acquisition interval of a multiaspect image like embodiment 2 (Step S34).
[0080]
And the display image generating part 103 arranges a parallax image to a parallax image arrangement table at intervals of the viewpoint determined at Step S34, generates an element image array (Step S37), and displays an element image array on the display part 104 (Step S38).
[0081]
Also in such modifications 1 and 2, when an observation position separates largely from the transverse plane of the display part 104, without barring ideal grant of motion parallax, by stopping the amount of elutriation depth, an abnormal image can be prevented and the display of a high-definition stereoscopic picture can be realized.
[0082]
In the above-mentioned embodiment and a modification, to give the both sides of a horizontal direction and vertical direction parallax information, it is necessary to apply the above-mentioned stereoscopic picture display processing to the both sides of a horizontal direction and vertical direction but, and. The technique of reduction of the amount of elutriation depth according to the observing angle theta is independently realizable, respectively. In the stereoscopic picture display device which presents horizontal chisel parallax information, it constructs with the usual tracking perpendicularly and its ****** is good. The change of a multiaspect image of this embodiment can be made compatible with the viewing area expansion by optimization of N pixels, and it can also realize.

Microsoft Exhibit 1002 - Page 1276
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

[0083]
Although the amount of elutriation depth was decreased in the above-mentioned embodiment and the modification by decreasing a parallax amount according to the observing angle theta from the transverse plane of the display part 104, other techniques can also be used if it is a technique changed in the direction which decreases the amount of elutriation depth.
[0084]
In the stereoscopic picture display device 10-1700 of this embodiment, various composition of the observation position detection part 101 and the parallax amount deciding part 102 can be deformed.
[0085]
For example, in the stereoscopic picture display device 10-1700 of this embodiment, the table of the relation of the observing angle theta and the observation distance of the observer from the transverse plane of the display part 104 as shown in Fig.12 is preliminarily memorized to storage media, such as a memory. And in the table of the above-mentioned relation, the observer position detection part 101 may be constituted so that the observation distance corresponding to the observing angle theta detected by the observer position detection part 101 may be found. The parallax amount deciding part 102 may be constituted so that a parallax amount may be determined from an observing angle and observation distance in this case. In this case, since observation distance is also taken into consideration in addition to the observing angle theta, a parallax amount can be calculated with high degree of accuracy, and the display of a more nearly high-definition stereoscopic picture can be realized.
[0086]
The imaging means of an imaging camera etc. may be provided to the stereoscopic picture display device 10-1700 of this embodiment. In this case, the size of an observer's head can be computed from a captured image by an imaging means, and the observation position detection part 101 can consist of sizes of the computed head so that the observation distance of the observer from the transverse plane of the display part 104 may be found. The parallax amount deciding part 102 can also be constituted so that a parallax amount may be determined from the observing angle theta and observation distance. Also in this case, since observation distance is also taken into consideration in addition to the observing angle theta, a parallax amount can be calculated with high degree of accuracy, and the display of a more nearly high-definition stereoscopic picture can be realized.
[0087]
The stereoscopic picture display program run with the stereoscopic picture display device of the above-mentioned embodiment is preliminarily included in ROM etc., and is provided.
[0088]
The stereoscopic picture display program run with the stereoscopic picture display device of the above-mentioned embodiment, It may constitute so that it may record on the recording medium which can be read and may provide by the installable file of form or the form which can be performed by computers, such as CD-ROM, a flexible disk (FD), CD-R, and DVD (Digital Versatile Disk).
[0089]
The stereoscopic picture display program run with the stereoscopic picture display device of the above-mentioned embodiment may be stored on the computer connected to networks, such as the Internet, and it may constitute so that it may provide by making it download via a network. It may constitute so that the stereoscopic picture display program run with the stereoscopic picture display device of the above-mentioned embodiment may be provided or distributed via networks, such as the Internet.
[0090]
The stereoscopic picture display program run with the stereoscopic picture display device of the above-mentioned embodiment, It is the configuration of module containing each part (an input part, an observation position detection part, a parallax amount deciding part, a display image generating part) mentioned above, When CPU (processor) reads and runs a stereoscopic picture display program from the above-mentioned ROM as actual hardware, each part of the above is loaded on a main memory unit, and an input part, an observation position detection part, a parallax amount deciding part, and a display image generating part are generated on a main memory unit.
[0091]
The above-mentioned embodiment and a modification are illustration, and the scope of invention is not limited to them.
[Explanations of letters or numerals]
[0092]
10-1700 Stereoscopic picture display device
11 Observer
12 Viewing area width
13 Distance of sight
101 Observation position detection part
102-1702 Parallax amount deciding part
103-1703 Display image generating part
104 Display part
105 Input part
114 Display device array
115 Opening control part
116 Opening
140 Sub pixel
141 Element image

Microsoft Exhibit 1002 - Page 1277
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

To return to the top of

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Microsoft Exhibit 1002 - Page 1278
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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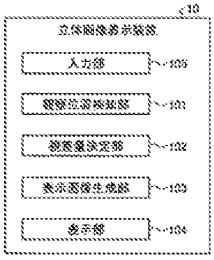
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(54)【発明の名称】立体画像表示装置、方法およびプログラム

(57)【要約】
【課題】利用者の観察位置にかかわらず、高品質な立体画像を表示すること。
【解決手段】実施の形態によれば、立体画像表示装置は、表示部と、前記表示部に対する観察者の観察位置を検出する検出部と、入力映像信号の視差量を、検出された観察位置が前記表示部正面からの角度が大きい、または、距離が近い程、減少した値に決定する決定部と、決定された視差量に基づいて前記表示部に表示すべき多視点画像を生成する生成部と、を備えている。
【選択図】図１



Microsoft Exhibit 1002 - Page 1279
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【特許請求の範囲】
【請求項１】
表示部と、
前記表示部に対する観察者の観察位置を検出する検出部と、
入力映像信号の視差量を、検出された観察位置が前記表示部正面からの角度が大きい、または、距離が近い程、減少した値に決定する決定部と、
決定された視差量に基づいて前記表示部に表示すべき多視点画像を生成する生成部と、
を備えたことを特徴とする立体画像表示装置。
【請求項２】
前記決定部は、前記視差量を、前記検出された観察位置が前記表示部正面からの角度が大きい、または、距離が近い程、連続的に減少した値に決定することを特徴とする請求項１に記載の立体画像表示装置。
【請求項３】
前記決定部は、前記視差量を、線形関数により連続的に減少させた値に決定することを特徴とする請求項２に記載の立体画像表示装置。
【請求項４】
前記決定部は、前記視差量を、余弦関数により連続的に減少させた値に決定することを特徴とする請求項２に記載の立体画像表示装置。
【請求項５】
前記決定部は、前記検出された観察位置が所定の閾値を超えたか否かを判断し、前記検出された観察位置が前記閾値を超えた場合に、前記視差量を減少した値に決定することを特徴とする請求項１に記載の立体画像表示装置。
【請求項６】
前記決定部は、前記検出された観察位置が前記閾値以下である場合に、前記視差量を連続的に減少させた値に決定することを特徴とする請求項５に記載の立体画像表示装置。
【請求項７】
前記決定部は、前記検出された観察位置が前記閾値を超えた場合に、前記視差量を０に決定することを特徴とする請求項５に記載の立体画像表示装置。
【請求項８】
前記決定部は、前記検出された観察位置が前記閾値を超えた場合に、前記入力映像信号と無関係な平面画像に決定することを特徴とする請求項７に記載の立体画像表示装置。
【請求項９】
前記無関係な平面画像は、無彩色画像であることを特徴とする請求項８に記載の立体画像表示装置。
【請求項１０】
前記決定部は、前記検出された観察位置が前記閾値以下である場合には、前記視差量を変化させず、前記検出された観察位置が前記閾値を超えた場合に、前記視差量を連続的に減少させることを特徴とする請求項５に記載の立体画像表示装置。
【請求項１１】
前記決定部は、前記視差量を、前記検出された観察位置が前記表示部正面からの角度が大きい、または、距離が近い程、前記多視点画像の取得間隔が小さい値に決定することを特徴とする請求項１に記載の立体画像表示装置。
【請求項１２】
前記検出部は、前記観察者に装着され、前記観察者の前記表示部に対する方向を検知する加速度センサからの出力から、前記表示部の正面からの前記観察者の観察角度を、前記観察位置として検出することを特徴とする請求項１に記載の立体画像表示装置。
【請求項１３】
前記観察角度と、前記表示部の正面からの前記観察者の観察距離との対応関係を予め記憶する記憶部をさらに備え、
前記検出部は、さらに、前記対応関係において、検出した前記観察角度に対応する前記

Microsoft Exhibit 1002 - Page 1280
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

観察距離を求め、
前記決定部は、前記視差量を、前記観察角度と前記観察距離とから決定することを特徴とする請求項１２に記載の立体画像表示装置。
【請求項１４】
ヘッドトラッキングセンサをさらに備え、
前記検出部は、前記加速度センサと前記ヘッドトラッキングセンサの出力から、前記表示部の正面からの前記観察者の観察角度を、前記観察位置として検出することを特徴とする請求項１２に記載の立体画像表示装置。
【請求項１５】
撮像手段をさらに備え、
前記検出部は、前記撮像手段により撮像画像から前記観察者の頭部の大きさを求め、前記頭部の大きさに基づいて、前記表示部の正面からの前記観察者の観察距離を求め、
前記決定部は、前記視差量を、前記観察角度と前記観察距離とから決定することを特徴とする請求項１４に記載の立体画像表示装置。
【請求項１６】
立体画像表示装置で実行される立体画像表示方法であって、
前記立体画像表示装置は、表示部を備え、
前記表示部に対する観察者の観察位置を検出することと、
入力映像信号の視差量を、検出された観察位置が前記表示部正面からの角度が大きい、または、距離が近い程、減少した値に決定することと、
決定された視差量に基づいて前記表示部に表示すべき多視点画像を生成することと、
を含むことを特徴とする立体画像表示方法。
【請求項１７】
コンピュータに実行させるためのプログラムであって、
前記コンピュータは、表示部を備え、
前記表示部に対する観察者の観察位置を検出する機能と、
入力映像信号の視差量を、検出された観察位置が前記表示部正面からの角度が大きい、または、距離が近い程、減少した値に決定する機能と、
決定された視差量に基づいて前記表示部に表示すべき多視点画像を生成する機能と、
を前記コンピュータに実行させるためのプログラム。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明の実施形態は、立体画像の表示技術に関する。
【背景技術】
【０００２】
近年、映画等では、観察者に眼鏡を装着させて、左右の眼に各々その位置から見える画像（視差画像）を見せることで、立体映像を見せる方式が普及しつつある。また、裸眼方式の立体画像の表示技術としては、ＦＰＤ（フラットパネルディスプレイ）の表示面側にたとえばピンホールやスリット、レンズアレイといった視差バリアを配置し、観察位置に応じて見えるサブ画素を切り替えることで、観察者の観察位置や観察者の左右の目の位置に応じた視差情報を視認させる技術が知られている。
【０００３】
いずれも、視差が大きければ、大きく手前に飛び出したり奥に引っ込んだりして知覚され、視差がなければ、平面画像として知覚される。
【０００４】
さらに、臨場感の高い三次元映像を表示する技術として、観察者の観察位置の移動にともなって、運動視差により側面が見えるようにする技術がある。
【先行技術文献】
【特許文献】

Microsoft Exhibit 1002 - Page 1281
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【０００５】
【特許文献１】特開２００６－１７４４３４号公報
【特許文献２】特許第３８９２８０８号公報
【特許文献３】特許第３９４４１８８号公報
【発明の開示】
【発明が解決しようとする課題】
【０００６】
このような立体画像の表示技術において、利用者の観察位置にかかわらず、高品質な立体画像を表示することが望まれている。
【課題を解決するための手段】
【０００７】
実施の形態によれば、立体画像表示装置は、表示部と、前記表示部に対する観察者の観察位置を検出する検出部と、入力映像信号の視差量を、検出された観察位置が前記表示部正面からの角度が大きい、または、距離が近い程、減少した値に決定する決定部と、決定された視差量に基づいて前記表示部に表示すべき多視点画像を生成する生成部と、を備えている。
【図面の簡単な説明】
【０００８】
【図１】実施の形態１の立体画像表示装置の構成図。
【図２】表示部の構造図。
【図３】立体画像表示装置による立体画像の表示状態の図。
【図４】立体画像表示装置による立体画像の表示状態の図。
【図５】眼鏡式の立体画像表示装置による立体画像の表示状態の図。
【図６】観察位置検知部の機能の説明図。
【図７】表示面が狭く認識される現象の説明図。
【図８】観察角度と見た目の幅の関係のグラフ。
【図９】視域幅が狭くなることの説明図。
【図１０】観察角度と視域角の関係のグラフ。
【図１１】視距離が短くなることの説明図。
【図１２】観察角度と視域幅の関係のグラフ。
【図１３】観察角度とクロストーク量の関係のグラフ。
【図１４】実施の形態１の観察角度と飛び出し奥行き量の関係のグラフ。
【図１５】各パラメータの関係図。
【図１６】実施の形態１の立体画像表示処理のフローチャート。
【図１７】実施の形態２の立体画像表示装置の構成図。
【図１８】実施の形態２の観察角度と飛び出し奥行き量の関係のグラフ。
【図１９】平面表示領域と三次元画像表示領域の図。
【図２０】実施の形態２の立体画像表示処理のフローチャート。
【図２１】変形例１の観察角度と飛び出し奥行き量の関係のグラフ。
【図２２】変形例１の立体画像表示処理のフローチャート。
【図２３】変形例２の観察角度と飛び出し奥行き量の関係のグラフ。
【図２４】変形例２の立体画像表示処理のフローチャート。
【発明を実施するための形態】
【０００９】
以下、本実施形態について図面を用いて説明する。なお、以下に示す実施の形態では、説明の都合上、図面上の大きさの比率は実際の実施の形態とは異なる部分があり、また上下左右等の向きは相対的な位置関係であり、重力方向を基準とした向きとは異なる部分がある。
【００１０】
また、以下に示す実施の形態では、裸眼方式として、垂直方向に延伸したレンチキュラ

Microsoft Exhibit 1002 - Page 1282
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

ーレンズのアレイを用い、光線の集合によって自然でフリッピング（画像の飛び）が抑制された、インテグラルイメージング方式（以下、ＩＩ方式と略称する）と呼ばれる表示方式で三次元画像を表示する立体画像表示装置を例にあげて説明する。ただし、ＩＩ方式に限定されるものではなく、他の裸眼方式の立体画像表示装置の他、眼鏡式の立体画像表示装置にも本実施形態を適用することができる。

【００１１】

（実施の形態１）

本実施の形態の立体画像表示装置１０は、図１に示すように、入力部１０５と、観察位置検知部１０１と、視差量決定部１０２と、表示画像生成部１０３と、表示部１０４とを主に備えている。本実施の形態の立体画像表示装置１０は、表示対象の三次元画像を外部の画像生成装置や画像再生装置から入力してリアルタイムに表示部１０４に表示するものである。

【００１２】

入力部１０５は、多視点画像や三次元画像信号を、カメラ等の画像生成装置から入力したり、三次元画像信号を画像再生装置などのデコーダを介して入力する。

【００１３】

観察位置検知部１０１は、表示部１０４に対する観察者の観察位置を検出する。本実施の形態では、立体画像表示装置１０の重力方向に対する角度を測定するための加速度センサを設け、加速度センサの出力から、表示部１０４に対する観察者の観察角度を、観察位置として検知する。

【００１４】

なお、観察位置検知部１０１は、これに限定されるものではなく、カメラによる撮像画像を用いて認識された顔や頭の方向を推定するためのヘッドトラッキングセンサを立体画像表示装置１０に装着し、観察位置検知部１０１が、このヘッドトラッキングセンサからの出力から、表示部１０４の正面に対する観察者の観察角度を、前記観察位置として検知するように観察位置検知部１０１を構成してもよい。さらに、立体画像表示装置１０に、観察者と表示部１０４との距離を測定するための距離センサを設け、距離センサからの出力により表示部１０４からの観察者の距離を観察位置として検知するように観察位置検知部１０１を構成してもよい。

【００１５】

視差量決定部１０２は、表示画像生成部１０３が表示部１０４に表示するために生成する要素画像アレイを生成するため、入力部１０５によって入力された三次元画像信号の視差情報の視差量を、観察位置としての、表示部１０４の正面からの観察角度θが大きい程、連続的に減少した値に決定する。また、この他、上記視差量を、観察位置としての、表示部１０４の正面から距離が近い程、減少した値に決定するように視差量決定部１０２を構成してもよい。なお、視差量決定部１０２の詳細については後述する。

【００１６】

ここで、要素画像とは、後述する射出瞳（開口部１１６）に対応したサブ画素単位で表示された視差画像の集合をいい、要素画像アレイは、表示部１０４に表示される要素画像群をいう。

【００１７】

表示画像生成部１０３は、視差量決定部１０２によって決定された視差量に基づいて要素画像からなる要素画像アレイ（多視点画像）を生成し、生成された要素画像アレイを表示部１０４に表示する。

【００１８】

表示部１０４は、表示画像生成部１０３によって生成された多視点画像を表示するデバイスである。図２は、本実施の形態の表示部１０４の構造の一例を概略的に示した斜視図である。図２では、視点数ｎ＝１８として説明する。図２に例示されるように、表示部１０４は、表示素子アレイ１１４と、当該表示素子アレイ１１４の前面に配置された開口制御部１１５とを備える。表示素子アレイ１１４としては、例えばＬＣＤ(Liquid Crystal

Microsoft Exhibit 1002 - Page 1283
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Display)を用いることができる。

【００１９】

開口制御部１１５は、透過する光線を制限して光線を所定方向に向けて出射させる光線制御素子である。本実施の形態の開口制御部１１５としては、図２に示すように、レンチキュラーシートが用いられている。レンチキュラーシートは、入射および射出光線を制御して光線を所定方向に向けるレンズセグメントのアレイ板である。開口制御部１１５として、光透過領域を適宜設けたスリットなどのアレイ板を用いることもできる。これら光透過領域およびレンズセグメントは、表示素子アレイ１１４からその前方に向けて発散される光線中のうち特定の方向に向かう光線のみを選択的に出射する機能を有する。以下では、レンズセグメントおよび光透過領域を、纏めて開口部と称する。

【００２０】

開口制御部１１５は、例えば表示素子アレイ１１４における画面の垂直方向に母線を有するレンズのアレイ板であるレンチキュラーシートを用いる。レンズセグメントの各開口部１１６、１１６、…が画素に対応して配置される。開口制御部１１５は、上述したレンチキュラーセグメントや光透過領域を集積したアレイ板に限らず、時間と共に光透過領域の位置および形状を変えることができる光シャッタとしてＬＣＤを利用することもできる。

【００２１】

ここで、一般的なＦＰＤでは、１つの画素はＲＧＢ各色のサブ画素から構成される。１つの表示素子が１つのサブ画素に対応するものとする。図２の例では、表示素子アレイ１１４には、画素が正方形になるように縦横比が３：１にされた表示素子（サブ画素１４０、１４０、…）がマトリクス状に配列される。各サブ画素は、それぞれ、Ｒ（赤）、Ｇ（緑）、Ｂ（青）のいずれかを担う。行方向については、各サブ画素を視差の数だけ行方向に並べた画素群に表示される画像、すなわち射出瞳（開口部１１６）に対応したサブ画素単位で表示された視差画像の集合を要素画像と呼ぶ。なお、サブ画素は、Ｒ、Ｇ、Ｂに限定されるものではない。

【００２２】

列方向については、図２の例では、列方向に並ぶ６つのサブ画素の組で要素画像が構成されている。すなわち、行方向に１８画素、列方向に６画素で、１つの要素画像１４１（図２内で枠を付して示す）を表示する。図２では、水平方向に１８視差を与える立体表示が可能となり、さらに列方向を６画素にすることで、要素画像、すなわち立体表示用の画素が正方形になる。なお、１つの実効画素内の水平方向における画素の位置は、開口制御部１１５と対応し、射出される光線の角度と相関を持つ。光線方向を表すアドレスを視差アドレスと呼ぶ。視差アドレスは、１実効画素内の水平方向における画素の位置に対応する。視差アドレスは、画面の右方向に向けて大きくなる。

【００２３】

開口制御部１１５における開口部１１６、１１６、…は、要素画像の位置に対応して設けられる。図２の例では、開口部１１６の幅（レンズピッチ）Ｐｓと、１要素画像の幅とが一致させられている。

【００２４】

上述のような構成において、例えば、カメラ等の画像生成装置や画像再生装置などのデコーダなどから、同一被写体から異なる複数の視差でそれぞれ取得された複数の画像が入力部１０５に供給される。複数の画像は、位置が対応する画素毎にそれぞれインターリーブして１の画像データとして供給される。これに限らず、複数の画像データをそれぞれ供給するようにもできる。表示画像生成部１０３は、例えば供給された複数の画像について、位置が対応し視差が異なる画素を視差に応じた順番に配分する。表示画像生成部１０３は、配分により要素画像を構成して表示部１０４の表示素子アレイ１１４に供給する。

【００２５】

ここで、開口制御部１１５の開口部１１６は、要素画像１４１と対応するように設けられた射出瞳である（以降、開口部１１６を射出瞳と呼ぶ場合もある）。このため、要素画

Microsoft Exhibit 1002 - Page 1284
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

像１４１内の、観察者の視点からの方向に応じた視差の画素からの光線が、選択的に観察者の視点に到達する。観察者の両眼にそれぞれ異なる視差の画素からの光線が到達することで、観察者は、立体的な画像を観察することができる。

【００２６】

観察者から見てレンチキュラーシートの後ろ側に配置される表示素子アレイ１１４は、上述した開口部１１６と、複数の画素が配列された要素画像とにより、角度に応じて微妙に見え方の違う視差画像群、すなわち多視点画像を表示する。この多視点画像による光線は、開口制御部１１５の何れかの開口部１１６を通って射出方向が定まり、立体画像が再生される。

【００２７】

図３は、本実施の形態の立体画像表示装置１０において、立体画像表示装置１０の断面、サブ画素、ある観察距離（視距離）での立体画像が観察される範囲である視域幅１２および視差アドレスの関係を模式的に表している。サブ画素の集合である要素画像は有限の幅を持っており、サブ画素に表示された視差画像が観察される視域幅１２も有限の幅を有する。図３に係る例では、開口制御部１１５の開口部１１６である射出瞳１つに割り当てられたサブ画素数、すなわち視点数は２である。観察者が有限の距離で立体視できるようにするためには、射出瞳（開口部１１６）に割り当てられた２個のサブ画素の画素幅より開口部１１６の幅、すなわちレンズピッチＰｓを狭く設定する。

【００２８】

図４に示す例では、射出瞳（開口部１１６）１つに割り当てられたサブ画素数、すなわち視点数は４である。図４の例でも、射出瞳（開口部１１６）に割り当てられた４個のサブ画素の画素幅より開口部１１６のレンズピッチＰｓを狭く設定する。逆に、レンズピッチＰｓを４個のサブ画素の画素幅に等しくする場合は、全ての開口部１１６の後ろに、４個、ときどき５個のサブ画素を配置し、サブ画素の幅の平均値を４個のサブ画素の画素幅より少し大きくすることにより、有限の視距離で視域を広げることができる。

【００２９】

本実施の形態を眼鏡式の立体画像表示装置に適用した場合には、図５に示すように、時間的に２枚の左右の眼に見せるべき視差画像を偏光または円偏光方向が互いに直交する２方向に切り替えて表示し、表示される視差画像の偏光または円偏光方向と観察者１１の眼鏡の左右に設けられた偏光板の、偏光または円偏光方向をそれぞれ左の眼、右の眼の視差画像の偏光または円偏光方向に一致させておくことで、両眼視差を与えて立体視を実現する。

【００３０】

次に、観察者の表示部１０４に対する観察位置と立体画像の表示の関係について説明する。図６は、観察位置検知部１０１の機能を説明する図である。立体画像表示装置１０の角度を傾けた場合、立体画像表示装置１０を基準とした観察者１１の位置が変化する。立体画像表示装置１０の重力方向を加速度センサで検出し、その出力を観察位置検知部１０１に入力することにより、観察者１１の表示部１０４の正面に対する観察位置を間接的に取得する。図６に示すように、観察者の観察位置は、表示部１０４の表示面と平行な方向であるＸＹ方向と表示面との距離方向（Ｚ方向）とがあるが、少なくともＸ方向を取得する。ここで、Ｘ方向とは、開口制御部１１５（レンチキュラーシート）の延伸方向に垂直な方向である。

【００３１】

図７は、表示部１０４が平面かつ矩形の立体画像表示装置を傾けて観察したときに、表示面が狭く認識されることを説明するための概念図である。図８は、正面からの観察角度θと、見た目の幅（または高さ）の関係を示すグラフである。観察者１１が立体画像表示装置１０を正面から左右に傾けると、図７に示すように、見た目の幅が狭くなり、観察者１１が立体画像表示装置１０を９０度傾けると表示部１０４の表示面は視認できなくなる。また、観察者１１が立体画像表示装置１０を正面から上下に傾けると、見た目の高さが狭くなり、９０度傾けると表示部１０４の表示面は視認できなくなる。すなわち、図８に

Microsoft Exhibit 1002 - Page 1285
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

示すように、観察者１１が立体画像表示装置１０を傾け、観察角度θが大きくなる程、見た目の幅は小さくなり視認しにくくなる。

【００３２】

図９は、本実施の形態の立体画像表示装置１０において、正面から角度を成して観察すると、同じ視域幅ＶＷでも、視域が狭くなることを説明するための図である。画素幅をｐｐ、射出瞳一つに割り当てられた画素の数をＮ、射出瞳と画素までの距離をｇ、表示部１０４の表示面から観察位置までの距離を視距離Ｌとすると、視域幅ＶＷは（１）式で算出される。

【００３３】

$$VW = (pp \times N) \times L / g \quad \cdots (1)$$

【００３４】

表示部１０４の表示面から観察位置までの視距離Ｌが一定の場合、射出瞳に割り当てるＮ個の画素を切り替えても、視域幅ＶＷは一定になる。言い換えれば、図９に示す視域角φは、表示部１０４の正面から離れるに従って狭くなる。図１０は、視域角φが観察角度θに依存する関係を示す説明図である。図１０に示すように、観察角度θが大きくなるにつれて、視域幅ＶＷが維持されても視域角φは狭くなり、両眼が視域に入ることが困難になる。

【００３５】

図１１は、観察者１１が立体画像表示装置１０を保持して、立体画像表示装置１０を観察角度θだけ傾けた場合に、視距離Ｌが短くなることを示す図である。（１）式に示すように、視距離Ｌと視域幅ＶＷは比例関係にあるので、表示部１０４の正面からの観察角度θと視域幅ＶＷの関係は、図１２に示すようになり、観察角度θが大きくなると視域幅ＶＷが狭くなり、両目が視域に入らなくなると、正しい三次元画像を視認できなくなる。

【００３６】

さらに、本実施の形態のように、表示部１０４において光線制御子としての開口制御部１１５にレンチキュラーシートを用いた場合には、図１３に示すように、観察位置の表示部１０４の正面からの観察角度θが大きくなると、像面湾曲によりクロストーク量が増大し、視差画像の空間的な分離が不十分となる。ここでクロストーク量は、本来見えるべき視差画像に対する、当該視差画像以外の視差画像の混入する割合である。

【００３７】

このように、表示部１０４の表示面正面から観察角度θが増大するに従って、見た目の表示面の幅もしくは高さが減少したり（図８参照）、視域角φが狭くなったり（図１０参照）、クロストーク量が増大する（図１３参照）。さらに、観察者１１が手で立体画像表示装置１０を保持する場合は、視距離Ｌの減少に伴って視域幅ＶＷも狭くなる（図１２参照）。この結果、三次元画像の飛び出し奥行きが表現できなくなったり、隣接した射出瞳（開口部１１６）から出射されるはずの視差画像を視認してしまうことにより視差の並びが逆転して三次元画像の凹凸が逆転して視認される逆視や、複数の視差画像が重畳する多重像等の異常画像が発生して、三次元画像の画質が低下する。

【００３８】

このため、本実施の形態では、観察者の観察位置として表示部１０４の表示面正面からの観察角度θが増大した場合、上述した飛び出し奥行きの表現への制約や画質低下が発生すると判定し、三次元画像の飛び出し奥行き表現を抑制して三次元画像の表示の品質を維持している。すなわち、視差量決定部１０２は、観察位置検知部１０１が検知した観察角度θが増大するにしたがって飛び出し奥行き量を減少させるため、表示画像生成部１０３が要素画像アレイを生成するために用いる画像情報として視差量が少ない画像を用いるべく、図１４に示すように、観察角度θの増加に伴い、視差量を連続的に小さい値に決定している。

【００３９】

より具体的には、視差量決定部１０２は、観察角度θの増加に伴い、多視点画像の取得間隔（視点間隔）を連続的に狭い距離に決定することにより、視差量を小さくし、これに

Microsoft Exhibit 1002 - Page 1286
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

より、観察角度θが増大するにしたがって飛び出し奥行き量を減少させている。

【００４０】

図１４に示す例では、表示部１０４の正面で観察される飛び出し奥行き表現量を１とした場合に、観察角度θの増大に応じて、点線で示す線形関数により、または曲線で示すｃｏｓ関数のような非線形関数により連続的に視差量を減少させる決定を行って飛び出し奥行きを抑える。

【００４１】

視差量決定部１０２により、観察角度θの増大に伴って減少させる多視点画像の取得間隔の値の決定手法としては、以下の手法がある。図１５は、観察角度θの増大に伴って減少させる多視点画像の取得間隔の値の決定手法を説明するための図である。

【００４２】

視差数をＮ、要素画像ピッチをＰ、開口部１１６の幅、すなわちレンズピッチをＰｓ、水平方向のサブ画素ピッチ［ｍｍ］をｐｐ，開口制御部１１５（レンチキュラーシート）と画素間の距離［ｍｍ］をｇ，表示部１０４の表示面からの距離［ｍｍ］をＬ，視域最適化距離をＬ０，観察距離をＬｖ，光線間隔をＰｌ［ｍｍ］をＰｌ（Ｌ）とすると、ｐｐ、Ｐｌ（Ｌ）、ｇ、Ｌ、Ｐ、Ｐｅ、Ｌ０は、（２）、（３）式で算出される。

【００４３】

ｐｐ：Ｐｌ（Ｌ）＝ｇ：Ｌ　・・・（２）

Ｐ：Ｐｓ＝（Ｌ０＋ｇ）：Ｌ０・・・（３）

【００４４】

ここで、ｐｐ＝０．０５において、Ｌｖ＝４００でＰｌ（４００）＝６２（眼間距離）にする場合には、ｇを（４）式のように設定する。

【００４５】

０．０５：６２＝ｇ：４００、ｇ＝０．３２　・・・（４）

【００４６】

さらに、Ｌ０＝５００で、視域幅（ＶＷ（５００））を最大にするためには、（５）式を満たすように、ＰとＰｓを設定する。

【００４７】

Ｐ：Ｐｓ＝１：（５００＋０．３２）／５００　＝１：１．０００６４　・・・（５）

【００４８】

このとき、視域幅ＶＷ（Ｌ０）と観察角度θは、（６）、（７）式で算出される。ここで、ＶＷ（Ｌ０）右端）、（ＶＷ（Ｌ０）左端）は、視域幅ＶＷ（Ｌ０）の両端の座標である。

【００４９】

ＶＷ（Ｌ０）＝Ｐ×Ｌ０／ｇ　・・・（６）

θ＝｛ａｔａｎ（ＶＷ（Ｌ０）右端　／Ｌ０）－ａｔａｎ（ＶＷ（Ｌ０）左端／Ｌ０）｝／２　・・・（７）

【００５０】

上式からわかるように、観察角度θが増大すると視域幅ＶＷが狭くなる。一方、観察に必要な視域角φは、眼間距離を６２とすると、（８）式で算出される。

【００５１】

φ＝ａｔａｎ（６２／Ｌｖ）／２　・・・（８）

【００５２】

（８）式からわかるように、視域角φは、眼間距離と観察距離に依存する。これらの式から、例えば、（θ－φ）の値に連動して、飛び出し奥行き量を少なくするために、多視点画像の取得間隔を狭い値に決定したり、θ＞φで三次元画像、θ≦φで，平面画像になるように視差量決定部１０２を構成すればよい。

【００５３】

次に、以上のように構成された本実施の形態の立体画像表示処理について図１６のフローチャートを用いて説明する。

Microsoft Exhibit 1002 - Page 1287
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【００５４】
まず、入力部１０５は、三次元画像信号を、カメラ等の画像生成装置から入力したり、三次元画像信号を画像再生装置などのデコーダを介して入力する（ステップＳ１１）。そして、観察位置検知部１０１が、加速度センサ等により、観察者の表示部１０４の正面からの観察角度θを検知する（ステップＳ１２）。
【００５５】
次に、視差量決定部１０２が、ステップＳ１２で検知された観察角度θに応じて、多視点画像の取得間隔（視点間隔）を決定する（ステップＳ１３）。具体的には、視差量決定部１０２は、図１４のグラフおよび図１５の手法に従って、観察角度θが増大する程、小さい値の視点間隔を決定する。
【００５６】
そして、表示画像生成部１０３が、ステップＳ１３で決定された視点間隔で視差画像を視差画像配置テーブルに配列して要素画像アレイを生成し（ステップＳ１７）、要素画像アレイを表示部１０４に表示する（ステップＳ１８）。
【００５７】
ここで、視差画像配置テーブルは、表示部１０４の表示面に表示される多視点画像、すなわち要素画像アレイの各要素画像内に各視差画像がどのように配置されるかを示す配置表であり、その詳細については特許文献３に詳述されている。
【００５８】
このように本実施の形態では、観察角度θの増加に伴い、連続的に視差量を小さくすることにより、図８、１０、１２、１３に示すように連続的に変化する見た目の幅、視域角φ、視域幅ＶＷ、クロストーク量の変化に違和感なく合致させることができ、立体画像を高品位に表示することができる。すなわち、表示部１０４の正面から観察位置が大きくはずれた場合に、運動視差の理想的な付与を妨げずに、飛び出し奥行き量を抑えることで、異常画像を防止して高品位な立体画像の表示を実現することができる。なぜなら、視差量が減少しても、運動視差を別途提供できることから、広い範囲で立体感を提供し続けることができるからである。
【００５９】
なお、本実施の形態では、表示対象の三次元画像を外部の画像生成装置や画像再生装置から入力してリアルタイムに表示部１０４に表示する立体画像表示装置を例にあげて説明したが、これに限定されるものではなく、ハードディスクドライブ装置（ＨＤＤ）や揮発性または不揮発性のメモリ等の記憶媒体に蓄積された三次元画像を読み込んで表示部１０４に表示する立体画像表示装置に本実施の形態を適用することもできる。
【００６０】
（実施の形態２）
実施の形態１では、観察角度θの増加に伴い、連続的に視差量を小さくしていたが、この実施の形態２では、観察角度θが増加して閾値を超えたときに表示画像を急峻に平面画像に切り替えるものである。また、実施の形態１では、三次元画像信号を、外部の画像生成装置や画像再生装置などから入力して表示部１０４に表示していたが、この実施の形態２では、予め画像記憶部１７０５に記憶された多視点画像や単視点画像を表示部１０４に表示する。
【００６１】
ただし、三次元画像信号を外部の画像生成装置や画像再生装置などから入力して表示部１０４に表示する立体画像表示装置に本実施の形態を適用してもよい。
【００６２】
実施の形態２にかかる立体画像表示装置１７００は、図１７に示すように、画像記憶部１７０５と、観察位置検知部１０１と、視差量決定部１７０２と、表示画像生成部１７０３と、表示部１０４とを主に備えている。ここで、観察位置検知部１０１および表示部１０４の機能および構成は実施の形態１と同様である。
【００６３】

Microsoft Exhibit 1002 - Page 1288
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

画像記憶部１７０５は、多視点画像や単視点画像からなる三次元画像信号を予め記憶するＨＤＤやメモリ等の記憶媒体である。

【００６４】

視差量決定部１７０２は、観察位置検知部１０１で検知された観察角度θが所定の閾値を超えたか否かを判断し、閾値を超えた場合には、視差量を減少させた画像に決定する。具体的には、視差量決定部１７０２は、図１８に示すように、観察角度θが閾値以下である場合には、視差量を変更せず、観察角度θが閾値を超えた場合、平面画像を選択することを決定する。なお、立体画像表示装置１７００を、表示対象の三次元画像をカメラ等の画像生成装置や画像再生装置から入力してリアルタイムに表示部１０４に表示する装置に適用した場合には、観察角度θが所定の閾値を超えた場合に、視差量を０、すなわち多視点画像の取得間隔（視点間隔）を０に決定するように構成すればよい。

【００６５】

このように、閾値を設けることによって、両眼が視域に入らない、または、クロストーク量が許容値を超える状態になる前まで、正面と同等の三次元画像を維持する。図１９に一例として、平面表示をする領域と三次元画像の表示領域の分割例を示す。

【００６６】

ここで、観察角度θが閾値を超えたときに平面画像に切り替える場合おいて、異常画像防止の目的を満たすためには、切り替える平面画像は、表示対象の三次元画像と関連の有無は問わない。例えば、表示対象の三次元画像と無関係な平面画像や黒表示（非表示）等の無彩色画像を選択するように構成してもよい。

【００６７】

図１７に戻り、表示画像生成部１７０３は、実施の形態１と同様に、要素画像アレイを生成し、生成された要素画像アレイを表示部１０４に表示するが、観察角度θが閾値を超えた場合には、視差量決定部１７０２で決定された平面画像を画像記憶部１７０５から選択して、要素画像アレイを生成する。

【００６８】

次に、以上のように構成された本実施の形態の立体画像表示処理について図２０のフローチャートを用いて説明する。

【００６９】

まず、観察位置検知部１０１が、加速度センサ等により、観察者の表示部１０４の正面からの観察角度θを検知する（ステップＳ２２）。

【００７０】

次に、視差量決定部１７０２が、ステップＳ２２で検知された観察角度θが閾値を超えたか否かを判断する（ステップＳ２３）。そして、観察角度θが閾値以下である場合には（ステップＳ２３：Ｎｏ）、視差量の変更は行わない。観察角度θが閾値を超えた場合には（ステップＳ２３：Ｙｅｓ）、視差量決定部１７０２は平面画像を選択することを決定する（ステップＳ２４）。

【００７１】

そして、表示画像生成部１７０３が、ステップＳ２４で決定された平面画像を画像記憶部１７０５から取得して、視差画像配置テーブルに配列して要素画像アレイを生成し（ステップＳ２７）、要素画像アレイを表示部１０４に表示する（ステップＳ２８）。

【００７２】

このように本実施の形態では、観察角度θが増加して閾値を超えたときに表示画像を急峻に平面画像に切り替えて表示部１０４に表示するので、正面から観察位置が大きくはずれた場合に、運動視差の理想的な付与を妨げずに、飛び出し奥行き量を抑えることで、異常画像を防止して高品位な立体画像の表示を実現することができる。また、視差をなくすだけなら、平面画像ではあっても運動視差を別途提供できることから、程度は少ないが立体感を提供し続けることができる。

【００７３】

（変形例１）

Microsoft Exhibit 1002 - Page 1289
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

実施の形態１と実施の形態２とを組み合わせて立体画像表示を行うこともできる。変形例１では、図２１に示すように、視差量決定部１０２が観察位置検知部１０１で検知した観察角度θが閾値以下である場合には、視差量の変更を行わず、観察角度θが閾値を超えた場合に、実施の形態１と同様に、視差量を連続的に減少した値、すなわち多視点画像の視点間隔を連続的に小さくなる値に決定する。

【００７４】

この変形例１の立体画像表示処理について、図２２のフローチャートを用いて説明する。三次元画像信号の入力、観察角度θの検知の処理までは（ステップＳ４１、Ｓ４２）、実施の形態１と同様である。

【００７５】

次に、視差量決定部１０２が、ステップＳ４２で検知された観察角度θが閾値を超えたか否かを判断する（ステップＳ４３）。そして、観察角度θが閾値以下である場合には（ステップＳ４３：Ｎｏ）、視差量の変更は行わない。観察角度θが閾値を超えた場合には（ステップＳ４３：Ｙｅｓ）、ステップＳ４２で検知された観察角度θに応じて，多視点画像の取得間隔（視点間隔）を決定する（ステップＳ４４）。具体的には、視差量決定部１０２は、図２１のグラフに従って、観察角度θが増大する程、小さい値の視点間隔を決定する。

【００７６】

そして、表示画像生成部１０３が、ステップＳ４４で決定された視点間隔で視差画像を視差画像配置テーブルに配列して要素画像アレイを生成し（ステップＳ４７）、要素画像アレイを表示部１０４に表示する（ステップＳ４８）。

【００７７】

（変形例２）

変形例２では、図２３に示すように、視差量決定部１０２が観察角度θが閾値以下である場合には、実施の形態１と同様に、視差量を連続的に減少した値、すなわち多視点画像の視点間隔を連続的に小さくする。一方、観察角度θが閾値を超えた場合には、視差量決定部１０２が平面画像を選択する。

【００７８】

この変形例２の立体画像表示処理について、図２４のフローチャートを用いて説明する。三次元画像信号の入力、観察角度θの検知の処理までは（ステップＳ３１、Ｓ３２）、実施の形態１と同様である。

【００７９】

次に、視差量決定部１０２が、ステップＳ３２で検知された観察角度θが閾値を超えたか否かを判断する（ステップＳ３３）。そして、観察角度θが閾値以下である場合には（ステップＳ３３：Ｎｏ）、ステップＳ３２で検知された観察角度θに応じて、多視点画像の取得間隔（視点間隔）を決定する（ステップＳ３５）。具体的には、視差量決定部１０２は、図２３のグラフに従って、観察角度θが増大する程、小さい値の視点間隔を決定する。一方、観察角度θが閾値を超えた場合には（ステップＳ３３：Ｙｅｓ）、視差量決定部１０２は、実施の形態２と同様に、多視点画像の取得間隔を０、すなわち平面画像を選択することを決定する（ステップＳ３４）。

【００８０】

そして、表示画像生成部１０３が、ステップＳ３４で決定された視点間隔で視差画像を視差画像配置テーブルに配列して要素画像アレイを生成し（ステップＳ３７）、要素画像アレイを表示部１０４に表示する（ステップＳ３８）。

【００８１】

このような変形例１，２においても、表示部１０４の正面から観察位置が大きくはずれた場合に、運動視差の理想的な付与を妨げずに、飛び出し奥行き量を抑えることで、異常画像を防止して高品位な立体画像の表示を実現することができる。

【００８２】

なお、上記実施の形態および変形例において、水平方向と垂直方向の双方に視差情報を

Microsoft Exhibit 1002 - Page 1290
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

付与する場合には、水平方向と垂直方向の双方に上記立体画像表示処理を適用する必要があるが、観察角度θに応じた飛び出し奥行き量の低減の手法はそれぞれ独立に実現することができる。水平方向のみ視差情報を提示する立体画像表示装置では、垂直方向は通常のトラッキングと組みわせてよい。また、N個の画素の最適化による視域拡大と、本実施の形態の、多視点画像の切り替えを両立して実現することもできる。

【００８３】

なお、上記実施の形態および変形例では、表示部１０４の正面からの観察角度θに応じて視差量を減少させることにより、飛び出し奥行き量を減少させていたが、飛び出し奥行き量を減少させる方向に変更する手法であれば、他の手法を用いることもできる。

【００８４】

また、本実施の形態の立体画像表示装置１０，１７００において、観察位置検知部１０１，視差量決定部１０２の構成を種々変形することができる。

【００８５】

例えば、本実施の形態の立体画像表示装置１０，１７００において、図１２に示すような、観察角度θと、表示部１０４の正面からの観察者の観察距離との対応関係のテーブルをメモリ等の記憶媒体に予め記憶しておく。そして、上記対応関係のテーブルにおいて、観察者位置検知部１０１により検知した観察角度θに対応する観察距離を求めるように観察者位置検知部１０１を構成してもよい。さらに、この場合，視差量を、観察角度と観察距離とから決定するように視差量決定部１０２を構成してもよい。この場合には、観察角度θに加え、観察距離も考慮するので、視差量を高精度で求めることができ、より高品位な立体画像の表示を実現することができる。

【００８６】

また、本実施の形態の立体画像表示装置１０，１７００に撮像カメラ等の撮像手段を設けてもよい。この場合，撮像手段により撮像画像から観察者の頭部の大きさを算出し、算出された頭部の大きさから、表示部１０４の正面からの観察者の観察距離を求めるように観察位置検知部１０１を構成することができる。さらに、視差量を、観察角度θと観察距離とから決定するように視差量決定部１０２を構成することもできる。この場合にも，観察角度θに加え、観察距離も考慮するので、視差量を高精度で求めることができ，より高品位な立体画像の表示を実現することができる。

【００８７】

なお，上記実施の形態の立体画像表示装置で実行される立体画像表示プログラムは、ＲＯＭ等に予め組み込まれて提供される。

【００８８】

上記実施の形態の立体画像表示装置で実行される立体画像表示プログラムは、インストール可能な形式又は実行可能な形式のファイルでＣＤ－ＲＯＭ、フレキシブルディスク（ＦＤ）、ＣＤ－Ｒ、ＤＶＤ（Ｄｉｇｉｔａｌ Ｖｅｒｓａｔｉｌｅ Ｄｉｓｋ）等のコンピュータで読み取り可能な記録媒体に記録して提供するように構成してもよい。

【００８９】

さらに、上記実施の形態の立体画像表示装置で実行される立体画像表示プログラムを，インターネット等のネットワークに接続されたコンピュータ上に格納し、ネットワーク経由でダウンロードさせることにより提供するように構成しても良い。また、上記実施の形態の立体画像表示装置で実行される立体画像表示プログラムをインターネット等のネットワーク経由で提供または配布するように構成しても良い。

【００９０】

上記実施の形態の立体画像表示装置で実行される立体画像表示プログラムは，上述した各部（入力部、観察位置検知部、視差量決定部，表示画像生成部）を含むモジュール構成となっており、実際のハードウェアとしてはＣＰＵ（プロセッサ）が上記ＲＯＭから立体画像表示プログラムを読み出して実行することにより上記各部が主記憶装置上にロードされ，入力部、観察位置検知部，視差量決定部，表示画像生成部が主記憶装置上に生成されるようになっている。

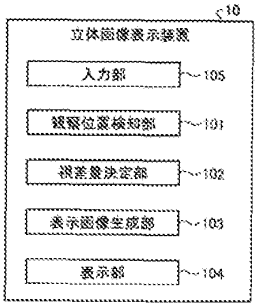
Microsoft Exhibit 1002 - Page 1291
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【００９１】
なお、上記実施の形態および変形例は、例示であり、発明の範囲はそれらに限定されない。

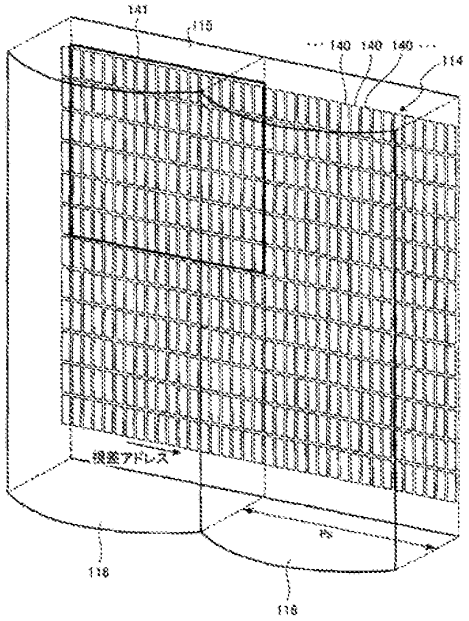
【符号の説明】

【００９２】
１０，１７００　立体画像表示装置
１１　観察者
１２　視域幅
１３　視距離
１０１　観察位置検知部
１０２，１７０２　視差量決定部
１０３，１７０３　表示画像生成部
１０４　表示部
１０５　入力部
１１４　表示素子アレイ
１１５　開口制御部
１１６　開口部
１４０　サブ画素
１４１　要素画像

【図１】

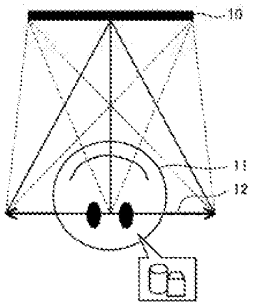


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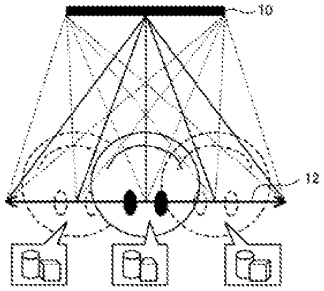


Microsoft Exhibit 1002 - Page 1292
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

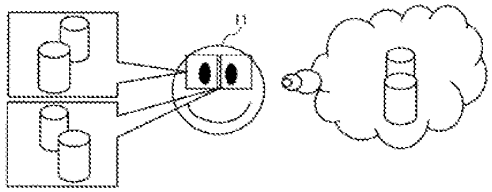
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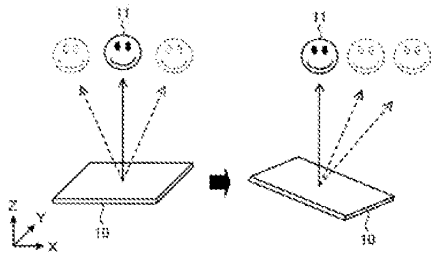
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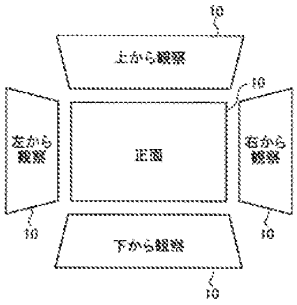
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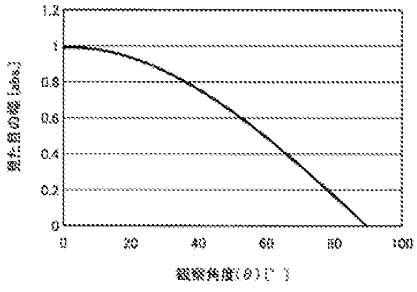
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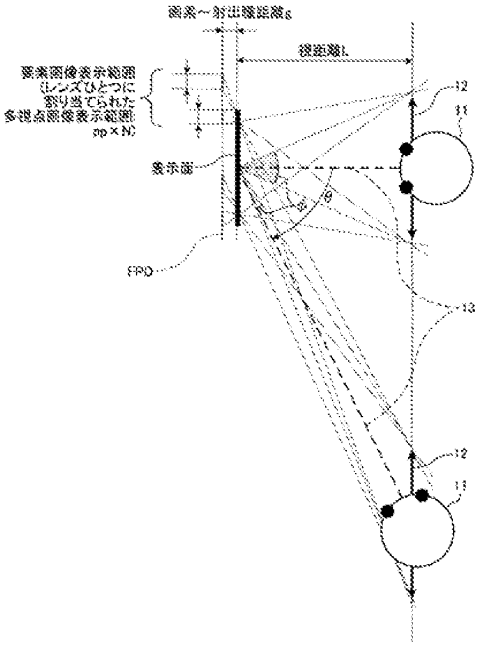
【図７】



【図８】

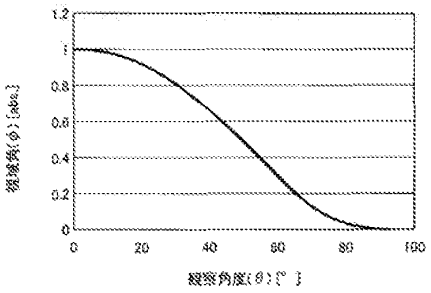


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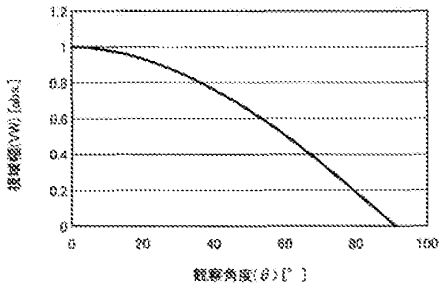


Microsoft Exhibit 1002 - Page 1293
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

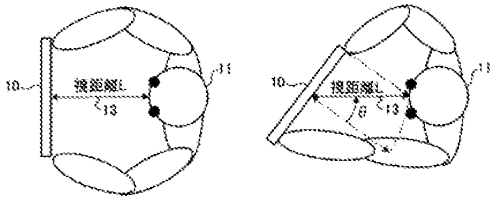
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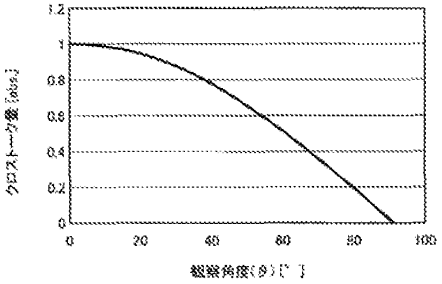
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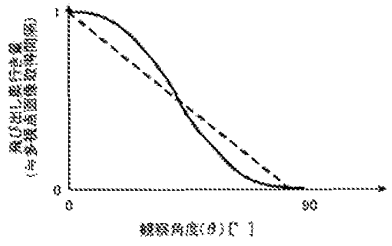
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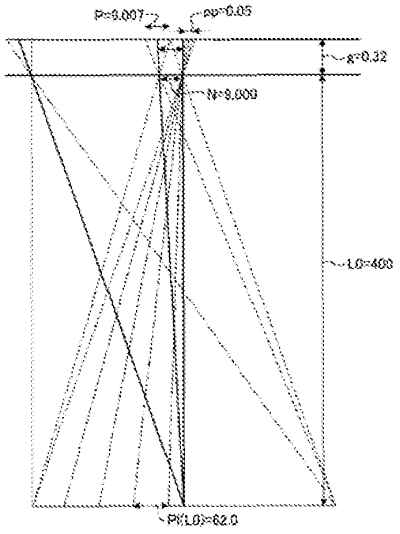
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【図１４】

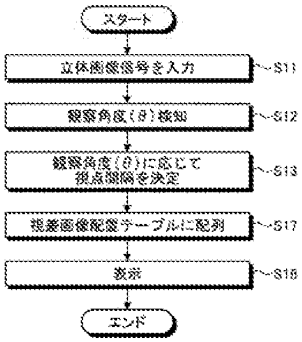


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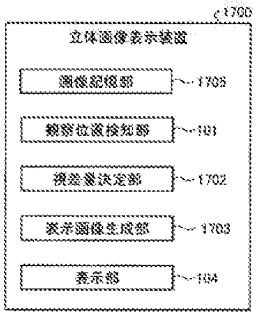


Microsoft Exhibit 1002 - Page 1294
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

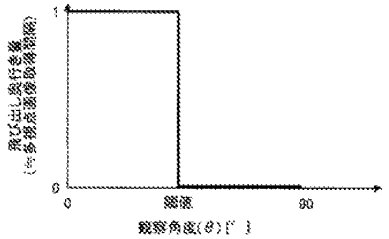
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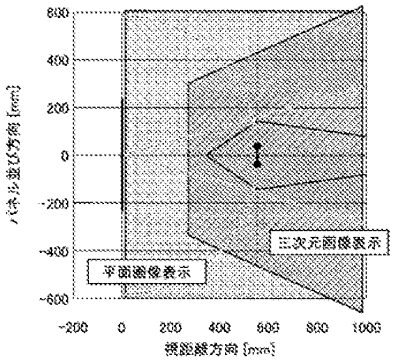
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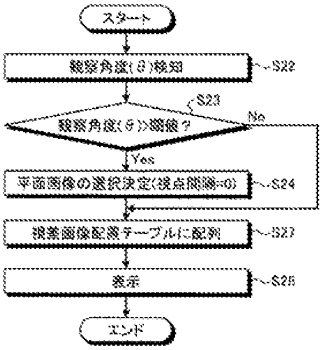
【図１８】



【図１９】

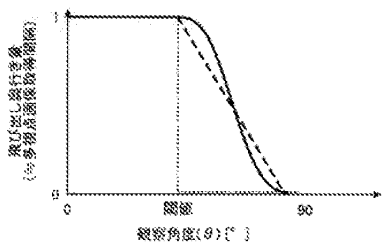


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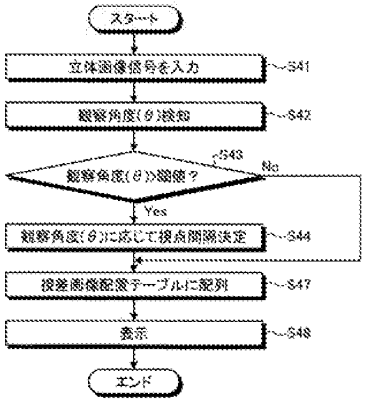


Microsoft Exhibit 1002 - Page 1295
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

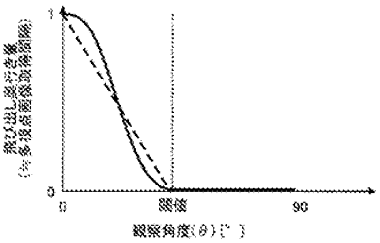
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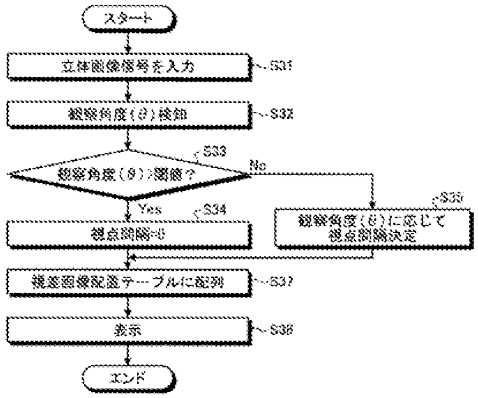
【図２２】



【図２３】



【図２４】



Microsoft Exhibit 1002 - Page 1296
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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5C080 CC04 DD01 GG12 JJ02 JJ05 JJ06
5C082 AA21 BA47 CA81 CB01 DA53 DA87 MM05 MM10

Microsoft Exhibit 1002 - Page 1297
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Espacenet

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DISPLAY UNIT

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Applicant(s): JAPAN DISPLAY WEST CO LTD + (JAPAN DISPLAY WEST CO LTD, ; 株式会社ジャパンディスプレイ)

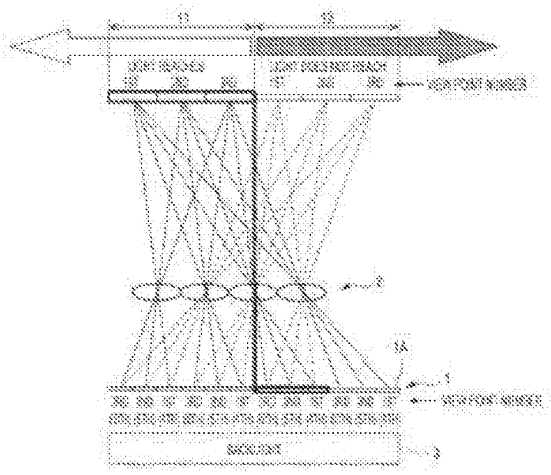
Classification: - international: *G02B27/22; G02F1/13; G02F1/13357; H04N13/04*
- cooperative: G02B27/2214; G02B6/0076; H04N13/32; H04N13/354; G02B6/0038

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Priority number (s): JP20110147211 20110701

Also published as: CN102857775 (A) CN102857775 (B) JP5649526 (B2) US2013003176 (A1) US9081196 (B2)

Abstract of JP2013015619 (A)



PROBLEM TO BE SOLVED: To enable the number of eye points which are stereoscopically visible and an observation area to be expanded.SOLUTION: A display unit comprises: a display part dividing a plurality of viewpoint images in N times (N is an integer number equal to or more than 2) and performing time division display of the viewpoint images; a back light for emitting light for image display toward the display part; and a separation part for separating M viewpoint images (M is an integer number equal to or more than 2) displayed in a same time zone in the display part. The light emission direction of the back light can be switch-controlled in N directions, and accordingly, the light emission direction is switch-controlled in a

Microsoft Exhibit 1002 - Page 1298
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

time-division manner in synchronization with the time division display by the display part.

Microsoft Exhibit 1002 - Page 1299
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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(P2013-15619A)
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G02F 1/13	(2006.01)	G02F	1/13　505	2H191
G02F 1/13357	(2006.01)	G02F	1/13357	2H199
H04N 13/04	(2006.01)	H04N	13/04	5C061

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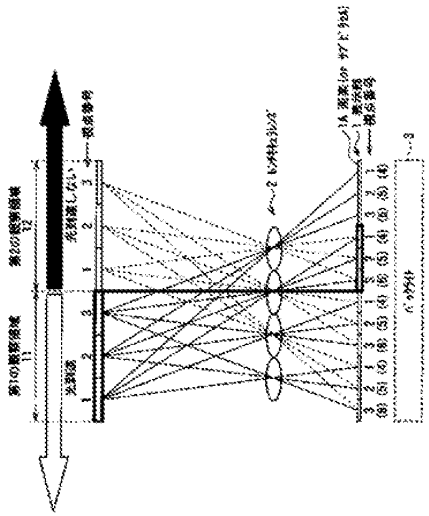
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Fターム(参考) 2H088 EA06 HA26 HA28 MA03

最終頁に続く

(54)【発明の名称】表示装置

(57)【要約】
【課題】立体視可能な視点数および観察領域を拡大することができるようにする。
【解決手段】複数の視点画像をN回（Nは２以上の整数）に分けて時分割表示する表示部と、前記表示部に向けて画像表示用の光を照射するバックライトと、前記表示部において同一時間帯に表示されたM個（Mは２以上の整数）の視点画像を分離する分離部とを備える。前記バックライトは、N個の方向に光の出射方向を切り替え制御可能なものであり、前記表示部による時分割表示のタイミングに同期して、光の出射方向を時分割で切り替え制御する。
【選択図】図１



Microsoft Exhibit 1002 - Page 1300
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

【特許請求の範囲】
【請求項１】
複数の視点画像をＮ回（Ｎは２以上の整数）に分けて時分割表示する表示部と、
前記表示部に向けて画像表示用の光を照射するバックライトと、
前記表示部において同一時間帯に表示されたＭ個（Ｍは２以上の整数）の視点画像を分離する分離部と
を備え、
前記バックライトは、Ｎ個の方向に光の出射方向を切り替え制御可能なものであり、前記表示部による時分割表示のタイミングに同期して、光の出射方向を時分割で切り替え制御する
表示装置。
【請求項２】
前記分離部は、Ｎ個の観察領域のそれぞれにおいて前記Ｍ個の視点画像を形成させる
請求項１に記載の表示装置。
【請求項３】
前記バックライトは、前記Ｎ個の観察領域に対応する前記Ｎ個の方向に光の出射方向を切り替え制御可能なものである
請求項２に記載の表示装置。
【請求項４】
前記表示部は、各回の時分割表示においてそれぞれ異なる視点画像を表示する
請求項１に記載の表示装置。
【請求項５】
前記表示部は、前記複数の視点画像を２回に分けて時分割表示し、
前記分離部は、２つの観察領域のそれぞれにおいて前記Ｍ個の視点画像を形成し、
前記２つの観察領域の境界位置は、前記表示部の中央位置に対応し、
前記バックライトは、前記２つの観察領域の境界位置を境界にして２つの方向に光の出射方向を切り替え制御可能である
請求項３に記載の表示装置。
【請求項６】
前記表示部は、前記複数の視点画像を３回以上に分けて時分割表示し、
前記分離部は、３つ以上の観察領域のそれぞれにおいて前記Ｍ個の視点画像を形成し、
前記バックライトは、前記各観察領域の両端部を境界とするような３つ以上の方向に光の出射方向を切り替え制御可能である
請求項３に記載の表示装置。
【請求項７】
前記バックライトは、
光源と、
前記光源からの光を透過する開口部と光を遮光する遮光部とを有し、前記開口部の位置をＮ個の異なる位置に時分割で可変制御可能な光変調素子と、
前記開口部を透過した光を集光させるレンチキュラレンズとを有する
請求項１に記載の表示装置。
【請求項８】
前記バックライトは、
互いに対向配置され、互いに光の出射方向の異なる複数の導光板と、
複数のプリズムが形成され、前記複数の導光板に対向配置されたプリズムシートと
を有し、
前記複数の導光板を時分割で駆動することにより、光の出射方向を切り替え制御可能である
請求項１に記載の表示装置。
【請求項９】

Microsoft Exhibit 1002 - Page 1301
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

前記各プリズムは、前記複数の導光板側に第１の頂点を向けた、断面が逆三角形状の逆プリズムであり、
前記逆プリズムの底辺側にある第２の頂点と第３の頂点とのそれぞれの頂点角度が互いに異なる
請求項８に記載の表示装置。
【発明の詳細な説明】
【技術分野】
【０００１】
本開示は、パララックスバリア等の視差分離手段を用いて裸眼方式による立体表示を行う表示装置に関する。
【背景技術】
【０００２】
立体表示を行う手法としては、立体視用の眼鏡を用いる眼鏡方式と、立体視用の特殊な眼鏡を用いることなく裸眼での立体視を可能にした裸眼方式とがある。眼鏡方式の代表的なものとしては、左眼用シャッタと右眼用シャッタとを有するシャッタめがねを用いるシャッタめがね方式がある。シャッタめがね方式では、２次元表示パネルに左眼用と右眼用の各視差画像をフレームシーケンシャルで高速で交互に表示する。そして、各視差画像の表示タイミングに合わせて左眼用シャッタと右眼用シャッタとを交互に切り換えることにより、観察者の左眼には左眼用視差画像、右眼には右眼用視差画像のみを入射させることで、立体視を可能にしている。
【０００３】
一方、裸眼方式の代表的なものとしては、パララックスバリア方式とレンチキュラレンズ方式とがある。パララックスバリア方式やレンチキュラ方式の場合、２次元表示パネルに立体視用の視差画像（２視点の場合には右眼用視差画像と左眼用視差画像）を空間分割して表示し、その視差画像を視差分離手段によって水平方向に視差分離することで立体視が行われる。パララックスバリア方式の場合、視差分離手段としてスリット状の開口が設けられたパララックスバリアを用いる。レンチキュラ方式の場合、視差分離手段として、シリンドリカル状の分割レンズを複数並列配置したレンチキュラレンズが用いられる。
【先行技術文献】
【特許文献】
【０００４】
【特許文献１】特開平１０－２８２４５３号公報
【特許文献２】特開２００５－９１４４７号公報
【発明の概要】
【発明が解決しようとする課題】
【０００５】
しかしながら、視差分離手段を用いた裸眼方式では、複数の視点画像を２次元表示パネルの１つの画面内に空間分割して表示するため、表示パネル自体の本来の表示解像度よりも、各視点画像の表示解像度が劣化してしまう問題がある。この表示解像度の劣化は、視点画像の数が多くなるほど大きくなる。
【０００６】
一方、裸眼方式の場合、正常な立体視を行える観察領域が中央にあり、これをメインローブと呼ぶ。メインローブを挟んで横方向には、メインローブと同様に正常な立体視を行える観察領域が複数あり、これをサイドローブと呼ぶ。メインローブとサイドローブにはそれぞれ、複数の視点画像が同じ状態（配列）で表示される。例えば、３視点の立体表示を行う場合、メインローブとサイドローブにはそれぞれ、３視点分の視点画像が同じ配列で表示される。特許文献１，２には、２次元表示パネルの画像表示面側に視差分離手段を配置すると共に、２次元表示パネルと視差分離手段との間に、ローブ制御手段を配置した立体表示装置の構成が記載されている。この立体表示装置では、ローブ制御手段によってメインローブとサイドローブとを時分割で交互に表示すると共に、２次元表示パネルに表

Microsoft Exhibit 1002 - Page 1302
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

示する複数の視点画像を時分割で切り替えることで、メインローブとサイドローブとに異なる視点画像を表示する。これにより、視点数および観察領域の拡大を図っている。

【０００７】

本開示の目的は、立体視可能な視点数および観察領域を拡大することができるようにした表示装置を提供することにある。

【課題を解決するための手段】

【０００８】

本開示による表示装置は、複数の視点画像をＮ回（Ｎは２以上の整数）に分けて時分割表示する表示部と、表示部に向けて画像表示用の光を照射するバックライトと、表示部において同一時間帯に表示されたＭ個（Ｍは２以上の整数）の視点画像を分離する分離部とを備えたものである。そして、バックライトを、Ｎ個の方向に光の出射方向を切り替え制御可能なものであり、表示部による時分割表示のタイミングに同期して、光の出射方向を時分割で切り替え制御するようにしたものである。

【０００９】

本開示の表示装置では、複数の視点画像がＮ回に分けて表示部に時分割表示される。バックライトは、Ｎ個の方向に光の出射方向を切り替え、表示部による時分割表示のタイミングに同期して、光の出射方向を時分割で切り替える。これにより、Ｎ個の観察領域が全体として連続的な立体視が可能な領域となる。

【発明の効果】

【００１０】

本開示の表示装置によれば、表示部に複数の視点画像をＮ回に分けて時分割表示すると共に、表示部による時分割表示のタイミングに同期して、バックライトによる光の出射方向を時分割で切り替えるようにしたので、立体視可能な視点数および観察領域を拡大することができる。

【図面の簡単な説明】

【００１１】

【図１】本開示の一実施の形態に係る表示装置の全体構成および第１の表示状態を示す断面図である。

【図２】図１に示した表示装置における第２の表示状態を示す断面図である。

【図３】図１に示した表示装置におけるバックライトの第１の構成例を示す断面図である。

【図４】図１に示した表示装置におけるバックライトの第２の構成例を示す断面図である。

【図５】図４に示したバックライトを用いた表示装置における時分割制御のタイミング例を示す説明図である。

【図６】図４に示したバックライトによって左側方向に出射される光の輝度分布を示す特性図である。

【図７】図４に示したバックライトによって右側方向に出射される光の輝度分布を示す特性図である。

【図８】図４に示したバックライトを用いた表示装置による表示状態の一例を示す断面図である。

【図９】変形例に係る表示装置の全体構成および表示状態を示す断面図である。

【図１０】（Ａ）は変形例に係る表示装置におけるバックライトの出射方向の説明図である。（Ｂ）は変形例に係る表示装置における視差分離手段としてのレンチキュラレンズによって形成される１つの観察領域の説明図である。

【発明を実施するための形態】

【００１２】

以下、本開示の実施の形態について図面を参照して詳細に説明する。

【００１３】

［表示装置の全体構成］

Microsoft Exhibit 1002 - Page 1303
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

図１および図２は、本開示の一実施の形態に係る表示装置の一構成例を示している。この表示装置は、表示部１と、視差分離手段（分離部）としてのレンチキュラレンズ２と、バックライト３とを備えている。

【００１４】

表示部１は、透過型の２次元表示ディスプレイ、例えば透過型の液晶表示パネルで構成されている。表示部１の表示画面には、複数の画素（またはサブピクセル）１Ａが２次元的に配列されている。表示部１の表示画面には、複数の視点画像がＮ回（Ｎは２以上の整数）に分けて時分割表示されるようになっている。

【００１５】

図１および図２の例では、第１～第６の視点画像をＮ＝２回に分けて時分割表示する例を示しており、図１では第１～第３の視点画像を表示し、図２では第４～第６の視点画像を表示している。すなわち、図１の表示状態では、複数の画素（またはサブピクセル）１Ａに第１～第３の視点画像が循環的に割り当てられ、第１～第３の視点画像が１画面内に合成された視差合成画像が表示されている。図２の表示状態では、複数の画素（またはサブピクセル）１Ａに第４～第６の視点画像が循環的に割り当てられ、第４～第６の視点画像が１画面内に合成された視差合成画像が表示されている。

【００１６】

レンチキュラレンズ２は、例えばシリンドリカル状の分割レンズを複数並列配置したものとなっている。レンチキュラレンズ２は、表示部１において同一時間帯に表示されたＭ個（Ｍは２以上の整数）の視点画像を分離し、Ｎ個の観察領域のそれぞれにおいてＭ個の視点画像を形成させるようになっている。図１および図２の例では、同一時間帯に表示されたＭ＝３個の視点画像を分離し、Ｎ＝２個の観察領域（第１の観察領域１１、第２の観察領域１２）のそれぞれにおいて３個の視点画像を形成させている。

【００１７】

なお、本実施の形態では、レンチキュラレンズ２を用いたレンチキュラレンズ方式を例に説明するが、パララックスバリア方式による表示装置の構成にすることも可能である。この場合、レンチキュラレンズ２に代えて、視差分離手段としてパララックスバリア素子が用いられる。パララックスバリア素子は、光を透過する開口部と、光を遮蔽する遮蔽部とを備えたものである。

【００１８】

バックライト３は、Ｎ個の観察領域に対応するＮ個の方向に光の出射方向を切り替え制御可能なものであり、表示部１による時分割表示のタイミングに同期して、光の出射方向を時分割で切り替え制御するようになっている。

【００１９】

図１および図２の例では、バックライト３は、Ｎ＝２個の観察領域（第１の観察領域１１、第２の観察領域１２）に対応するＮ＝２個の方向に光の出射方向を切り替えている。すなわち、図１では第１の観察領域１１に対応する方向に光の出射方向を切り替え、図２では第２の観察領域１２に対応する方向に光の出射方向を切り替えている。図１および図２の例では、２つの観察領域（第１の観察領域１１、第２の観察領域１２）の境界位置は、表示部１の中央位置に対応している。バックライト３は、２つの観察領域の境界位置を境界にして２つの方向に光の出射方向を切り替えている。

【００２０】

［表示装置の全体動作］

この表示装置では、複数の視点画像がＮ回に分けて表示部１に時分割表示される。バックライト３は、Ｎ個の観察領域に対応するＮ個の方向に光の出射方向を切り替え、表示部１による時分割表示のタイミングに同期して、光の出射方向を時分割で切り替える。これにより、Ｎ個の観察領域が全体として連続的な立体視が可能な領域となり、立体視可能な視点数および観察領域を拡大することができる。

【００２１】

図１および図２の例では、まず、第１の表示状態（図１）として、表示部１に第１～第

Microsoft Exhibit 1002 - Page 1304
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

３の視点画像が表示される。レンチキュラレンズ２は、第１の観察領域１１および第２の観察領域１２のそれぞれにおいて第１～第３の視点画像を形成させる。これに同期してバックライト３は、第１の観察領域１１に対応する方向に光の出射方向を切り替える。この場合、第２の観察領域１２には光が到達しない状態となるので、結果的に、第１の観察領域１１に表示された第１～第３の視点画像のみを観察可能となる。

【００２２】

次に、第２の表示状態（図２）として、表示部１に第４～第６の視点画像が表示される。レンチキュラレンズ２は、第１の観察領域１１および第２の観察領域１２のそれぞれにおいて第４～第６の視点画像を形成させる。これに同期してバックライト３は、第２の観察領域１２に対応する方向に光の出射方向を切り替える。この場合、第１の観察領域１１には光が到達しない状態となるので、結果的に、第２の観察領域１２に表示された第４～第６の視点画像のみを観察可能となる。

【００２３】

図１の第１の表示状態と図２の第２の表示状態とを人間の眼には判別できないような高速のタイミングで交互に切り替えることにより、全体としての正常な立体視可能な観察領域は、第１の観察領域１１と第２の観察領域１２とを合わせた領域となる。また、全体としての視点数は６つとなる。

【００２４】

〔バックライト３の第１の具体例〕

図３は、バックライト３の第１の具体例を示している。なお、図３では第１の表示状態では第１～第４の視点画像を表示し、第２の表示状態では第５～第８の視点画像を表示して全体としての視点数は８つにした場合を例にしている。

【００２５】

この第１の具体例では、バックライト３は、光源２１と、光変調素子２２と、レンチキュラレンズ２３とを備えている。光源２１は、ＣＣＦＬ（冷陰極蛍光ランプ）等の蛍光ランプや、ＬＥＤ（Light Emitting Diode）等を用いた面状光源となっている。

【００２６】

光変調素子２２は、例えば液晶素子で構成されている。光変調素子２２は、光源２１からの光を透過する開口部２２Ａと、光を遮光する遮光部２２Ｂとを有し、開口部２２Ａの位置をＮ個の異なる位置に時分割で可変制御可能となっている。レンチキュラレンズ２３は、例えばシリンドリカル状の分割レンズを複数並列配置したものとなっている。レンチキュラレンズ２３は、開口部２２Ａを透過した光を表示部１側に集光させるようになっている。

【００２７】

この第１の具体例では、光変調素子２２の開口部２２Ａの位置を変化させることにより、光の出射方向を切り替え制御可能となっている。図３では、第２の観察領域１２に対応する方向に光の出射方向を切り替えている状態を示している。

【００２８】

〔バックライト３の第２の具体例〕

図４は、バックライト３の第２の具体例を示している。この第２の具体例では、バックライト３は、下側から順に、反射板３５と、下側導光板３１と、上側導光板３２と、プリズムシート３３とを備えている。下側導光板３１と上側導光板３２は、互いに対向配置され、互いに光の出射方向が異なるような構成とされている。下側導光板３１の１つの側面には、ＣＣＦＬ等の蛍光ランプや、ＬＥＤ等を用いた光源３１Ａが配置されている。上側導光板３２の１つの側面にも同様に光源３２Ａが配置されている。下側導光板３１に配置された光源３１Ａと上側導光板３２に配置された光源３２Ａは、互いに配置方向が逆側となっている。図４では、光源３１Ａを左側、光源３２Ａを右側に配置した例を示している。

【００２９】

下側導光板３１の底面には複数の傾斜面３１Ｂが形成されている。傾斜面３１Ｂは、光

Microsoft Exhibit 1002 - Page 1305
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

源３１Ａが配置された向きに傾斜し、光源３１Ａから照射された光を下側導光板３１の上面から外部へ所定の角度で出射させるようになっている。下側導光板３１からの出射光は、上側導光板３２およびプリズムシート３３を介して、第２の観察領域１２に対応する方向に出射される。

【００３０】

上側導光板３２の底面には複数の傾斜面３２Ｂが形成されている。傾斜面３２Ｂは、光源３２Ｂが配置された向きに傾斜し、光源３２Ａから照射された光を上側導光板３２の上面から外部へ所定の角度で出射させるようになっている。上側導光板３２からの出射光は、プリズムシート３３を介して、第１の観察領域１１に対応する方向に出射される。

【００３１】

プリズムシート３３は、下側導光板３１と上側導光板３２とに対向配置されている。プリズムシート３３には、導光板側に第１の頂点を向けた、断面が逆三角形状の逆プリズム３４が複数、設けられている。逆プリズム３４の第１の面３４Ａは、上側導光板３２からの出射光を、第１の観察領域１１に対応する方向に反射するようになっている。逆プリズム３４の第２の面３４Ｂは、下側導光板３１からの出射光を、第２の観察領域１２に対応する方向に反射するようになっている。

【００３２】

この第２の具体例では、下側導光板３１と上側導光板３２とを時分割で交互に駆動することにより、光の出射方向を切り替え制御可能となっている。図５は、バックライト３を図４の構成にした場合における時分割制御のタイミング例を示している。図４（Ａ）は表示部１への視点画像データの書き込みタイミングを示し、図４（Ｂ）は表示部１を液晶ディスプレイとした場合の液晶応答タイミングを示している。図４（Ｃ）は、バックライト３における下側導光板３１（左側の光源３１Ａ）と上側導光板３２（右側の光源３２Ａ）との光源点灯タイミングを示している。

【００３３】

図４（Ａ）において、まず、第１～第３の視点画像のデータを表示部１に書き込む。次に、図４（Ｂ）および図４（Ｃ）に示したように、表示部１の液晶応答が完全になされた状態で右側の光源３２Ａを点灯する。これにより、第１の観察領域１１に表示された第１～第３の視点画像のみを観察可能となる。次に、図４（Ａ）において、第４～第６の視点画像のデータを表示部１に書き込む。次に、図４（Ｂ）および図４（Ｃ）に示したように、表示部１の液晶応答が完全になされた状態で左側の光源３１Ａを点灯する。これにより、第２の観察領域１２に表示された第４～第６の視点画像のみを観察可能となる。

【００３４】

（逆プリズム３４の頂点角度について）

図６は、図４に示したバックライト３において右側の光源３２Ａを点灯して、左側方向（第１の観察領域１１）に出射される光の輝度分布を示している。図７は、図４に示したバックライト３において左側の光源３１Ａを点灯して、右側方向（第２の観察領域１２）に出射される光の輝度分布を示している。横軸は表示部１の中心方向を０°、左側方向をマイナス、右側方向をプラスとしている。

【００３５】

図６および図７の特性は、逆プリズム３４の第１の頂点（第１の面３４Ａと第２の面３４Ｂとによって形成される下側の頂点）の角度を約７０°とし、底辺側にある第２の頂点の角度θａと第３の頂点の角度θｂとを互いに等しくした場合の輝度特性をシミュレーションしたものである。このような構成にした場合、図６および図７に示したように、輝度のピークは左側では－１５°、右側では１２°と非対称になる。これは、下側導光板３１からの出射光の角度が上側導光板３２の影響を受けるためである。逆プリズム３４における底辺側の第２の頂点の角度θａと第３の頂点の角度θｂとを互いに等しくした、通常の左右対称型のプリズムを使うと、上側導光板３２からの光は相対的に左方向に大きく屈折する。下側導光板３１による右側への光の屈折角度は相対的に若干小さくなる。これを改善ために、第２の頂点の角度θａと第３の頂点の角度θｂとを異ならせることが好ましい

Microsoft Exhibit 1002 - Page 1306
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

。具体的には例えば、以下の値のようにして、第２の頂点の角度θａを、第３の頂点の角度θｂよりも小さくすることが好ましい。これにより、バックライト３からの光は左右方向に±１３．６°付近にほぼ均等に出射される。

θａ＝５４．３°，θｂ＝５５．７°

【００３６】

なお、図６および図７の特性のように、バックライト３による光の輝度分布が左右方向で異なる状態となる場合、２つの観察領域（第１の観察領域１１、第２の観察領域１２）の境界位置をその輝度分布の違いに応じてずらした位置となるようにすれば良い。図８は、そのような表示状態の一例を示している。図１および図２の例では、２つの観察領域の境界位置は、表示部１の中央位置に対応させるようにしたが、図８の表示例では、２つの観察領域の境界位置を左側にずらしている。

【００３７】

［変形例］

以上の説明では、Ｎ＝２回に分けて時分割表示する場合を例に説明したが、Ｎ＝３回以上に分けて時分割表示することも可能である。

【００３８】

図９は、第１～第１２の視点画像をＮ＝３回に分けて時分割表示する例を示している。図９の例では、レンチキュラレンズ２は、同一時間帯に表示されたＭ＝４個の視点画像を分離し、Ｎ＝３個の観察領域（第１の観察領域５１、第２の観察領域５２、第３の観察領域５３）のそれぞれにおいて４個の視点画像を形成させている。第１の観察領域５１は、いわゆるメインローブ、第２の観察領域５２は第１のサイドローブ、第３の観察領域５３は第２のサイドローブに対応する。

【００３９】

図１０（Ａ）はこの変形例に係る表示装置におけるバックライト３の出射方向を示している。なお、図１０（Ａ）では、バックライト３として図３に示した光変調素子２２とレンチキュラレンズ２３とを有する構成にした場合を例にしている。図１０（Ｂ）は視差分離手段（分離部）としてのレンチキュラレンズ２によって形成される第１の観察領域５１を示している。図１０（Ａ），（Ｂ）に示したように、バックライト３は、第１の観察領域５１の両端部を境界とするような３つの方向に光の出射方向を切り替え制御する。

【００４０】

この変形例では、第１の表示状態では、表示部１に第５～第８の視点画像が表示されると共に、バックライト３は、第１の観察領域５１に対応する方向に光の出射方向を切り替える。この場合、第２の観察領域５２と第３の観察領域５３とには光が到達しない状態となるので、結果的に、第１の観察領域５１に表示された第５～第８の視点画像のみを観察可能となる。同様にして、第２の表示状態では、第２の観察領域５２に表示された第１～第４の視点画像のみを観察可能となり、第３の表示状態では、第３の観察領域５３に表示された第９～第１２の視点画像のみを観察可能となる。

【００４１】

なお、本変形例においても、バックライト３として図４のような導光板方式のものを用いることも可能である。図４では下側導光板３１と上側導光板３２との２つの導光板を対向配置した構成例を示したが、例えば３つ以上の導光板を対向配置することによって、３つ以上の方向に光の出射方向を切り替え制御可能である。

【００４２】

［効果］

以上説明したように、本実施の形態に係る表示装置によれば、表示部１に複数の視点画像をＮ回に分けて時分割表示すると共に、表示部１による時分割表示のタイミングに同期して、バックライト３による光の出射方向を時分割で切り替えるようにしたので、立体視可能な視点数および観察領域を拡大することができる。

【００４３】

＜その他の実施の形態＞

Microsoft Exhibit 1002 - Page 1307
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

本開示による技術は、上記実施の形態の説明に限定されず種々の変形実施が可能である。

【００４４】

例えば、本技術は以下のような構成を取ることができる。

（１）

複数の視点画像をＮ回（Ｎは２以上の整数）に分けて時分割表示する表示部と、

前記表示部に向けて画像表示用の光を照射するバックライトと、

前記表示部において同一時間帯に表示されたＭ個（Ｍは２以上の整数）の視点画像を分離する分離部と

を備え、

前記バックライトは、Ｎ個の方向に光の出射方向を切り替え制御可能なものであり、前記表示部による時分割表示のタイミングに同期して、光の出射方向を時分割で切り替え制御する

表示装置。

（２）

前記分離部は、Ｎ個の観察領域のそれぞれにおいて前記Ｍ個の視点画像を形成させる

上記（１）に記載の表示装置。

（３）

前記バックライトは、前記Ｎ個の観察領域に対応する前記Ｎ個の方向に光の出射方向を切り替え制御可能なものである

上記（２）に記載の表示装置。

（４）

前記表示部は、各回の時分割表示においてそれぞれ異なる視点画像を表示する

上記（１）ないし（３）のいずれか１つに記載の表示装置。

（５）

前記表示部は、前記複数の視点画像を２回に分けて時分割表示し、

前記分離部は、２つの観察領域のそれぞれにおいて前記Ｍ個の視点画像を形成し、

前記２つの観察領域の境界位置は、前記表示部の中央位置に対応し、

前記バックライトは、前記２つの観察領域の境界位置を境界にして２つの方向に光の出射方向を切り替え制御可能である

上記（３）に記載の表示装置。

（６）

前記表示部は、前記複数の視点画像を３回以上に分けて時分割表示し、

前記分離部は、３つ以上の観察領域のそれぞれにおいて前記Ｍ個の視点画像を形成し、

前記バックライトは、前記各観察領域の両端部を境界とするような３つ以上の方向に光の出射方向を切り替え制御可能である

上記（３）に記載の表示装置。

（７）

前記バックライトは、

光源と、

前記光源からの光を透過する開口部と光を遮光する遮光部とを有し、前記開口部の位置をＮ個の異なる位置に時分割で可変制御可能な光変調素子と、

前記開口部を透過した光を集光させるレンチキュラレンズとを有する

上記（１）ないし（６）のいずれか１つに記載の表示装置。

（８）

前記バックライトは、

互いに対向配置され、互いに光の出射方向の異なる複数の導光板と、

複数のプリズムが形成され、前記複数の導光板に対向配置されたプリズムシートと

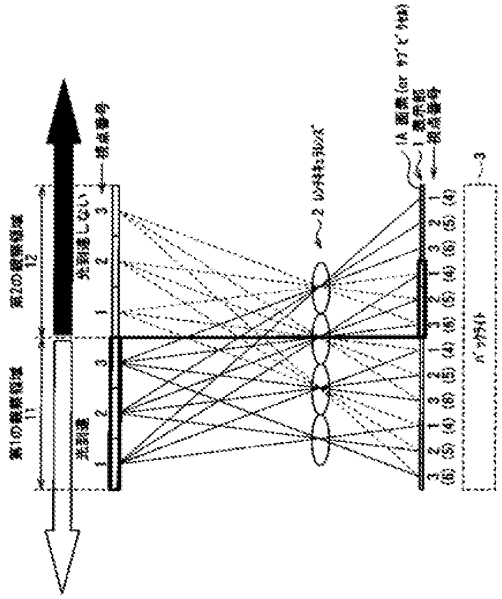
を有し、

前記複数の導光板を時分割で駆動することにより、光の出射方向を切り替え制御可能で

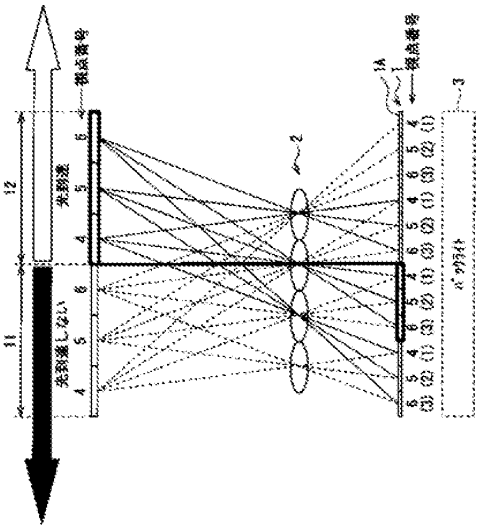
Microsoft Exhibit 1002 - Page 1308
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

ある
上記（１）ないし（５）のいずれか１つに記載の表示装置。
（９）
前記各プリズムは，前記複数の導光板側に第１の頂点を向けた、断面が逆三角形状の逆プリズムであり、
前記逆プリズムの底辺側にある第２の頂点と第３の頂点とのそれぞれの頂点角度が互いに異なる
上記（８）に記載の表示装置。
【符号の説明】
【００４５】
１…表示部、１Ａ…画素（またはサブピクセル）、２…レンチキュラレンズ、３…バックライト、１１…第１の観察領域、１２…第２の観察領域、２１…光源、２２…光変調素子、２２Ａ…開口部、２２Ｂ…遮光部、２３…レンチキュラレンズ、３１…下側導光板、３１Ａ…光源、３１Ｂ…傾斜面、３２…上側導光板、３２Ａ…光源、３２Ｂ…傾斜面、３３…プリズムシート、３４…逆プリズム、３４Ａ…第１の面、３４Ｂ…第２の面、３５…反射板、５１…第１の観察領域（メインローブ）、５２…第２の観察領域（第１のサイドローブ）、５３…第３の観察領域（第２のサイドローブ）。

【図１】

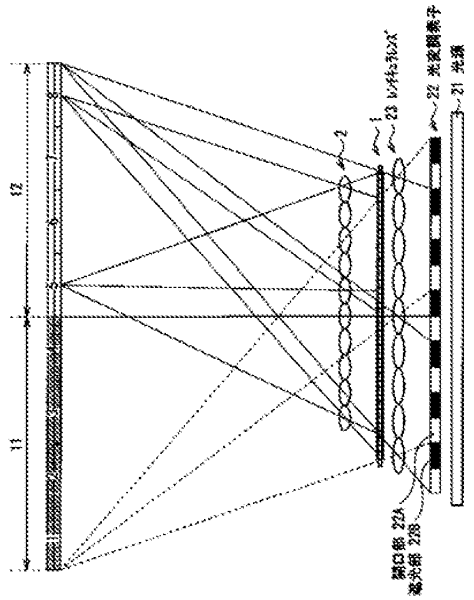


【図２】

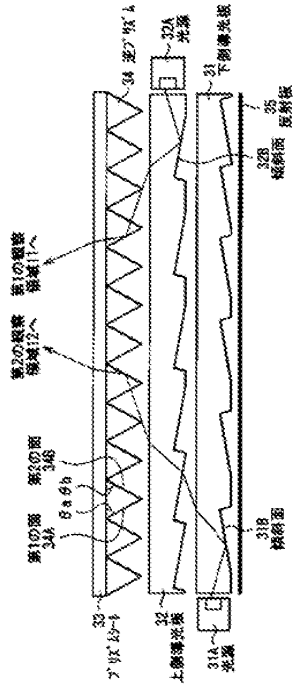


Microsoft Exhibit 1002 - Page 1309
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

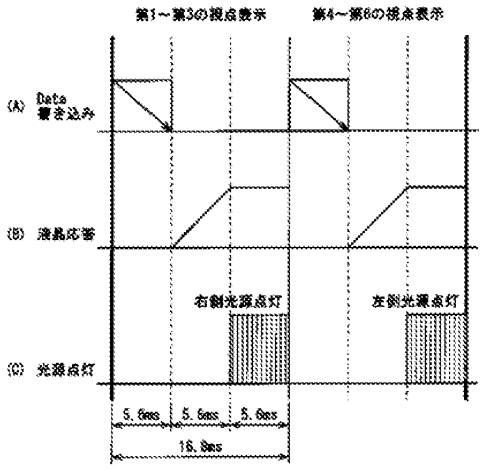
【図３】



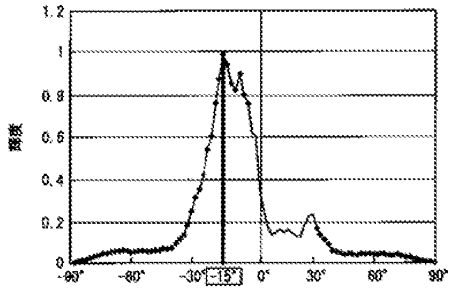
【図４】



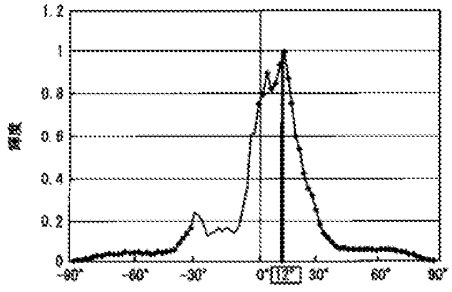
【図５】



【図６】

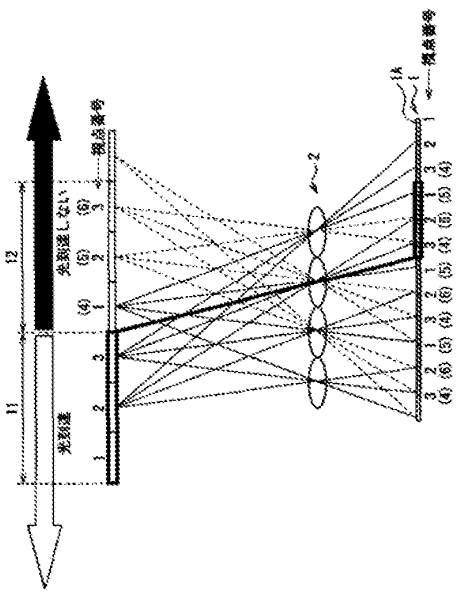


【図７】

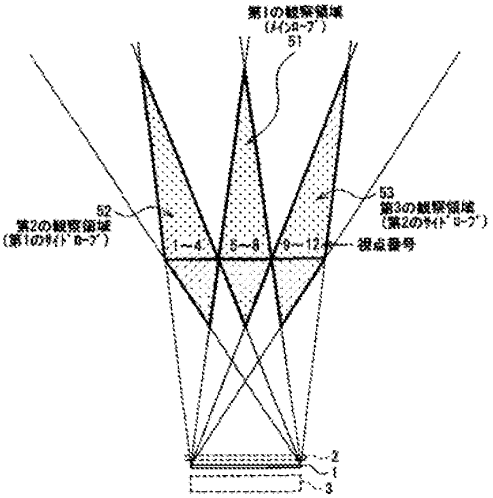


Microsoft Exhibit 1002 - Page 1310
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

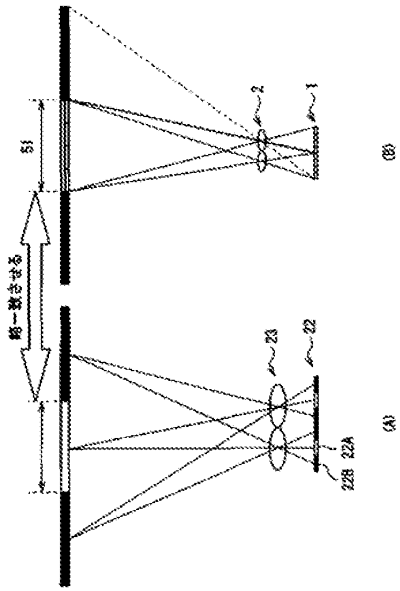
【図８】



【図９】



【図１０】



フロントページの続き

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Microsoft Exhibit 1002 - Page 1312
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

TITLE: LIGHT GUIDE PLATE FOR A BACKLIGHT UNIT HAVING AN ASYMMETRICAL PRISM ON A REAR SURFACE AND A LIQUID CRYSTAL DISPLAY DEVICE USING THE SAME, TO IMPROVE BRIGHTNESS AND UNIFORMITY AND VISIBILITY OF LIGHT

DWPI Abstract

?

Novelty: The plate has side surfaces (102) on which light is incident, and a front surface (104) from which the light is emitted, where the front surface is connected to the side surfaces. A rear prism part (120) including a set of prisms (122) is formed on a rear surface (106) on which the light is reflected. Each prism includes a longitudinal direction perpendicular to a direction of light emitted from a light source (L) e.g. cold cathode fluorescence lamp (CCFL), and an asymmetric triangular cross-section. The prism has an internal angle adjacent to the source.
Use: Wedge-type light guide plate for use in a back light unit e.g. direct-type back light unit and edge-type back light unit such as wedge-type back light unit and flat-type back light unit, for an LCD device (all claimed) i.e. LCD TV.
Advantage: The plate enables uniform increase in amount of light reaching an overall surface of a panel of an LCD device, increase in vertical half-viewing angle and improvement in brightness, without using a diffusion sheet and a prism sheet, so that a back light unit can be realized without the diffusion sheet and the prism sheet, thus reducing manufacturing cost of the back light unit. The design of the plate significantly improves brightness and visibility of the plate. The plate is generally made of transparent acrylic resin, which has high strength, and is break and deformation resistant, light in weight, and provides high transmittance of visible light.

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전체 청구항 수 : 총 8 항 심사관 : 유주호

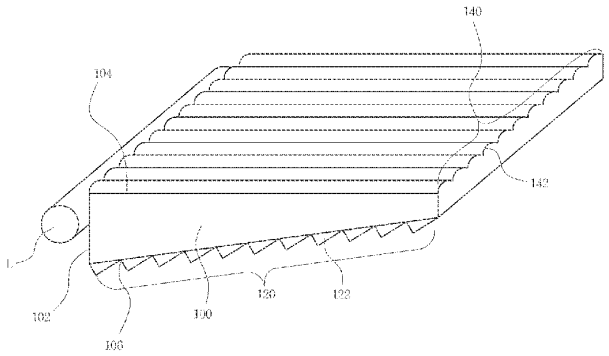
(54) 배면에 비대칭 프리즘을 구비하는 백라이트 유닛용 도광판및 이를 이용한 액정표시장치

(57) 요 약

본 발명은 액정표시장치 백라이트 유닛용 도광판에 관한 것으로, 보다 상세하게는 배면에 프리즘을 포함하는 쐐기형 도광판에서 프리즘이 비대칭의 단면 형상을 가지도록 함으로써, 수직 반치 시야각을 개선함과 동시에 광특성을 향상시킬 수 있는 액정표시장치 백라이트 유닛용 도광판에 관한 것이다.

본 발명은 빛이 입사되는 측면, 상기 측면에 연결되어 상기 빛을 출사시키는 전면(前面) 및 빛을 반사하는 배면(背面)을 포함하는 액정표시 장치용 도광판에 있어서, 상기 배면에 빛이 입사되는 방향과 수직인 길이방향을 가지며, 단면이 비대칭 삼각형의 형태를 가지는 프리즘으로 구성된 배면 프리즘부가 형성되어 있는 것을 특징으로 하는 도광판을 제공한다.

대 표 도



Microsoft Exhibit 1002 - Page 1314
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

특허청구의 범위

청구항 1

빛이 입사되는 측면, 상기 측면에 연결되어 상기 빛을 출사시키는 전면(前面) 및 빛을 반사하는 배면(背面)을 포함하는 액정표시 장치용 도광판에 있어서,

상기 배면에 빛이 입사되는 방향과 수직인 길이방향을 가지며, 단면이 비대칭 삼각형의 형태를 가지는 프리즘으로 구성된 배면 프리즘부가 형성되며,

상기 프리즘은 광원측의 내각이 70° ~90° 범위이고, 광원 반대측의 내각이 40° ~50° 범위이고,

상기 전면에는 높이 : 피치의 비율이 0.09 내지 0.29 범위인 타원형상의 단면을 가지는 광학부재로 구성되는 전면렌즈부가 형성되어 있는 것을 특징으로 하는 도광판.

청구항 2

삭제

청구항 3

삭제

청구항 4

삭제

청구항 5

제 1 항에 있어서,

상기 전면렌즈부의 길이방향은 프리즘의 길이방향과 80° ~100° 각도를 이루는 것을 특징으로 하는 도광판.

청구항 6

제 1 항에 있어서,

상기 광학부재는 높이 : 피치의 비율이 0.16 내지 0.29 범위인 타원형상의 단면을 가지는 것을 특징으로 하는 도광판.

청구항 7

제 1 항에 있어서,

상기 광학부재와 광학부재 사이의 사이각이 60° 내지 120° 범위인 것을 특징으로 하는 도광판.

청구항 8

제 1 항에 있어서,

상기 광학부재의 곡률반경은 상기 렌즈 피치의 0.58 내지 1.0배의 범위인 것을 특징으로 하는 도광판.

청구항 9

제 1 항에 있어서,

상기 배면 프리즘부는 빛이 입사되는 측면에서 멀어질수록 폭이 증가하는 스트라이프 패턴의 형태로 형성되는 것을 특징으로 하는 도광판.

청구항 10

삭제

Microsoft Exhibit 1002 - Page 1315
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

청구항 11

제 1 항의 도광판; 및

상기 도광판의 일측 또는 양측에 배치되는 광원을 포함하는 액정표시장치용 백라이트 유닛.

청구항 12

제 1 항의 도광판; 및

상기 도광판의 일측에 배치되는 광원을 포함하는 액정표시장치.

명 세 서

발명의 상세한 설명

기 술 분 야

<1> 본 발명은 액정표시장치 백라이트 유닛용 도광판에 관한 것으로, 보다 상세하게는 배면에 프리즘을 포함하는 쐐기형 도광판에서 프리즘이 비대칭의 단면 형상을 가지도록 함으로써, 수직 반치 시야각을 개선함과 동시에 광특성을 향상시킬 수 있는 액정표시장치 백라이트 유닛용 도광판에 관한 것이다.

배 경 기 술

<2> 일반적으로 액정표시장치(Liquid crystal display device)는 액체와 고체 중간 상태의 물질인 액정이 전극으로 형성된 두장의 유리기판 사이에 주입되어 전계를 가하여 숫자나 영상을 표시하는 기기를 말한다.

<3> 이러한 액정표시장치는 자체발광소자가 아니므로 빛을 발생시키는 광원(Light source)으로서 백라이트 유닛(back light unit)을 구비하여야 하며, 이러한 백라이트 유닛에서 발생한 빛을 액정이 일정하게 배열되어 있는 패널부에서 빛의 투과량을 조절하면서 영상 등을 표시하게 된다.

<4> 액정표시장치의 백라이트 유닛은 빛을 발산시키는 광원의 위치에 따라 액정표시장치의 패널의 바로 아래 광원이 위치하는 직하형과 액정표시장치 패널의 측면부에 광원 위치하는 에지형(edge type)으로 구분될 수 있으며, 도광판의 형태에 따라 쐐기형(wedge type)과 평판형(flat type)으로 세분화 할 수 있다.

<5> 도 9는 종래의 쐐기형 도광판을 사용한 백라이트 유닛의 구조를 나타낸 구성도이다.

<6> 광원(2)은 액정표시장치에 있어서 최초로 빛을 발산하는 부분으로서 사용될 수 있는 광원(2)은 여러 종류가 있으나 일반적으로 액정표시장치에 사용되는 광원은 전력소모가 적고 매우 밝은 백색광을 발산시키는 CCFL(Cold Cathode Fluorescence Lamp : 냉음극 형광램프)를 사용한다.

<7> 도광판(Light guide plate; 4)은 LCD 패널 하부 및 광원(2)의 일측면에 형성되며 광원(2)에서 발생한 점광(spot light)을 면광(plane light)으로 변환시켜 전면에 빛을 투사시켜 주는 역할을 한다.

<8> 반사판(reflector plate : 3)은 도광판(4)의 후면에 형성되며 광원(2)으로부터 나오는 빛을 전면의 LCD 패널 방향으로 반사시키는 역할을 한다.

<9> 확산시트(Diffuser plate : 5)는 도광판(4)의 상면에 형성되며 광원(2)을 통해 나온 빛을 균일(uniform)하게 해주는 역할을 한다.

<10> 프리즘 시트(prism sheet : 6)는 확산시트(5)를 지나면서 수평 및 수직 양방향으로 확산이 일어나 휘도(brightness)가 급격히 떨어지게 되는 빛을 굴절, 집광시켜 휘도를 높이기 위해서 사용된다.

<11> 보호시트(protector sheet : 7)는 프리즘 시트(6) 상면에 위치하며 프리즘 시트의 흡집을 방지하고, 수직 및 수평 방향을 두 층으로 형성된 프리즘 시트 사용시 발생하는 모아레 현상(Moire effect)을 방지하기 위하여 사용된다.

<12> 그리고, 백라이트유닛은 백라이트유닛을 구성하는 각 부품을 고정하여 일체형 부품인 백라이트 유닛으로 만들어 주는 케이스의 역할을 하는 프레임(mold frame, housing) 및 백라이트유닛을 보호하며 강도유지 및 지지의 역할을 하는 커버(back cover, lamp cover)를 더 포함한다.

Microsoft Exhibit 1002 - Page 1316
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1317
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

<13> 도 9에 도시된 바와 같이 광원(2)은 보통 백라이트유닛의 가장자리에 위치한다(LCD TV의 경우는 직접 패널 뒤쪽에 위치하기도 함). 이로 인해 빛이 전면적에 걸쳐 균일하게(uniformly) 투과되지 않고 가장자리(edge)가 더 밝은 경향을 띄게 되는데 이를 방지하기 위해 도광판(4)을 사용한다. 도광판의 재질은 보통 투명 아크릴 수지로 강도가 높아 깨지거나 변형이 작으며, 가볍고 가시광선 투과율이 높은 것이 특징이다.

<14> 즉, 도광판(4)은 광원(2)이 도광판(4)의 전면에 균일하게 투사되도록 하는 역할을 하는데, 실제로 백라이트유닛을 분해하여 도광판 측면에 광원을 대고 빛을 발생시켜 보면 도광판(4)의 표면이 균일하게 밝은 것이 아니라 빛이 양 끝단으로 집중되는 것을 볼 수 있는데, 이는 도광판(4)이 광원(2)의 빛을 반대편으로 유도하기 때문이다.

<15> 따라서, 도광판(4)의 후면에는 난반사를 일으켜 도광판(4) 전체가 빛을 균일하게 발산하도록 하기 위해 특수한 처리, 구체적으로는 광원(2)으로부터의 거리 등을 고려해서 설계한 소정의 형상을 가진 요철(prominence and depression)면을 형성하여 주게 되는데, 이러한 요철 형성에 의한 패턴처리 결과 액정표시장치의 패널 전체에서 비교적 빛의 휘도 및 균일도가 높은 평면광이 얻어진다.

<16> 그러나, 상기와 같은 방법만 사용하여 액정표시장치를 제조할 경우에는 패널에서 실제로 요철이 형성된 부분은 밝게 보이고, 요철이 형성되지 않은 부분은 어둡게 보이게 되어 패널에 얼룩(spot)져 보이는 현상이 발생하여 시인성이 떨어지게 되며, 특히 최근 패널의 크기가 대형화됨에 따라 광원(2)으로부터 멀리 떨어진 영역에서는 빛이 도달하는 절대적인 양이 부족하게 되어 어둡게 보이는 현상이 발생하기도 한다.

<17> 또한, 확산시트 및 프리즘시트는 빛의 균일도를 증가시키기 위해서 사용되는데 이러한 확산시트나 프리즘 시트는 백라이트유닛의 제조원가를 상승시키는 문제점이 있다.

<18> 따라서, 별도의 확산시트나 프리즘시트를 사용하지 않고도 액정표시장치의 패널 전면에서 시인성이 우수하고 휘도 및 균일도가 높은 평면광을 얻기 위한 보다 많은 연구가 필요하다.

발명의 내용

해결 하고자하는 과제

<19> 본 발명이 해결하고자 하는 과제는 액정표시장치의 패널 전체 면에 있어서 휘도가 높고 빛의 균일도 및 시인성이 우수한 액정표시장치 백라이트 유닛용 도광판을 제공하는 데 있다.

<20> 본 발명이 해결하고자 하는 다른 과제는 본 발명에 의한 도광판을 이용한 액정표시장치의 백라이트 유닛을 제공하는 데에 있다.

<21> 본 발명이 해결하고자 하는 과제들은 이상에서 언급한 기술적 과제들로 제한되지 않으며, 언급되지 않은 또 다른 기술적 과제들은 아래의 기재로부터 당업자에게 명확하게 이해될 수 있을 것이다.

과제 해결수단

<22> 본 발명은 빛이 입사되는 측면, 상기 측면에 연결되어 상기 빛을 출사시키는 전면(前面) 및 빛을 반사하는 배면(背面)을 포함하는 액정표시 장치용 도광판에 있어서, 상기 배면에 빛이 입사되는 방향과 수직인 길이방향을 가지며, 단면이 비대칭 삼각형의 형태를 가지는 프리즘으로 구성된 배면 프리즘부가 형성되어 있는 것을 특징으로 하는 도광판을 제공한다.

효 과

<23> 본 발명에 따른 액정표시장치용 도광판은 액정표시장치의 패널에 도달하는 빛의 양을 패널 전체에 걸쳐서 균일하게 증가시키는 동시에, 수직 반치각과 휘도 증가 효과를 가져온다. 아울러 이러한 휘도 증가 효과와 시인성의 개선은 종래의 전면에 프리즘을 형성한 도광판에 비하여 현저한 것으로 확인되었다.

<24> 따라서, 기존의 백라이트 유닛에 사용하고 있는 확산시트, 프리즘 시트의 전부 또는 일부를 생략하고 백라이트 유닛을 구성하는 것이 가능하게되어, 백라이트 유닛의 제조 원가를 절감해주는 효과도 가져온다.

발명의 실시를 위한 구체적인 내용

<25> 본 발명의 이점 및 특징, 그리고 그것들을 달성하는 방법은 첨부되는 도면과 함께 상세하게 후술되어 있는 실시예들을 참조하면 명확해질 것이다. 그러나, 본 발명은 이하에서 개시되는 실시 예들에 한정되는 것이 아니라 서로 다른 다양한 형태로 구현될 것이며, 단지 본 실시 예들은 본 발명의 개시가 완전하도록 하며, 본 발명이 속

하는 기술분야에서 통상의 지식을 가진 자에게 발명의 범주를 완전하게 알려주기 위해 제공되는 것이며, 본 발명은 청구항의 범주에 의해 정의될 뿐이다. 명세서 전체에 걸쳐 동일 참조 부호는 동일 구성요소를 지칭한다.

<26> 또한, 도면에서 발명을 구성하는 구성요소들의 크기는 명세서의 명확성을 위하여 과장되어 기술된 것이며, 어떤 구성요소가 다른 구성요소의 "내부에 존재하거나, 연결되어 설치된다"고 기재된 경우, 상기 어떤 구성요소가 상기 다른 구성요소와 접하여 설치될 수도 있고, 그 소정의 이격거리를 두고 설치될 수도 있으며, 이격거리를 두고 설치되는 경우엔 상기 어떤 구성요소를 상기 다른 구성요소에 고정 내지 연결시키기 위한 제3의 수단에 대한 설명이 생략될 수도 있다.

<27> 도 1 및 도 2는 본 발명의 실시예에 따른 액정표시장치 백라이트 유닛용 도광판을 서로 다른 각도에서 나타낸 사시도이다.

<28> 도시된 실시예는 광원(L)이 일측에 위치하는 쐐기형(wedge) 도광판을 나타낸 것이다. 도광판은 강도가 높고 깨지거나 변형이 적으며, 가볍고 가시광선 투과율이 높은 투명아크릴 재질로 제조되는 것이 일반적이다.

<29> 도 1을 참조하면, 도광판 본체(100)는 빛이 입사되는 측면(102)과, 상기 측면(102)에 연결되고 액정표시장치의 패널(미도시)과 대면하며 상기 액정표시장치의 패널측으로 빛을 출사시키는 전면(104)과, 상기 전면(104)과 대향하며 빛을 반사하는 배면(106)을 포함한다.

<30> 측면(102)의 본래 사전적 의미는 물체의 옆면을 의미하나, 본 발명에서는 광원(L)으로부터 빛이 입사되는 면으로 정의한다. 따라서, 도 1에 있어서 측면(102)은 광원(L)과 인접한 면이 해당된다.

<31> 상기 배면(106)에는 빛이 입사되는 방향과 수직인 길이방향을 가지며, 비대칭 삼각형의 단면형태를 가지는 프리즘(122)으로 구성되는 배면 프리즘부(120)가 형성되어 있다.

<32> 도 2를 참조하면, 상기 배면 프리즘부(120)는 도광판의 전면(104)의 휘도분포를 균일하게 해주기 위한 것으로, 도시된 바와 같이 광원(L)이 일측에만 구비되는 쐐기형 도광판의 경우에는 빛이 입사되는 측면(102)에서 멀어질수록 배면 프리즘부(120)의 폭(w)이 커지도록 형성된다. 이는 빛이 입사되는 측면(102)에서 멀어질수록 빛의 도달량이 줄어들게 되기 때문에 빛을 굴절 반사시키는 역할을 하는 프리즘들(120)의 길이를 길게 하여 빛의 도달량이 적은 대신, 빛의 굴절 및 반사량을 높여주어 전면(104)으로 출사되는 빛의 균일도를 높여주기 위한 것이다.

<33> 배면 프리즘부(120)는 도시한 바와 같이, 광원과의 거리에 따라 폭이 변화하는 스트라이프 패턴의 형태를 가질 수도 있고, 도트 패턴의 형태를 가질 수도 있다. 도트 패턴의 형태를 가지는 경우 광원과의 거리에 따라 도트 패턴의 밀도가 변화하게 되며, 광원과의 거리가 멀어질 수록 즉 빛이 입사되는 측면에서 멀어질수록 도트 패턴의 밀도가 높아지는 것이 바람직하다.

<34> 전면(104)에는 절단된 타원형상의 단면을 가지는 광학부재(142)로 구성되는 전면렌즈부(140)가 형성되어 있다. 상기 광학부재(142)의 길이 방향은 프리즘(122)의 길이방향과 80° ~100° 범위의 각도를 가지는 것이 바람직하며, 직각을 이루면 더욱 바람직하다.

<35> 상기 전면렌즈부(140)는 광특성 및 시인성을 개선하기 위한 것이다. 상기 광학부재(142)는 10㎛~250㎛ 범위를 피치값을 가지는 것이 바람직하다.

<36> 종래의 도광판에서 전면은 아무런 광학부재를 구비하지 않는 매끈한 표면을 가지거나, 삼각형의 단면을 가지는 프리즘을 구비하고 있었다.

<37> 그런데, 이러한 종래의 도광판은 배면에 형성된 배면 프리즘부가 전면에서 볼때 노출되어 시인성을 저하시키고, 프리즘의 두 면에서 간섭무늬가 발생하여 모아레 현상이 발생하는 문제점을 가지고 있었다.

<38> 본 발명은 전면에 타원형상의 단면을 가지는 광학부재(142)로 구성되는 전면렌즈부를 구비하여 배면 프리즘부(120)를 은폐함으로써 시인성과 광특성을 개선하는 효과를 가져온다.

<39> 도 3은 도 2의 A-A선에 따른 단면도이고, 도 4는 도 2의 B-B선에 따른 단면도이다.

<40> 도 3과 같이, 광원의 길이방향과 수직방향으로 도광판을 절단한 단면을 살펴보면 전면에는 광학부재(142)가 단면의 길이 방향을 따라서 형성되어 있다. 본 실시예의 경우 광학부재(142)로 랜티큘러렌즈를 사용하고 있으므로, 랜티큘러렌즈의 길이 방향이 단면이 길이방향과 동일하다. 즉 랜티큘러렌즈의 길이방향은 빛의 진행방향과 평행한 방향으로 형성된다.

Microsoft Exhibit 1002 - Page 1318
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1319
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

<41> 배면에 형성되는 비대칭 삼각형상의 단면을 가지는 프리즘(122)을 살펴보면, 프리즘(122)의 길이방향은 광원(L)의 길이방향과 평행하게 형성되어 있다.

<42> 이하에서, 비대칭 프리즘(122)의 내각 중 광원쪽에 위치하는 내각을 1차 내각(α)이라하고, 광원 반대편에 위치하는 내각을 2차 내각(β)이라 칭한다.

<43> 1차 내각(α)은 70° ~90° 범위를 가지고, 2 차 내각(β)은 40° ~50° 범위를 가진다. 삼각형의 모든 내각의 합은 180° 이므로 사이각(Θ)은 40° ~70° 범위를 가지게 된다. 이러한 범위로 프리즘의 형태를 한정하여 반치각의 개선 효과를 가져오게 된다. 반치각 개선효과는 구체적인 실험예를 참조하여 후술한다.

<44> 도 4와 같이, 광원의 길이방향과 평행하게 도광판을 절단한 단면을 살펴보면 전면의 광학부재(142)의 타원형의 단면을 가지고 있음을 알수 있다. 그리고 배면의 프리즘(122)이 소정간격으로 형성되어 있는 것을 알수 있다.

<45> 여기서 프리즘(122)의 길이는 광원으로 부터의 길이가 멀수록 길어지도록 형성된다.

<46> 이하에서는 본 발명의 실시예에 따른 도광판을 사용할 경우 광의 휘도(brightness), 광의 균일도(uniformity) 및 시인성을 측정시에 보다 우수한 성질을 가지고 있음을 구체적인 실험예들을 들어 설명한다. 여기에 기재되지 않은 내용은 이 기술 분야에서 숙련된 자이면 충분히 기술적으로 유추할 수 있는 것이므로 그 설명을 생략한다.

<47> 본 발명의 구성에 따른 효과를 입증하기 위하여 실시한 실험예들을 기술하면 다음과 같다.

<48> **1. 전면 광학부재의 실시예 및 비교예**

<49> 도 5는 본 발명에 따른 액정표시장치 백라이트 유닛용 도광판의 전면에 형성되는 렌티큘러 렌즈 형상의 광학부재의 구체적인 규격을 나타낸 단면도이다.

<50> 렌티큘러렌즈의 규격은 높이(H), 피치(P), 인접 렌즈의 사이각을 변형하며 살펴 보았고, 각각의 실험예들은 모두 동일한 곡률반경 25㎛ 을 가진다.

<51> 사이각을 0° , 20° , 40° , 60° , 80° , 100° , 120° , 140° 로 변형시키면서 높이와 피치를 측정하여 실험하였다.

<52> **<실험예 1>**

<53> 폭(W)*길이(L)*두께(T); 288.8*217.7*2.4(start)*0.8(end)㎜가 되도록 제작한 쐐기형 도광판의 배면의 배면 프리즘부는 패턴 피치가 430㎛인 스트라이프 패턴을 형성시키고, 높이 14.25㎛, 피치 25㎛, 내각 82.5° 인 프리즘을 형성하였다. 또한, 도광판 전면에 광원과 수직한 방향으로 곡률반경 25㎛R, 높이 25㎛, 피치 50㎛, 사이각 0° 인 타원형태의 단면을 가지는 렌티큘러 렌즈 배열을 형성하였다.

<54> **<실험예 2 내지 8>**

<55> 도광판 전면의 렌티큘러렌즈 사이각도를 20° 내지 140° 까지 20° 단위로 변화시키고, 이에 따라 렌즈의 높이, 피치가 변하는 것을 제외하고는 실험예 1과 동일하게 실시하였다. 실험예 1부터 8에 대한 구체적인 형태와 규격을 도 5와 표1에 간략히 나타내었다

표 1

구분	실험예1	실험예2	실험예3	실험예4	실험예5	실험예6	실험예7	실험예8
곡률반경	25.0㎛	25.0㎛	25.0㎛	25.0㎛	25.0㎛	25.0㎛	25.0㎛	25.0㎛
렌즈높이	25.0㎛	20.7㎛	16.5㎛	12.5㎛	8.9㎛	5.9㎛	3.4㎛	1.5㎛
렌즈피치	50.0㎛	49.2㎛	47.0㎛	43.3㎛	38.3㎛	32.1㎛	25.0㎛	17.1㎛
사이각	0 °	20 °	40 °	60 °	80 °	100 °	120 °	140 °

<56>

<57> **<비교예 1>**

<58> 폭(W)*길이(L)*두께(T); 288.8*217.7*2.4(start)*0.8(end)㎜가 되도록 제작한 쐐기형 도광판의 배면에 패턴 피치가 430㎛인 스트라이프 패턴 형태로 배면 프리즘부를, 높이 14.25㎛, 피치 25㎛, 내각 82.5° 인 프리즘을 형

성하였다. 도광판의 전면은 매끈한 표면으로 하였다.

<59> **<비교예 2>**

<60> 폭(W)*길이(L)*두께(T); 288.8*217.7*2.4(start)*0.8(end)㎜가 되도록 제작한 쐐기형 도광판의 배면에 패턴 피치가 430㎛인 스트라이프 패턴 형태로 배면 프리즘부를, 높이 14.25㎛, 피치 25㎛, 내각 82.5° 인 프리즘을 형성하였다. 또한, 도광판 전면에 광원과 수직한 방향으로 피치 50㎛, 높이 25㎛, 사이각 90° 인 프리즘을 형성하였다.

<61> **2. 전면 광학부재의 결과 분석**

표 2

구분	비교예1	비교예2	실험예1	실험예2	실험예3	실험예4	실험예5	실험예6	실험예7	실험예8
상부구조	X	프리즘	렌티큘러	렌티큘러	렌티큘러	렌티큘러	렌티큘러	렌티큘러	렌티큘러	렌티큘러
수직휘도(cd)	224.5	234.93	215.6	199.9	216.1	225.4	241.5	247.1	256.3	256.7
패턴 비침	1	1	4	4	4	3	3	3	2	2
렌즈높이/피치	-	-	0.5	0.42	0.35	0.29	0.23	0.18	0.16	0.09

패턴 비침 점수 : Excellent (5) > Very Good (4) > Good (3) > Not Bad (2) > Bad (1)

<62>

<63> 상기 표 2는 실시예 1 부터 8, 및 비교예 1, 비교예 2에 대한 결과를 나타낸 것이고, 도 6은 본 발명의 실험예와 비교예의 휘도측정 결과를 나타낸 그래프이다.

<64> 상기 표 2와 도 6을 참조하면, 렌즈 높이 대 렌즈 피치의 비가 0.23보다 작을 때 비교예 보다 높은 중앙 휘도값을 나타내며, 패턴 비침의 경우 모든 실험예에서 비교예 보다 좋은 결과를 나타내었다. 패턴 시인성과 휘도를 동시에 비교할 경우, 실험예 5와 실험예 6 사이의 결과가 가장 좋게 나타남을 알 수 있다.

<65> 따라서, 전면 광학부재는 높이 : 피치의 비율이 0.1 내지 0.35 범위인 것이 바람직하고, 전면 광학부재와 광학부재 사이의 사이각이 60° 내지 120° 범위인 것이 바람직하며, 전면 광학부재의 곡률반경은 상기 렌즈 피치의 0.58 내지 1.0배의 범위인 것이 바람직하다는 결과를 알 수 있다.

<66> **3. 배면 프리즘의 실시예 및 비교예**

<67> **<실험예 9>**

<68> 폭(W)*길이(L)*두께(T); 288.8*217.7*2.4(start)*0.8(end)㎜가 되도록 제작한 wedge형 도광판의 배면에 패턴 피치가 430㎛인 스트라이프 패턴을 형성 시키고, 패턴 내부에는 높이 25㎛, 피치 25㎛, 1차 내각(α)이 90° , 사이각(Θ)이 45° , 2차 내각(β)이 45° 인 프리즘을 형성하였으며, 도광판 전면은 경면상태로 하였다.

<69> **<실험예 10 내지 13>**

<70> 실험예 9 에서 배면 프리즘의 1차 내각(α)를 70° 까지 5° 간격으로 변화 시켰고, 이와 동시에 사이각(Θ)의 값도 65° 까지 5° 간격으로 변화시켰으며, 2차 내각(β)은 45° 를 유지시켰다.

<71> 실험예 9 부터 실험예 13의 형태를 표 3 과 도 7에 간략히 나타내었다.

표 3

<72>

	실험예9	실험예10	실험예11	실험예12	실험예13
1차내각(α)	90°	85°	80°	75°	70°
사이각(Θ)	45°	50°	55°	60°	65°
2차내각(β)	45°	45°	45°	45°	45°
프리즘 높이	25㎛	23㎛	21.2㎛	19.7㎛	18.3㎛

<73> **<비교예 3>**

<74> 폭(W)*길이(L)*두께(T); 288.8*217.7*2.4(start)*0.8(end)㎜가 되도록 제작한 wedge형 도광판의 하부에 패턴 피치가 430㎛인 스트라이프 패턴을 형성 시키고, 패턴 내부에는 높이 14.25㎛, 피치 25㎛, 내각 82.5° 인 배면

Microsoft Exhibit 1002 - Page 1320
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1321
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

프리즘을 형성하였다. 도광판의 전면은 경면상태로 하였다.

<75> **4. 배면 프리즘의 결과 분석**

표 4

<76>

	비교예 3	실험예9	실험예10	실험예11	실험예12	실험예13
수직휘도 (cd)	217.6	261.5	272.2	256.5	230.0	211.3
수직반치각	-9° /+7°	-10° /+12°	-10° /+12°	-10° /+12°	-10° /+15°	-10° /+17°
1차내각(α)	90°	90°	85°	80°	75°	70°
사이각(θ)	45°	45°	50°	55°	60°	65°
2차내각(β)	45°	45°	45°	45°	45°	45°

<77> 상기 표 4는 실험예 9 부터 13, 및 비교예 3에 대한 결과를 나타낸 것이고, 도 8은 본 발명의 배면 프리즘 실험예와 비교예의 휘도측정 결과를 나타낸 그래프이다.

<78> 상기 표 4와 도 8을 참조하면, 1차 내각(α)가 70° 보다 클때 비교예 보다 높은 중앙 휘도값을 나타내며, 수직 반치각의 경우 모든 실험예에서 비교예 3보다 좋은 결과를 나타내었다. 휘도와 수직 반치각을 동시에 비교할 경우, 실험예 11에서 실험예 12 사이의 결과가 가장 좋게 나타남을 알 수 있다.

<79> 상기 실시예 및 실험예에서 설명한 도광판을 사용하면 종래의 액정표시장치용 백라이트 유닛에서 일반적으로 사용되었던, 프리즘시트(prism sheet)는 사용하지 않더라도 이들을 사용한 것과 같은 효과를 얻을 수 있다. 즉, 본 발명에 의한 도광판을 사용할 경우엔 기존 백라이트 유닛에 적용되던 시트들 중 1매 내지 2매의 프리즘 시트를 절감할 수 있다

<80> 이상 첨부된 도면을 참조하여 본 발명의 실시예들을 설명하였으나, 본 발명은 상기 실시예들에 한정되는 것이 아니라 서로 다른 다양한 형태로 제조될 수 있으며, 본 발명이 속하는 기술분야에서 통상의 지식을 가진 자는 본 발명의 기술적 사상이나 필수적인 특징을 변경하지 않고서 다른 구체적인 형태로 실시될 수 있다는 것을 이해할 수 있을 것이다. 그러므로 이상에서 기술한 실시예들은 모든 면에서 예시적인 것이며 한정적이 아닌 것으로 이해해야만 한다. 따라서, 본 발명의 전정한 기술적 보호범위는 아래의 특허청구범위에 의해서 정하여져야 할 것이다.

도면의 간단한 설명

<81> 도 1 및 도 2는 본 발명의 제 1 실시예에 따른 액정표시장치 백라이트 유닛용 도광판을 서로 다른 각도에서 나타낸 사시도,

<82> 도 3은 도 2의 A-A선에 따른 단면도,

<83> 도 4는 도 2의 B-B선에 따른 단면도,

<84> 도 5는 본 발명에 따른 전면 렌즈의 실험예들을 나타낸 단면도,

<85> 도 6은 본 발명에 따른 전면 렌즈의 실험예와 비교예의 휘도측정 결과를 나타낸 그래프,

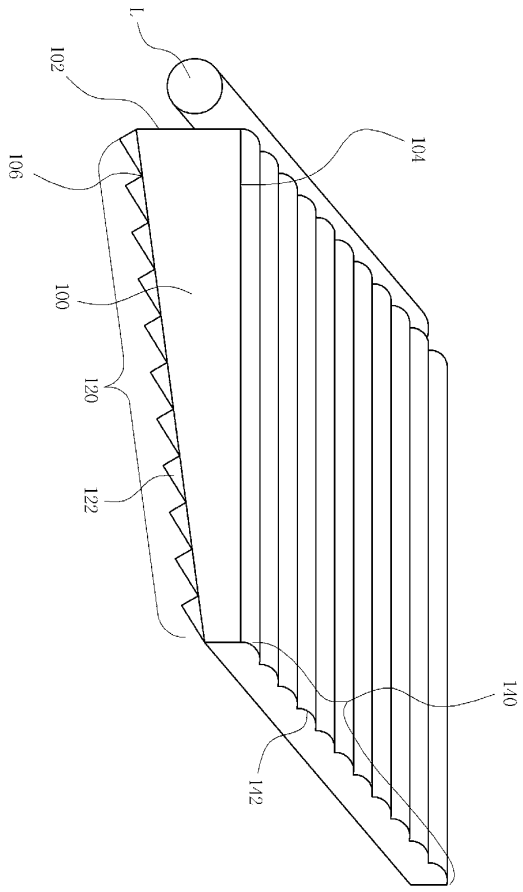
<86> 도 7은 본 발명에 따른 배면 프리즘의 실험예들을 나타낸 단면도,

<87> 도 8은 본 발명에 따른 배면 프리즘의 실험예와 비교예의 휘도측정 결과를 나타낸 그래프,

<88> 도 9는 종래의 폐기형 도광판을 사용한 백라이트 유닛의 구조를 나타낸 구성도임.

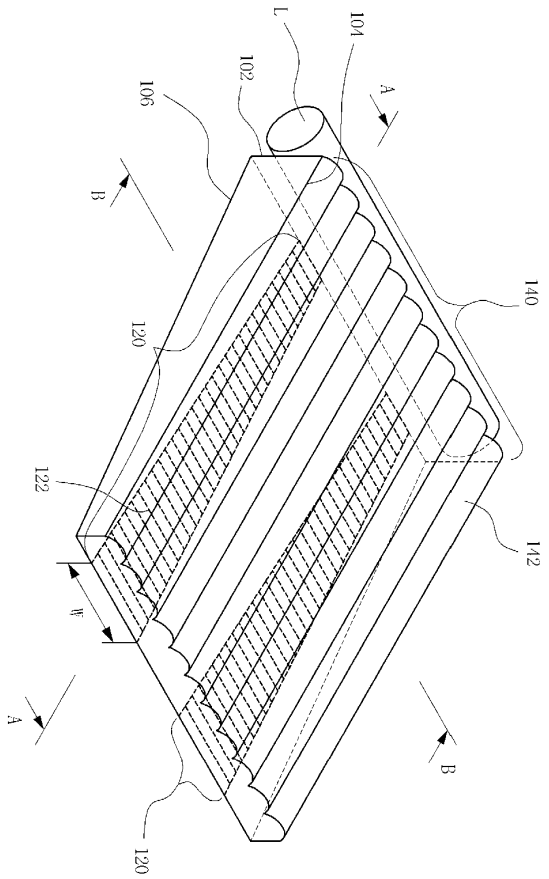
도면

도면1

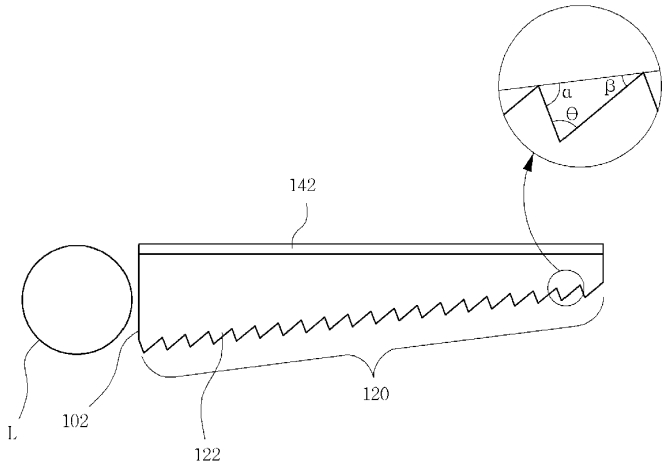


Microsoft Exhibit 1002 - Page 1322
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면2

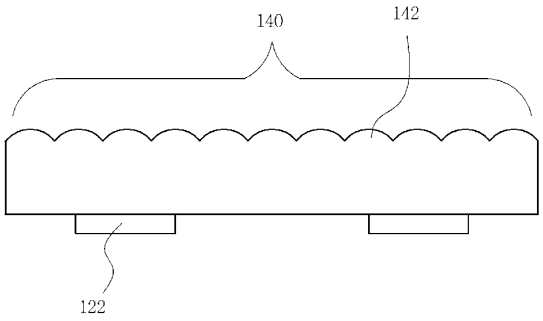


도면3



Microsoft Exhibit 1002 - Page 1323
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면4

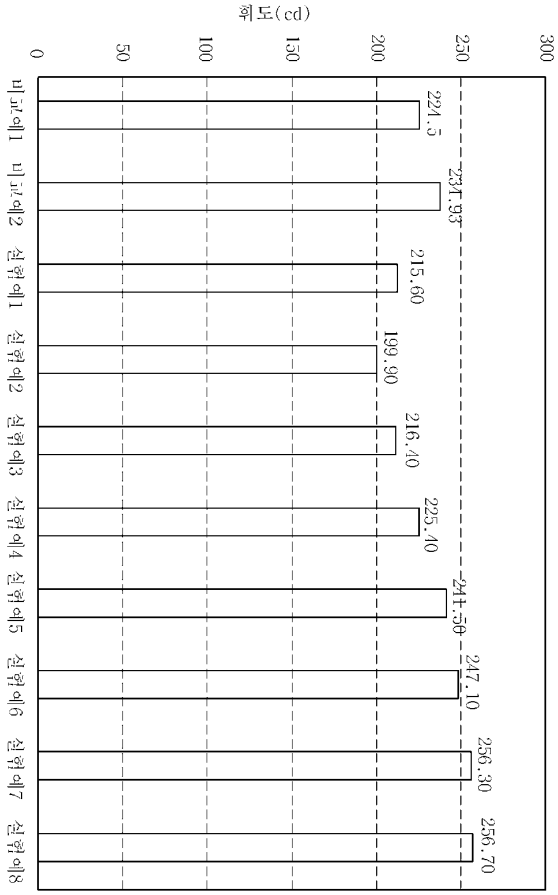


Microsoft Exhibit 1002 - Page 1324
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면 5

Microsoft Exhibit 1002 - Page 1325
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면6

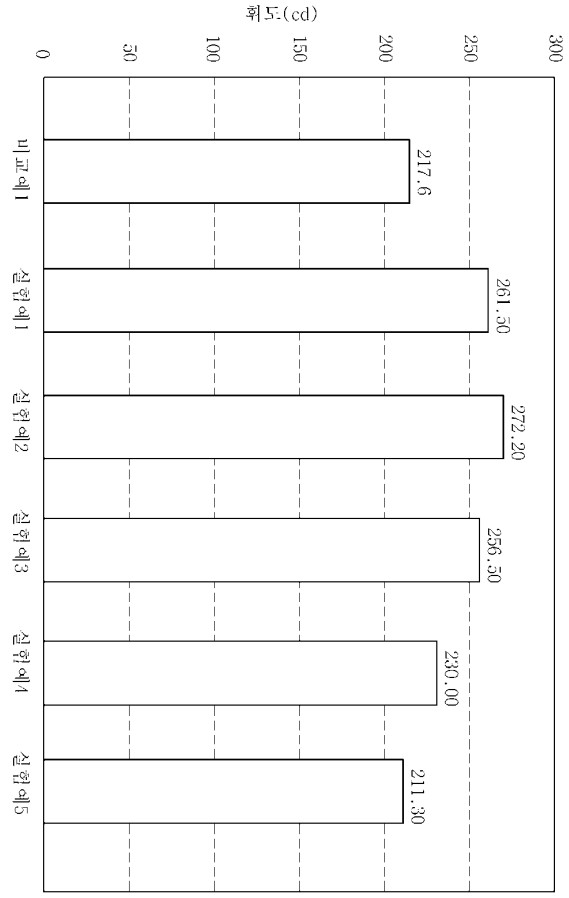


Microsoft Exhibit 1002 - Page 1326
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

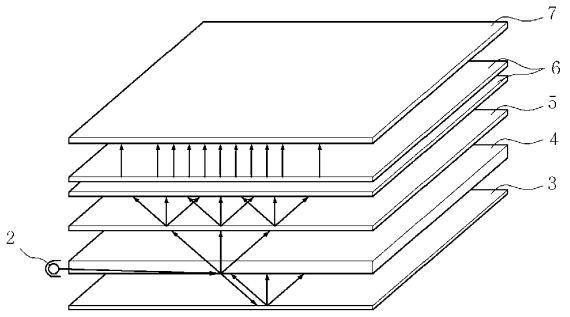
도면7

Microsoft Exhibit 1002 - Page 1327
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면8



도면9



Microsoft Exhibit 1002 - Page 1328
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Espacenet

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DISPLAY APPARATUS

No documents available for this priority number.

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Classification: - international: ***G02F1/1335; G02F1/13357***
- cooperative: **G02B6/0068**; **G02B6/0078**; **G02B6/0083**; G02B6/0073; G02B6/009

Application number: KR20090064312 20090715

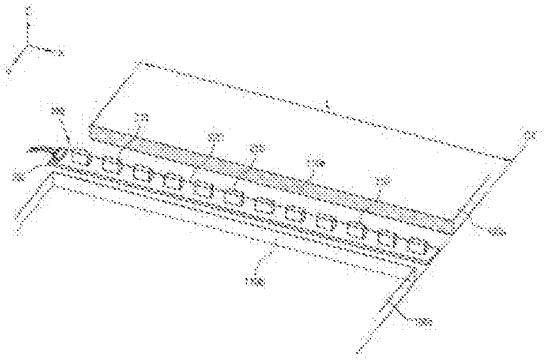
Priority number (s): KR20090064312 20090715

Also published as: EP2275846 (A1) US2011013098 (A1) JP2011023347 (A)

Abstract of KR20110006773 (A)

PURPOSE: A display device is provided to realize the light driving technique such as local diming and provide backlight unit available for sliming and a display device. CONSTITUTION: A plurality of light guide plate(100) irradiates light to each display area of divided display panel. A plurality of light source(210) generates the light emitted from each side light guide plate. The plurality of light source is arranged to correspond with a side of the light guide plate. A first light emitting direction and a second light emitting direction are mutually symmetric.

FIG. 3



Microsoft Exhibit 1002 - Page 1329
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Last updated: 23.09.2013 Worldwide Database 5.8.11.4; 93p

Microsoft Exhibit 1002 - Page 1330
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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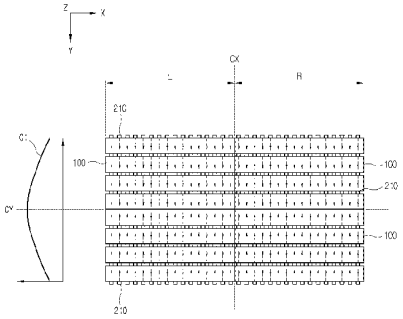
전체 청구항 수 : 총 20 항

(54) 디스플레이장치 및 텔레비전

(57) 요 약

디스플레이장치 및 백라이트유닛이 개시되어 있다. 이 디스플레이장치는, 디스플레이 패널과; 상기 디스플레이 패널의 분할된 각 디스플레이 영역에 광을 출사하는 복수의 도광판과; 각각의 도광판 측면에 입사되는 광을 생성하고, 도광판의 측면에 대응하게 배치된 복수의 광원을 포함하며, 하나의 도광판 측면에 대응하게 배치된 복수 광원 중 적어도 일부 광원에 의한 제1발광 방향이 이 하나의 도광판 측면에 대응하게 배치된 복수 광원 중 나머지의 적어도 일부 광원에 의한 제2발광 방향과 상이하게 복수 광원이 배치된 것을 특징으로 한다.

대 표 도 - 도4



Microsoft Exhibit 1002 - Page 1331
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

특허청구의 범위

청구항 1

디스플레이장치에 있어서,

디스플레이 패널과;

상기 디스플레이 패널의 분할된 각 디스플레이 영역에 광을 출사하는 복수의 도광판과;

각각의 상기 도광판 측면에 입사되는 상기 광을 생성하고, 상기 도광판의 측면에 대응하게 배치된 복수의 광원을 포함하며,

하나의 상기 도광판 측면에 대응하게 배치된 복수 광원 중 적어도 일부 광원에 의한 제1발광 방향이 상기 하나의 도광판 측면에 대응하게 배치된 복수 광원 중 나머지의 적어도 일부 광원에 의한 제2발광 방향과 상이하게 상기 복수 광원이 배치된 것을 특징으로 하는 디스플레이장치.

청구항 2

제1항에 있어서,

상기 제1발광 방향 및 상기 제2발광 방향은 상호 대칭적인 것을 특징으로 하는 디스플레이장치.

청구항 3

제1항에 있어서,

상기 각 도광판의 측면을 따라서 직렬 배치된 복수의 상기 광원을 가지는 광원 모듈을 포함하며,

하나의 상기 광원 모듈은 상기 제1발광 방향으로 발광하는 적어도 하나의 상기 광원과, 상기 제2발광 방향으로 발광하는 적어도 하나의 상기 광원을 가지는 것을 특징으로 하는 디스플레이장치.

청구항 4

제3항에 있어서,

상기 복수 광원의 배치 순서를 따라서, 하나 또는 상호 인접한 둘 이상의 상기 광원을 포함하는 복수의 광원 블록이 형성되며,

인접한 두 광원 블록은 상호 상이한 발광 방향을 가지는 것을 특징으로 하는 디스플레이장치.

청구항 5

제3항에 있어서,

상기 광원 모듈은 투명기판을 포함하며,

상기 복수의 광원은 상기 투명기판의 적어도 일 측면에 장착되는 것을 특징으로 하는 디스플레이장치.

청구항 6

제5항에 있어서,

상기 투명기판은 상기 복수의 광원을 구동하는 투명한 전기 배선을 포함하는 것을 특징으로 하는 디스플레이장치.

청구항 7

제1항에 있어서,

상기 복수의 광원은 적어도 하나 이상의 상기 광원을 단위로 하는 복수 개의 광원 그룹으로 구분되며,

상기 광원 그룹 별로 휘도를 조절하여 로컬 디밍(local dimming)을 수행하는 제어부를 더 포함하는 것을 특징으로 하는 디스플레이장치.

Microsoft Exhibit 1002 - Page 1332
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

청구항 8

제1항에 있어서,

상기 광원은 발광 다이오드 소자를 포함하는 것을 특징으로 하는 디스플레이장치.

청구항 9

디스플레이장치에 있어서,

영상을 수신하는 영상수신부와;

상기 영상수신부에 수신되는 영상을 처리하는 영상처리부와;

상기 영상처리부에 의해 처리되는 영상을 표시하는 디스플레이 패널과;

상기 영상을 표시 가능하게 상기 디스플레이 패널에 광을 공급하는 백라이트유닛을 포함하며,

상기 백라이트유닛은,

상기 디스플레이 패널의 분할된 각 디스플레이 영역에 광을 출사하는 복수의 도광판과;

각각의 상기 도광판 측면에 입사되는 상기 광을 생성하고, 상기 도광판의 측면에 대응하게 배치된 복수의 광원을 포함하며,

하나의 상기 도광판 측면에 대응하게 배치된 복수 광원 중 적어도 일부 광원에 의한 제1발광 방향이 상기 하나의 도광판 측면에 대응하게 배치된 복수 광원 중 나머지의 적어도 일부 광원에 의한 제2발광 방향과 상이하게 상기 복수 광원이 배치된 것을 특징으로 하는 디스플레이장치.

청구항 10

제9항에 있어서,

상기 복수의 광원은 적어도 하나 이상의 상기 광원을 단위로 하는 복수 개의 광원 그룹으로 구분되며,

상기 백라이트유닛은 상기 광원 그룹 별로 휘도를 조절하여 로컬 디밍을 수행하는 제어부를 더 포함하는 것을 특징으로 하는 디스플레이장치.

청구항 11

제9항에 있어서,

상기 복수 광원은 적어도 하나 이상의 상기 광원을 단위로 배치순서에 따라 발광방향이 교번적으로 반대인 것을 특징으로 하는 디스플레이장치.

청구항 12

디스플레이장치에 있어서,

디스플레이 패널과;

복수 개로 분할된 도광판과;

복수 개의 광원을 구비하고, 상기 분할된 도광판 사이에 배치되어 상기 분할된 도광판의 측면에 광을 입사하는 광원 모듈과;

상기 복수 광원의 휘도를 조절하는 제어부를 포함하며,

상기 광원 모듈에 구비된 상기 복수 광원은 적어도 하나 이상의 상기 광원을 단위로 배치순서에 따라 발광방향이 교번적으로 반대인 것을 특징으로 하는 디스플레이장치.

청구항 13

제12항에 있어서,

Microsoft Exhibit 1002 - Page 1333
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

상기 복수 광원은 적어도 하나 이상의 상기 광원을 단위로 하는 복수 개의 광원 그룹으로 구분되며,

상기 제어부는 상기 광원 그룹 별로 휘도를 조절하여 로컬 디밍을 수행하는 것을 특징으로 하는 디스플레이장치.

청구항 14

제12항에 있어서,

하나의 상기 광원 모듈에 구비된 상기 복수 광원은 일렬로 배치되는 것을 특징으로 하는 디스플레이장치.

청구항 15

제12항에 있어서,

상기 광원 모듈은 상기 복수 광원에 대한 전기배선이 형성된 지지기판을 포함하며,

상기 복수 광원은 상기 지지기판에 직립하여 장착되는 것을 특징으로 하는 디스플레이장치.

청구항 16

제12항에 있어서,

상기 복수 광원은 배치된 순서에 따라 적어도 하나 이상의 광원을 단위로 하여 교번적으로 발광 방향이 서로 반대인 것을 특징으로 하는 디스플레이장치.

청구항 17

제12항에 있어서,

상기 복수 도광판의 양단부에 배치된 광원 모듈을 더 포함하며,

상기 복수 도광판의 양단부에 배치된 광원 모듈에 구비되는 복수 광원의 발광 방향이 상기 디스플레이 패널의 디스플레이 영역의 중앙축을 향하는 것을 특징으로 하는 디스플레이장치.

청구항 18

제12항에 있어서,

상기 광원 모듈은 투명기판을 포함하며,

상기 복수 광원은 상기 투명기판의 적어도 일 측면에 장착되는 것을 특징으로 하는 디스플레이장치.

청구항 19

제18항에 있어서,

상기 투명기판은 상기 복수 광원을 구동하는 투명한 전기배선을 포함하는 것을 특징으로 하는 디스플레이장치.

청구항 20

제12항에 있어서,

상기 복수 개로 분할된 도광판은 행 또는 열방향으로 분할되는 것을 특징으로 하는 디스플레이장치.

명 세 서

발명의 상세한 설명

기 술 분 야

[0001] 본 발명은 광원 및 도광판에 의해 화상 표시를 위한 광을 공급하는 디스플레이장치에 관한 것으로서, 상세하게는 장치의 슬림화 및 선명한 화상 화질을 구현하도록 광원 및 도광판을 구성하는 디스플레이장치에 관한 것이다.

Microsoft Exhibit 1002 - Page 1334
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

배경 기술

[0002] TV, 모니터 등과 같은 디스플레이장치는 화상을 표시하는 디스플레이 패널을 구비함으로써, 방송신호 또는 다양한 포맷의 화상 데이터를 표시할 수 있다. 이러한 디스플레이 패널은 액정 패널, 플라즈마 패널 등과 같은 다양한 형식으로 구현되어 각종 디스플레이장치에 적용되고 있다. 여기서, 액정 패널 등과 같이 패널 자체적으로 광을 생성할 수 없는 경우, 디스플레이장치는 광을 패널에 공급하는 백라이트유닛을 구비한다.

[0003] 이와 같은 디스플레이장치의 백라이트유닛은 광을 형성하는 광원으로, 과거 일반적으로 채택되던 냉음극 형광램프보다 환경오염, 응답속도 등의 측면에서 우수한 특성을 가진 발광 다이오드 소자를 채택하는 비율이 증가하고 있다. 백라이트유닛은 이러한 광원의 배치 위치에 따라서, 직하형 및 에지형으로 구분할 수 있다.

[0004] 직하형 백라이트유닛은 광원이 액정 패널의 배면을 따라서 평행하게 배치됨으로써, 각 광원이 전면의 패널을 향해 직접 광을 투사한다. 반면, 에지형 백라이트유닛은 광원이 패널의 에지를 따라서 바(bar) 형태로 배치되고, 광원으로부터의 광이 도광판을 거쳐서 패널에 투사되는 구성이다.

[0005] 이와 같은 구성에 따라서, 직하형 백라이트유닛은 각 광원이 전면의 패널을 향해 광을 투사하므로 로컬 디밍(local dimming) 과 같은 광원 구동 기술을 구현하기 용이하지만, 광원이 패널의 배면에 배치되므로 디스플레이장치의 슬림화가 곤란하다. 한편, 종래의 에지형 백라이트유닛은 광원이 패널의 측면에 배치되므로 디스플레이장치의 슬림화가 용이하지만, 광원으로부터의 광이 도광판을 거쳐서 패널에 투사되므로 로컬 디밍과 같은 기술을 구현하기 곤란하다.

[0006] 따라서, 로컬 디밍과 같은 광원 구동 기술을 구현하면서도 장치의 슬림화가 가능한 백라이트유닛 및 디스플레이장치를 제공할 수 있다면 바람직할 것이다.

발명의 내용

[0007] 본 발명의 실시예에 따른 디스플레이장치는, 디스플레이 패널과; 상기 디스플레이 패널의 분할된 각 디스플레이 영역에 광을 출사하는 복수의 도광판과; 각각의 상기 도광판 측면에 입사되는 상기 광을 생성하고, 상기 도광판의 측면에 대응하게 배치된 복수의 광원을 포함하며, 하나의 상기 도광판 측면에 대응하게 배치된 복수 광원 중 적어도 일부 광원에 의한 제1발광 방향이 상기 하나의 도광판 측면에 대응하게 배치된 복수 광원 중 나머지의 적어도 일부 광원에 의한 제2발광 방향과 상이하게 상기 복수 광원이 배치된 것을 특징으로 한다.

[0008] 여기서, 상기 제1발광 방향 및 상기 제2발광 방향은 상호 대칭적일 수 있다.

[0009] 또한, 상기 각 도광판의 측면을 따라서 직렬 배치된 복수의 상기 광원을 가지는 광원 모듈을 포함하며, 하나의 상기 광원 모듈은 상기 제1발광 방향으로 발광하는 적어도 하나의 상기 광원과, 상기 제2발광 방향으로 발광하는 적어도 하나의 상기 광원을 가질 수 있다.

[0010] 여기서, 상기 복수 광원의 배치 순서를 따라서, 하나 또는 상호 인접한 둘 이상의 상기 광원을 포함하는 복수의 광원 블록이 형성되며, 인접한 두 광원 블록은 상호 상이한 발광 방향을 가질 수 있다.

[0011] 또한, 상기 광원 모듈은 투명기판을 포함하며, 상기 복수의 광원은 상기 투명기판의 적어도 일 측면에 장착될 수 있다.

[0012] 여기서, 상기 투명기판은 상기 복수의 광원을 구동하는 투명한 전기 배선을 포함할 수 있다.

[0013] 또한, 상기 복수의 광원은 적어도 하나 이상의 상기 광원을 단위로 하는 복수 개의 광원 그룹으로 구분되며, 상기 광원 그룹 별로 휘도를 조절하여 로컬 디밍(local dimming)을 수행하는 제어부를 더 포함할 수 있다.

[0014] 또한, 상기 광원은 발광 다이오드 소자를 포함할 수 있다.

[0015] 또한, 본 발명의 실시예에 따른 디스플레이장치는, 영상을 수신하는 영상수신부와; 상기 영상수신부에 수신되는 영상을 처리하는 영상처리부와; 상기 영상처리부에 의해 처리되는 영상을 표시하는 디스플레이 패널과; 상기 영상을 표시 가능하게 상기 디스플레이 패널에 광을 공급하는 백라이트유닛을 포함하며, 상기 백라이트유닛은, 상기 디스플레이 패널의 분할된 각 디스플레이 영역에 광을 출사하는 복수의 도광판과; 각각의 상기 도광판 측면에 입사되는 상기 광을 생성하고, 상기 도광판의 측면에 대응하게 배치된 복수의 광원을 포함하며, 하나의 상기 도광판 측면에 대응하게 배치된 복수 광원 중 적어도 일부 광원에 의한 제1발광 방향이 상기 하나의 도광판 측면에 대응하게 배치된 복수 광원 중 나머지의 적어도 일부 광원에 의한 제2발광 방향과 상이하게 상기 복수 광

Microsoft Exhibit 1002 - Page 1335
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1336
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

원이 배치된 것을 특징으로 한다.

[0016] 여기서, 상기 복수의 광원은 적어도 하나 이상의 상기 광원을 단위로 하는 복수 개의 광원 그룹으로 구분되며, 상기 백라이트유닛은 상기 광원 그룹 별로 휘도를 조절하여 로컬 디밍을 수행하는 제어부를 더 포함할 수 있다.

[0017] 또한, 상기 복수 광원은 적어도 하나 이상의 상기 광원을 단위로 배치순서에 따라 발광방향이 교번적으로 반대일 수 있다.

[0018] 또한, 본 발명의 실시예에 따른 디스플레이장치는, 디스플레이 패널과; 복수 개로 분할된 도광판과; 복수 개의 광원을 구비하고, 상기 분할된 도광판 사이에 배치되어 상기 분할된 도광판의 측면에 광을 입사하는 광원 모듈과; 상기 복수 광원의 휘도를 조절하는 제어부를 포함하며, 상기 광원 모듈에 구비된 상기 복수 광원은 적어도 하나 이상의 상기 광원을 단위로 배치순서에 따라 발광방향이 교번적으로 반대인 것을 특징으로 한다.

[0019] 여기서, 상기 복수 광원은 적어도 하나 이상의 상기 광원을 단위로 하는 복수 개의 광원 그룹으로 구분되며, 상기 제어부는 상기 광원 그룹 별로 휘도를 조절하여 로컬 디밍을 수행할 수 있다.

[0020] 또한, 하나의 상기 광원 모듈에 구비된 상기 복수 광원은 일렬로 배치될 수 있다.

[0021] 또한, 상기 광원 모듈은 상기 복수 광원에 대한 전기배선이 형성된 지지기판을 포함하며, 상기 복수 광원은 상기 지지기판에 직립하여 장착될 수 있다.

[0022] 또한, 상기 복수 광원은 배치된 순서에 따라 적어도 하나 이상의 광원을 단위로 하여 교번적으로 발광 방향이 서로 반대일 수 있다.

[0023] 또한, 상기 복수 도광판의 양단부에 배치된 광원 모듈을 더 포함하며, 상기 복수 도광판의 양단부에 배치된 광원 모듈에 구비되는 복수 광원의 발광 방향이 상기 디스플레이 패널의 디스플레이 영역의 중앙축을 향할 수 있다.

[0024] 또한, 상기 광원 모듈은 투명기판을 포함하며, 상기 복수 광원은 상기 투명기판의 적어도 일 측면에 장착될 수 있다.

[0025] 여기서, 상기 투명기판은 상기 복수 광원을 구동하는 투명한 전기배선을 포함할 수 있다.

[0026] 또한, 상기 복수 개로 분할된 도광판은 행 또는 열방향으로 분할될 수 있다.

발명의 실시를 위한 구체적인 내용

[0027] 이하에서는 첨부도면을 참조하여 본 발명에 대해 상세히 설명한다.

[0028] 도 1은 본 발명의 제1실시예에 따른 디스플레이장치(1)의 개략적인 분해 사시도이다. 도 1은 디스플레이장치(1)에서 본 실시예와 관련된 구성을 개략적으로 나타낸 것으로써, 본 발명의 사상을 명확히 표현하도록 일부 구성이 생략되어 있음을 밝힌다. 예컨대, 본 발명의 일실시예에 의한 디스플레이장치(1)는 TV나, PC의 모니터 등으로 구현될 수 있으며, 방송신호를 수신하는 튜너부, PC, DVD 등 영상기기로부터 영상신호를 입력받는 신호입력부, 수신되는 신호에 대하여 다양한 신호처리를 수행하는 신호처리부, 사용자의 입력을 수신하는 사용자입력부, 각 구성에 전력을 공급하는 전원부 등을 포함할 수 있다.

[0029] 도 1에 도시된 바와 같이, 본 실시예에 따른 디스플레이장치(1)는 화상이 표시되는 디스플레이 패널(10)과, 디스플레이 패널(10)을 구동시키는 구동회로기판(20)과, 화상이 표시되도록 디스플레이 패널(10)에 광을 생성 및 공급하는 백라이트유닛(30)을 포함한다.

[0030] 도 1에 나타난 각 방향에 대해 설명한다. X, Y, Z 방향은 기본적으로 각각 가로, 세로 및 높이를 나타낸다. 디스플레이 패널(10)은 X-Y 평면 상에 배치되며, 백라이트유닛(30) 및 디스플레이 패널(10)이 Z 방향을 따라서 적층되게 배치된다. 이하, 도 1을 포함한 각 도면 및 실시예에서는 이러한 방향 정의를 기초로 하여 설명한다. 여기서, X, Y, Z 방향의 반대방향은 각각 -X, -Y, -Z 방향으로 나타내고, X-Y 평면은 X 방향의 축 및 Y 방향의 축에 의해 형성되는 평면을 의미한다.

[0031] 이하, 디스플레이장치(1)의 각 구성요소에 관해 설명한다.

[0032] 디스플레이 패널(10)은 본 실시예에 따르면 액정 패널로 구현된다. 디스플레이 패널(10)은 두 개의 기판(미도시) 사이에 액정층(미도시)이 충진되며, 이 액정층(미도시)의 배열을 조정함으로써 화상을 표시한다. 디스플레이 패널(10)은 디스플레이 영역에 화상을 표시하기 위하여 백라이트유닛(30)으로부터 광을 제공받는다.

Microsoft Exhibit 1002 - Page 1337
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

여기서, 디스플레이 영역은 X-Y 평면과 평행하다.

[0033] 구동회로기판(20)은 디스플레이 패널(10) 일측에 전기적으로 연결되며, 디스플레이 패널(10)에 구동신호를 인가한다. 구동회로기판(20)으로부터 구동신호가 인가되면, 디스플레이 패널(10)의 액정(미도시)이 소정 각도로 회전한다. 이에 의하여 디스플레이 패널(10)의 디스플레이 영역을 구성하는 각 셀(미도시) 단위로 광의 투과 특성이 상이하게 되며, 이에 의하여 디스플레이 영역에 화상이 표시될 수 있다.

[0034] 백라이트유닛(30)은 디스플레이 패널(10)에 광을 공급하도록, 디스플레이 패널(10)의 배면에 배치된다. 백라이트유닛(30)은 디스플레이 패널(10)의 디스플레이 영역에 광을 출사하는 복수의 도광판(100)과, 광을 생성하여 복수의 도광판(100)에 입사시키는 복수의 광원 모듈(200)과, 복수의 도광판(100)으로부터 출사되는 광의 특성을 조정하는 광학시트류(300)를 포함한다.

[0035] 복수의 도광판(100)은 아크릴 사출물 등으로 구현된 플라스틱 성형 렌즈로서, 광원 모듈(200)로부터 입사되는 광을 디스플레이 패널(10)의 전체 디스플레이 영역에 균일하게 전달한다. 도 1에서의 복수의 도광판(100) 각각은 X 방향으로 연장된 직사각형 형상을 가지나, 이들의 개수, 형상, 연장 방향 등이 본 발명의 사상을 한정하지 않는다.

[0036] 복수의 도광판(100)은 표면상에 광투과 패턴이 형성됨으로써, 복수의 도광판(100)으로부터 출사되는 광의 균일성을 향상시키고 출사 광량을 조절할 수 있다. 즉, 광투과 패턴을 어떻게 형성하는가에 따라서, 각 도광판(100)에서 출사되는 광량이 상이할 수 있다.

[0037] 복수의 도광판(100)은 X-Y 평면 상에 병렬적으로 배치되며, 디스플레이 패널(10)의 디스플레이 영역에 대해 광을 Z 방향으로 출사한다.

[0038] 본 실시예에 따르면, X 방향을 디스플레이 영역의 가로 방향, Y 방향을 디스플레이 영역의 세로 방향이라고 하면, 디스플레이 영역의 가로 방향과 세로 방향 모두에 대하여, 도광판(100)이 복수 개 어레이(array) 배열된다. 그러나, 이는 복수 개의 도광판(100)을 배치하는 일례에 불과한 것으로서, 이러한 배치 관계가 본 발명의 사상을 한정하지 않는다.

[0039] 복수의 광원 모듈(200)은 디스플레이 패널(10)에 제공하기 위한 광을 생성하며, 복수의 광원 모듈(200) 각각은 생성한 광이 각 도광판(100)에 입사되도록 각 도광판(100)의 측면에 근접하게 배치된다. 복수의 광원 모듈(200)은 복수의 도광판(100)에 대응하여 배열될 수 있다. 즉, 복수의 광원 모듈(200)은 복수의 도광판(100)과 마찬가지로 X 방향을 따라서 연장된다. 또한, 본 실시예에서 광원 모듈(200)은 Y 방향을 따라서 인접하도록 배열된 한 쌍의 도광판(100) 사이 및/또는 Y 방향의 최외각에 배열된 도광판(100)의 일 측면에 배치된다.

[0040] 광원 모듈(200)로부터 생성된 광은 X-Y 평면에 평행한 방향으로 각 도광판(100)에 입사된 후, 각 도광판(100)으로부터 Z 방향으로 출사되어 디스플레이 패널(10)에 입사된다. 구동회로기판(20)에 의해 구동된 디스플레이 패널(10)은 이 입사된 광에 의해, X-Y 평면에 평행한 디스플레이 영역 상에 화상을 형성할 수 있다.

[0041] 이하, 광원 모듈(200) 및 도광판(100)에 관해 도 2를 참조하여 보다 자세히 설명한다. 도 2는 도 1에서 도광판(100) 및 광원 모듈(200)을 -Z 방향으로 본 모습을 나타낸 요부 평면도이다.

[0042] 도 2에 도시된 바와 같이, 본 실시예는 디스플레이 영역의 X 방향 폭을 2분할하는 소정의 CX 라인을 중심으로, 좌측 디스플레이 영역(L) 및 우측 디스플레이 영역(R)으로 구분된다.

[0043] 복수의 도광판(100)은 이 좌측 영역(L) 및 우측 영역(R) 각각에서, Y 방향을 따라 어레이 배열된다. 광원 모듈(200)은 상호 인접하는 도광판(100) 사이에 X 방향을 따라서 연장된다. CX 라인을 중심으로, 도광판(100) 및 광원 모듈(200)의 배치는 좌측 영역(L) 및 우측 영역(R)이 대칭적으로 형성된다.

[0044] 광원 모듈(200)은 도광판(100)의 측면을 따라서 X 방향으로 직렬 배치된 복수의 광원(210)과, 이 복수의 광원이 마운팅(mounting)되는 광원모듈기판(220)과, 광원(210)에 전원을 공급하도록 광원모듈기판(220)에 설치되는 전원입력부(230)를 포함한다. 또한, 각 광원(210)의 점멸을 제어하도록 광원모듈기판(220)에 연결된 제어부(240)가 더 구비될 수 있다. 본 실시예에서는 제어부(240)가 별도의 구성요소로서 광원모듈기판(220) 상에 마운팅된 각 광원(210)을 제어하는 것으로 표현하나, 본 발명의 사상이 이에 한정되지 않으며, 제어부(240)가 광원모듈기판(220)에 일체형으로 통합 구성될 수도 있다.

[0045] 광원(210)은 본 실시예에 따르면 발광 다이오드 소자(light-emitting diode, LED)로 구현되며, 제어부(240)의 제어에 의해 점멸한다. 광원(210)은 광원모듈기판(220)에 마운팅되는 형태에 따라서 발광 방향을 조절할 수 있

다.

[0046] 하나의 광원모듈기판(220)에 마운팅되는 광원(210)은 청색 LED, 녹색 LED 및 적색 LED를 포함할 수 있으며, 각 컬러의 LED로부터 방출되는 청색광, 녹색광 및 적색광이 상호 혼색됨으로써 우수한 컬러재현성을 가지는 백색광을 형성할 수 있다. 그러나 이는 실시예에 불과한 것으로, 광원(210)은 백색광을 직접 생성하는 백색 LED을 포함할 수도 있다.

[0047] 제어부(240)는 광원모듈기판(220)에 마운팅된 각 광원(210)의 개별적 또는 통합적인 점멸 제어를 수행한다. 광원모듈기판(220)에 마운팅된 복수 광원(210)은 그 배치 순서, 즉 X 방향을 따라서 상호 인접한 복수 개의 광원(210)을 각각 포함하는 복수의 광원(210) 블록, 즉 복수 광원(210)은 적어도 하나 이상의 광원(210)을 단위로 하는 복수의 광원(210) 그룹을 형성할 수 있다. 제어부(240)는 각 광원(210) 블록 별로 휘도가 조절되도록 각 광원(210) 블록의 점멸을 개별적으로 제어함으로써 로컬 디밍(local dimming)을 구현할 수 있다. 물론, 광원모듈기판(220)은 광원(210) 하나하나의 개별적인 점멸을 제어할 수도 있다.

[0048] 로컬 디밍은 디스플레이 패널(10)의 디스플레이 영역을 복수 개로 분할하고, 각 분할 디스플레이 영역의 그레이 레벨 값에 따라서, 해당 분할 디스플레이 영역의 휘도값을 개별적으로 조정하는 백라이트유닛(30)의 구동 기술이다. 즉, 제어부(240)는 표시 화상의 밝은 영역에 대응하는 광원(210) 블록을 턴온시키고, 표시 화상의 어두운 영역에 대응하는 광원(210) 블록을 상대적으로 낮은 휘도로 턴온시키거나 또는 턴오프시킬 수 있다. 이에 의하여, 광원(210)에 대한 전원 턴오프에 따른 에너지 절감과, 휘도가 높은 화상 영역 및 휘도가 낮은 화상 영역 사이에 휘도차를 명확하게 함으로써 화상의 선명도를 향상시킬 수 있다.

[0049] 전원입력부(230)는 광원모듈기판(220)의 일단부에 설치되며, 광원모듈기판(220) 상에 마운팅된 복수 광원(210)에 대해 전원이 공급되도록 한다. 전원입력부(230)는 디스플레이장치(1)의 전원공급부(미도시)로부터 전원을 입력받으며, 이러한 전원 입력이 간섭받지 않도록 전원입력부(230)는 전체 백라이트유닛(30)의 최외각 영역에 설치된다.

[0050] 도 2에서, 전원입력부(230)는 좌측 영역(L)의 경우에 -X 방향의 최외각 영역, 우측 영역(R)의 경우에 X 방향의 최외각 영역에 각각 배치된다. 이에 의하여, 전원입력부(230)는 도광판(100), 광원(210)의 구성 및 광의 경로를 방해하지 않도록 구성된다.

[0051] 이하, 광원(210)에서 생성되는 광이 도광판(100)에 입사되는 형태에 관해, 도 3을 참조하여 설명한다. 도 3은 도 2에서 좌측 영역(L)의 도광판(100) 및 광원 모듈(200)의 배치 형태를 나타낸 요부 사시도이다. 도 3에서는 도광판(100) 및 광원 모듈(200) 사이의 거리가 넓게 배치된 것으로 표현하나, 이는 도면에서 각 구성요소를 명확히 나타내기 위한 편의적 선택임을 밝힌다.

[0052] 도 3에 도시된 바와 같이, CX 라인으로부터 좌측 영역(L)에는, Y 방향을 따라서 제1도광판(100a) 및 제2도광판(100b)이 배치된다. 제1도광판(100a) 및 제2도광판(100b) 각각은 X 방향을 따라서 연장된 제1측면(110a) 및 제2측면(110b)을 가지며, 이 제1측면(110a) 및 제2측면(110b)은 상호 마주보게 배치된다.

[0053] 이 상호 마주보는 제1측면(110a) 및 제2측면(110b) 사이에는 광원모듈기판(220)이 배치되며, 복수의 광원(210)이 X 방향을 따라서 직렬 배치된다.

[0054] 여기서, 광원(210)이 광원모듈기판(220)에 마운팅되는 형태에 따라서, 광원(210)의 발광 방향은 -Y 방향을 향하거나 또는 Y 방향을 향하도록 할 수 있다. -Y 방향으로 향하는 광은 제1측면(110a)을 통해 제1도광판(100a)으로 입사하며, Y 방향으로 향하는 광은 제2측면(110b)을 통해 제2도광판(100b)으로 입사한다.

[0055] 본 실시예에 따르면, 백라이트유닛(30)이 포함하는 복수의 광원(210) 중에서, 적어도 일부 광원(210)의 제1발광 방향이 나머지의 적어도 일부 광원(210)의 제2발광 방향과 상이하도록 각 광원(210)을 배치한다. 이에 의하여, 전체 디스플레이 영역에서의 휘도 균일성을 향상시킬 수 있다.

[0056] 여기서, 제1발광 방향으로 광을 출사하는 광원(210) 및 제2발광 방향으로 광을 출사하는 광원(210)은 동일한 광원 모듈(200)에 포함될 수 있다. 또는, 하나의 광원 모듈(200)에 포함되는 광원(210)은 동일한 발광 방향을 가지고, 각 광원 모듈(200) 별로 발광 방향이 상이하도록 마련될 수도 있다.

[0057] 이하, 본 실시예에 따라서 광원(210)을 배치하는 방법에 관해 도 4를 참조하여 설명한다. 도 4는 본 실시예에 따른 각 광원(210)의 발광 방향을 나타낸 평면도 및 이에 따른 휘도 분포를 나타낸 그래프이다.

[0058] 도 4에서, 우측의 평면도는 도 1의 도광판(100) 및 광원(210)의 구성을 -Z 방향으로 본 것으로서, 본 발명을 명

Microsoft Exhibit 1002 - Page 1338
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1339
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

확히 나타내기 위해 광원모듈기판(220) 및 전원입력부(230)의 구성을 표시하지 않았음을 밝힌다. 좌측 그래프의 커브 C1은 도광판(100) 및 광원(210) 구성의 Y 방향 길이에 따른 디스플레이 영역의 휘도 변화를 나타낸 것으로서, 그래프의 세로축은 그래프 우측에 도시된 도광판(100) 및 광원(210) 구성의 Y 방향 위치에 대응하며, 가로축은 휘도이다.

[0059] 도 4에 도시된 바와 같이, CX 라인을 중심으로 좌측 영역(L) 및 우측 영역(R) 각각에 도광판(100) 및 광원(210)이 배치되어 있다. 배치 형태는 앞서 설명한 도광판(100) 및 광원(210)의 구성에 따른다. 복수의 도광판(100)은 디스플레이 영역에 대응한다.

[0060] CX 라인에 대해 90도의 각도 차이를 가지고, 디스플레이 영역의 Y 방향 폭을 2분할하는 소정의 CY 라인이 나타나 있다.

[0061] 본 실시예에 따른 복수 광원(210)은 각각의 발광 방향이 CY 라인을 중심으로 하여 상호 대향하도록 배치된다. 즉, 각 광원(210)의 발광 방향이 CY 라인을 중심으로 대칭적으로 형성되며, CX 라인을 중심으로 한 좌측 영역(L)의 광원(210)과 우측 영역(R)의 광원(210)은 상호 동일한 발광 방향을 가진다. 또한, 이 경우 하나의 광원 모듈(200)에 포함되는 광원(210)은 동일한 발광 방향을 가짐을 알 수 있다.

[0062] 이러한 구성에 의해, 전체 디스플레이 영역의 휘도는 커브 C1으로 나타나듯이 CY 라인을 중심으로 가장 높아지며, CY 라인으로부터 Y 방향 또는 -Y 방향으로 갈수록 휘도가 저하됨을 알 수 있다.

[0063] 만일, 도면 상에 나타난 모든 광원(210)이 동일한 발광 방향, 예를 들어 Y 방향을 향한다고 한다. 이러한 경우, 커브 C1은 디스플레이 영역의 상측 가장자리에서부터 Y 방향을 따라서 급격히 상승하며, 휘도는 디스플레이 영역의 하측 가장자리에서 최고점을 형성할 것이다. 이와 같이 디스플레이 패널(10)의 가장자리에서 휘도가 가장 높으면, 시인성이 저하되며 사용자에게 안정감을 주지 못한다.

[0064] 또한, 이러한 경우 도광판(100)의 Y 방향 배치 순서에 따라서 광량을 조절해야 하므로, 도광판(100)의 위치에 따라서 도광판(100)에 광투과 패턴을 상이하게 적용할 필요가 있다. 이는 도광판(100) 제조 설비를 증가시키는 원인이 된다.

[0065] 본 실시예에 따르면, 상기와 같이 모든 광원(210)이 동일한 발광 방향을 가지는 경우에 비해 커브 C1의 구배, 즉 휘도 분포 구배를 완만하게 하며, 휘도의 최고점이 CY 라인, 즉 디스플레이 영역의 중앙 영역에 형성된다. 휘도 최고점이 디스플레이 영역의 중앙 영역에 위치하면, 디스플레이 영역의 가장자리에 휘도 최고점이 있는 경우에 비해 시인성이 개선되며 사용자에게 안정감을 줄 수 있다. 또한, 도광판(100) 패턴 종류를 상대적으로 저감시킬 수 있다.

[0066] 한편, CY 라인을 중심으로 상측의 광원(210)과 하측의 광원(210) 각각의 발광 방향이, 도 4와 달리 대향하지 않고 배향하는 경우를 고려할 수도 있다. 이 경우 또한 모든 광원(210)이 동일한 발광 방향을 가지는 경우에 비해 휘도 분포 구배를 완만하게 할 수 있으며, 이에 따른 디스플레이 영역에 대한 휘도 균일화의 향상을 기대할 수 있다.

[0067] 다만, 이 경우는 휘도의 최고점이 CY 라인이 아닌 디스플레이 영역의 Y 방향 단부 및 -Y 방향 단부에 형성되므로, 시인성 측면에서 도 4의 경우가 상대적으로 우수하다고 볼 수 있다.

[0068] 이와 같이, 본 실시예에 따르면 각 광원(210)의 발광 방향을 상이하게 배치함으로써, 디스플레이 영역의 휘도 균일화를 향상시킬 수 있다.

[0069] 한편, 상기한 제1실시예는 광원 모듈(200), 광원모듈기판(220)을 좌측 영역(L) 및 우측 영역(R) 각각에 대해 상이하게 설계하게 된다. 도 4에 도시된 바와 같이, 좌측 영역(L) 및 우측 영역(R)의 광원(210)은 상호 동일한 발광 방향을 가지므로, 좌측 영역(L)의 광원 모듈(200)을 우측 영역(R)에 적용하게 되면 전원입력부(230)의 배치 때문에 발광 방향이 반대가 된다. 따라서, 광원 모듈(200)을 좌측 영역(L) 및 우측 영역(R)에 공통으로 적용할 수 없다.

[0070] 이에, 광원 모듈(200)을 공용화하고, 나아가서 제1실시예의 경우보다 디스플레이 영역의 휘도 분포 구배를 완만하게 할 수 있다면 더욱 바람직할 것이다.

[0071] 이하, 이와 같은 구성을 제2실시예로 하여, 도 5를 참조하여 설명한다. 도 5는 광원(210)의 발광 방향이 제1실시예와 상이하게 구성된 예시를 나타내는 평면도 및 이에 대한 휘도 분포 그래프이다. 도 5에 나타난 방향, 라인, 구성 등에 관한 기본적 설명은 제1실시예를 준용할 수 있는 바, 자세한 설명을 생략한다.

[0072] 도 5에 도시된 바와 같이, 우선 좌측 영역(L)을 고려하면, X 방향을 따라서 배치된 각 광원(210)은 인접한 타 광원(210)과 상이한 발광 방향을 가지도록 배치된다. 즉, 하나의 광원 모듈(200) 내의 각 광원(210)은 소정의 제1발광 방향 및 이와 상이한 제2발광 방향 중 어느 하나를 가지도록, 자세하게는 그 배치 순서에 따라서 Y 방향 또는 -Y 방향을 향해 발광하도록 선택적으로 배치된다. 이에 의하여, Y 방향을 따라 배치된 광원(210) 열은 인접한 광원(210) 열과 반대 방향으로 발광함으로써, 좌측 영역(L) 전체로 볼 때 지그재그 형태로 발광 방향을 형성하게 된다.

[0073] 요약하면, 하나의 광원 모듈(200) 내의 각 광원(210)은 적어도 하나 이상의 광원(210)을 단위로 배치순서에 따라서 발광방향이 교번적으로 반대가 되도록 배치된다.

[0074] 한편, 우측 영역(R) 또한 좌측 영역(L)의 경우와 동일하게 지그재그 형태로 발광 방향이 형성된다. 여기서, 광원 모듈(200)에 포함된 각 광원(210)은 그 배치 순서를 따라서 반대 방향으로 발광하도록 배치되어 있다. 따라서, 좌측 영역(L)의 광원 모듈(200)을 Z 방향을 중심으로 180도 회전시켜 우측 영역(R)에 적용하면, 우측 영역(R) 또한 지그재그 형태의 발광 방향을 형성할 수 있다.

[0075] 즉, 본 실시예는 제1실시예의 경우와 달리, 광원 모듈(200) 및 광원모듈기판(220)을 좌측 영역(L) 및 우측 영역(R) 각각에 대해 동일한 구성을 적용할 수 있는 바, 좌측 영역(L) 및 우측 영역(R) 각각에 대해 별도로 광원 모듈(200)을 구성할 필요가 없다.

[0076] 좌측의 그래프에서 커브 C1은 도 4의 커브 C1과 동일하며, 커브 C2는 본 실시예에 따른 휘도 분포 구배를 나타내고 있다. 커브 C2는 CY 라인에서 휘도가 가장 높게 나타난다는 점에서 커브 C1과 동일하나, 커브 C1에 비해 구배가 완만함을 알 수 있다.

[0077] 즉, 제2실시예는 제1실시예에 비해 전체 디스플레이 영역에 대한 휘도 분포가 고르게 이루어짐으로써 휘도 균일화가 향상된다.

[0078] 이와 같이, 하나의 광원 모듈(200)은 하나의 도광판(100) 측면에 대응하게 배치된 복수 광원(210)을 포함하며, 이 복수 광원(210) 중 적어도 일부의 제1발광 방향과, 이 복수 광원(210) 중 나머지의 적어도 일부의 제2발광 방향이 상이하게 배치됨으로써, 전체 디스플레이 영역에 대한 휘도 균일화를 향상시킬 수 있다.

[0079] 한편, 상기한 제2실시예에서는 어느 하나의 광원(210)이 인접한 광원(210)과 반대의 발광 방향을 가지는 것으로 표현하였으나, 본 발명의 사상이 이에 한정되지 않는다. 이에, 광원(210)의 발광 방향에 대한 구성이 제2실시예와 상이한 경우를 제3실시예로 하고, 이에 관해 도 6을 참조하여 설명한다. 도 6은 제3실시예에 따른 광원(210)의 발광 방향을 나타낸 평면도이다.

[0080] 도 6에 도시된 바와 같이, 각 도광판(100)의 측면을 따라서, 복수의 광원(210)이 X 방향으로 직렬 배치된다. 이러한 배치 순서를 따라서 상호 인접한 하나 이상의 광원(210)이 광원(210) 블록을 형성할 수 있다. 본 실시예에 따르면, 상호 인접한 두 개의 광원(210)이 하나의 광원(210) 블록을 형성하나 이는 한정된 것이 아니며, 필요에 따라서 셋 이상의 광원(210)이 하나의 광원(210) 블록을 형성할 수도 있다.

[0081] 상호 인접한 각 광원(210) 블록은 상호 상이한 발광 방향, 즉 Y 방향 또는 -Y 방향으로 발광하도록 배치된다. 도면에 따르면 Y 방향을 따라서 배치된 최초 두 개의 광원(210) 열이 Y 방향을, 다음 두 개의 광원(210) 열이 -Y 방향을 향해 발광하며, 이러한 광원(210) 열의 배치가 X 방향을 따라서 반복됨을 알 수 있다. 이러한 구성에 의하여, 앞서 설명한 실시예와 같이 디스플레이 영역의 휘도 균일화 향상을 기대할 수 있다.

[0082] 이상 여러 실시예들에 따라서, 디스플레이 영역의 휘도 균일화 및 시인성 향상, 나아가서 도광판(100)의 광투과 패턴 및 광원 모듈(200) 종류의 절감 등을 기대할 수 있다.

[0083] 복수 광원(210)이 Y 방향 또는 -Y 방향의 상이한 발광 방향을 가지는 것에 있어서, Y 방향으로 발광하는 광원(210)의 개수와 -Y 방향으로 발광하는 광원(210)의 개수의 비율은 한정되지 않으며, 다양한 비율이 적용될 수 있다. 다만, 전자와 후자 사이의 개수 차이는 기 설정된 개수 이하인 것이 휘도 균일화 측면에 있어서 바람직하다. 만일 이 개수 차이가 커지게 되면 어느 한 쪽으로 휘도 레벨이 편중됨으로서 휘도 균일화를 저해할 수도 있기 때문이다.

[0084] 한편, 광원 모듈(200)의 구성은 도 3의 경우에 한정할 수 없으며 다양한 구현이 가능한 바, 이에 관하여 도 7을 참조하여 설명한다.

[0085] 도 7은 도 3의 경우와 상이한 구성의 도광판(100a, 100b) 및 광원 모듈(200a) 일부를 나타낸 요부 평면도이다.

Microsoft Exhibit 1002 - Page 1340
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

[0086] 도 7에 도시된 바와 같이, 광원 모듈(200a)은 제1도광판(100a) 및 제2도광판(100b)의 사이에 배치된다. 여기서, 광원 모듈(200a)은 제1도광판(100a) 및 제2도광판(100b)의 측면(110a, 110b)에 각각 대응하는 판면(241a, 241b)을 가지는 투명기판(240)과, 투명기판(240)의 각 판면(241a, 241b) 상에 배치된 복수의 광원(210a, 210b)을 포함한다.

[0087] 여기서, 제1도광판(100a) 측면(110a)과 제2도광판(100b) 측면(110b)은 상호 마주보게 배치된다.

[0088] 투명기판(240)은 광이 투과될 수 있도록 투명한 재질로 구현된다. 투명기판(240)은 제1도광판(100a) 측면(110a)과 마주보는 제1판면(241a)과, 이 제1판면(241a)에 배향하며 제2도광판(100b) 측면(110b)과 마주보는 제2판면(241b)을 가진다. 또한, 투명기판(240)은 복수 광원(210a, 210b)을 구동하는 투명한 전기 배선(미도시)을 가진다. 이 전기 배선(미도시)은 투명기판(240) 내부에 형성된 투명 전극으로 구현될 수 있다.

[0089] 복수 광원(210a, 210b)은 투명기판(240)의 양 판면(241a, 241b) 상에 직립하여 장착되며, 복수 광원(210a, 210b) 중 일부(210a)는 제1판면(241a) 상에 배치되며, 복수 광원(210a, 210b) 중 나머지(210b)는 제2판면(241b) 상에 배치된다. 이에 의하여, 제1판면(241a) 상의 광원(210a)은 제1도광판(100a) 측면(110a)을 향해, 제2판면(241b) 상의 광원(210b)은 제2도광판(100b) 측면(110b)을 향해 각각 발광한다.

[0090] 여기서, X 방향을 따라서 제1판면(241a) 및 제2판면(241b) 상에 각각 배치되는 광원(210a, 210b)은, 그 배치 위치가 상호 발광 방향을 간섭하지 않도록 엇갈리게 배치된다. 이에 의하여, 디스플레이 영역 전체로 볼 때 Y 방향 및 -Y 방향 각각으로 진행하는 광이 상호 간섭하는 것을 최소화시킬 수 있다.

[0091] 한편, 상기와 같이 설명한 실시예는 다양한 형태로 구현되는 디스플레이장치(1)에 적용될 수 있다. 이하, 디스플레이장치(1)가 TV로 구현되는 경우 본 발명의 실시예가 적용되는 예시에 관해 도 8을 참조하여 설명한다.

[0092] 도 8은 본 발명의 실시예에 따른 디스플레이장치(1)의 구성 블록도이다. 도 8에서 실선은 영상 신호 또는 제어 신호의 전달, 점선은 광의 전달을 의미한다.

[0093] 도 8에 도시된 바와 같이, 본 실시예에 따른 디스플레이장치(1)는 영상을 수신하는 영상수신부(50)와, 영상수신부(50)에 수신되는 영상을 처리하는 영상처리부(60)와, 영상처리부(60)에 의해 처리되는 영상을 표시하는 디스플레이 패널(70)과, 디스플레이 패널(70)에 영상이 표시될 수 있도록 광을 공급하는 백라이트유닛(80)을 포함한다.

[0094] 백라이트유닛(80)은 디스플레이 패널(70)의 분할된 각 디스플레이 영역에 광을 출사하는 복수의 도광판(81)과, 각 도광판(81) 측면에 입사되는 광을 생성하고 각 도광판(81) 측면에 대응하게 배치되며 복수의 그룹을 형성하는 복수의 광원(83)과, 각 광원(83) 그룹 별로 휘도를 조절 가능한 제어부(85)를 포함한다.

[0095] 영상수신부(50)는 다음과 같이 다양한 규격을 가질 수 있다. 예를 들면 디스플레이장치(1)가 TV로 구현되는 경우, 영상수신부(50)는 방송국(미도시)으로부터 송출되는 RF(radio frequency) 신호를 무선으로 수신하거나, 또는 컴포지트(composite) 비디오, 컴포넌트(component) 비디오, 슈퍼 비디오(super video), SCART, HDMI(high definition multimedia interface) 규격 등에 의한 영상신호를 수신할 수 있다. 또는, 영상수신부(50)는 디스플레이장치(1)가 컴퓨터 모니터인 경우에 VGA방식에 따른 RGB신호를 전달 가능한 D-SUB나, DVI(digital video interactive), HDMI 규격 등의 영상신호를 수신하도록 구현될 수 있다.

[0096] 영상처리부(60)는 영상수신부(50)로부터 전달되는 영상신호에 대해, 기 설정된 다양한 영상처리 프로세스를 수행한다. 영상처리부(60)가 수행하는 영상처리 프로세스의 종류는 한정되지 않는 바, 예를 들면 다양한 영상 포맷에 대응하는 디코딩(decoding) 및 인코딩(encoding), 디인터레이싱(de-interlacing), 프레임 리프레시 레이트(frame refresh rate) 변환, 스케일링(scaling), 영상 화질 개선을 위한 노이즈 감소(noise reduction), 디테일 인핸스먼트(detail enhancement) 등을 포함할 수 있다.

[0097] 영상처리부(60)는 이러한 각 프로세스를 독자적으로 수행할 수 있는 개별적 구성으로 구현되거나, 또는 여러 기능을 통합시킨 일체형 구성으로 구현될 수 있다.

[0098] 영상처리부(60)는 백라이트유닛(80)이 로컬 디밍을 구현하고자 할 때, 이를 위한 영상 정보를 제어부(85)에 전달한다. 제어부(85)는 영상처리부(60)로부터 수신한 영상 정보에 기초하여, 복수 광원(83) 그룹 별로 휘도를 조절함으로써 로컬 디밍을 구현할 수 있다.

[0099] 디스플레이 패널(70) 및 백라이트유닛(80)과, 백라이트유닛(80)의 하위 구성인 도광판(81), 광원(83) 및 제어부(85)의 구성은 앞서 설명한 실시예의 구성과 실질적으로 동일한 바, 자세한 설명을 생략한다.

Microsoft Exhibit 1002 - Page 1341
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1342
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

[0100] 상기한 실시예는 예시적인 것에 불과한 것으로, 당해 기술 분야의 통상의 지식을 가진 자라면 다양한 변형 및 균등한 타 실시예가 가능하다. 따라서, 본 발명의 진정한 기술적 보호범위는 하기의 특허청구범위에 기재된 발명의 기술적 사상에 의해 정해져야 할 것이다.

도면의 간단한 설명

[0101] 도 1은 본 발명의 제1실시예에 따른 디스플레이장치의 분해 사시도,

[0102] 도 2는 도 1의 디스플레이장치에서 도광판 및 광원 모듈을 나타낸 요부 평면도,

[0103] 도 3은 도 2의 도광판 및 광원 모듈 일부를 나타낸 요부 사시도,

[0104] 도 4는 도 1의 디스플레이장치에서 각 광원의 발광 방향을 나타낸 평면도 및 이에 따른 휘도 분포를 나타낸 그래프,

[0105] 도 5은 본 발명의 제2실시예에 따른 각 광원의 발광 방향을 나타낸 평면도 및 이에 따른 휘도 분포를 나타낸 그래프,

[0106] 도 6은 본 발명의 제3실시예에 따른 각 광원의 발광 방향을 나타낸 평면도

[0107] 도 7는 도 3의 경우와 상이한 구성의 도광판 및 광원 모듈 일부를 나타낸 요부 평면도,

[0108] 도 8은 본 발명의 실시예에 따른 디스플레이장치의 구성 블록도이다.

[0109] * 도면의 주요 부분에 대한 부호의 설명

[0110] 1 : 디스플레이장치 10 : 디스플레이 패널

[0111] 20 : 구동회로기판 30 : 백라이트유닛

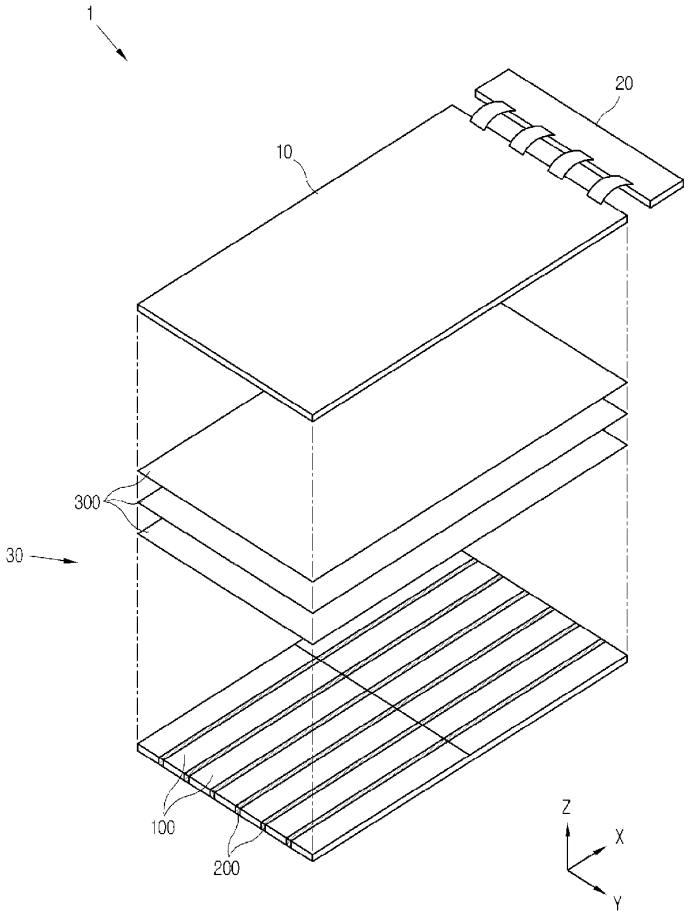
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[0113] 210 : 광원 220 : 광원모듈기판

[0114] 230 : 전원입력부

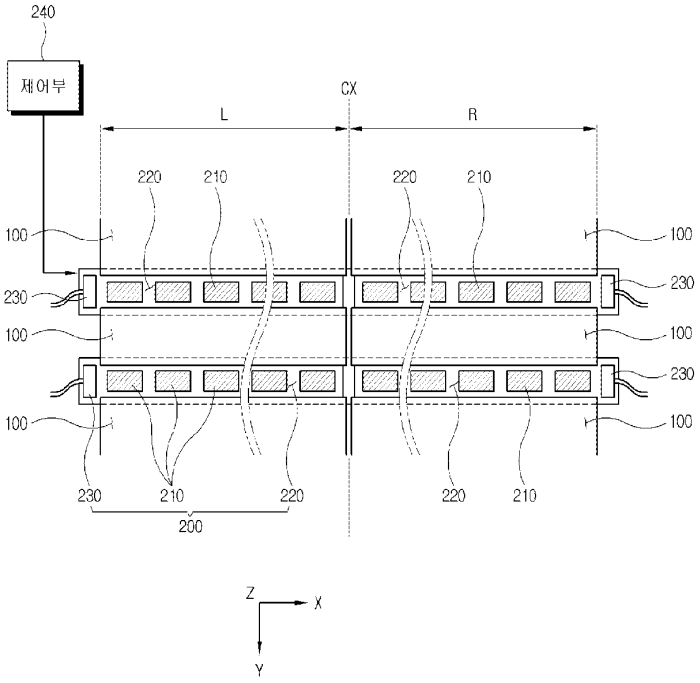
도면

도면1



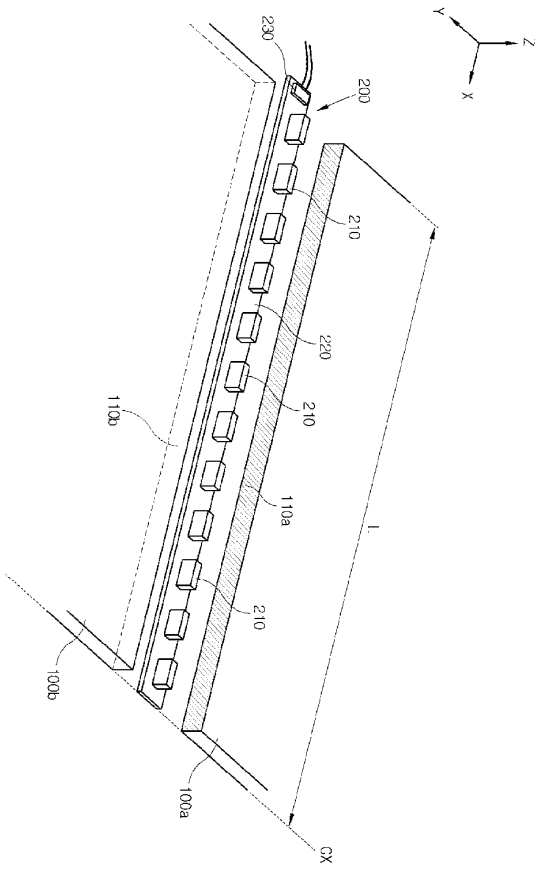
Microsoft Exhibit 1002 - Page 1343
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면2



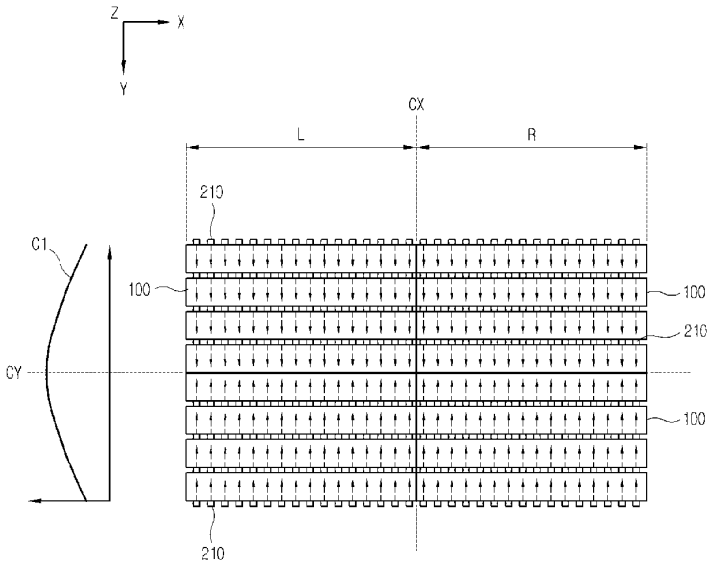
Microsoft Exhibit 1002 - Page 1344
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면3

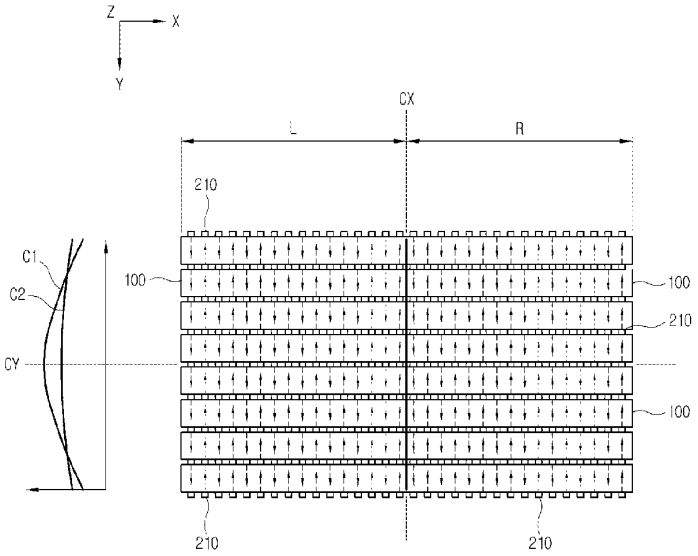


Microsoft Exhibit 1002 - Page 1345
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면4

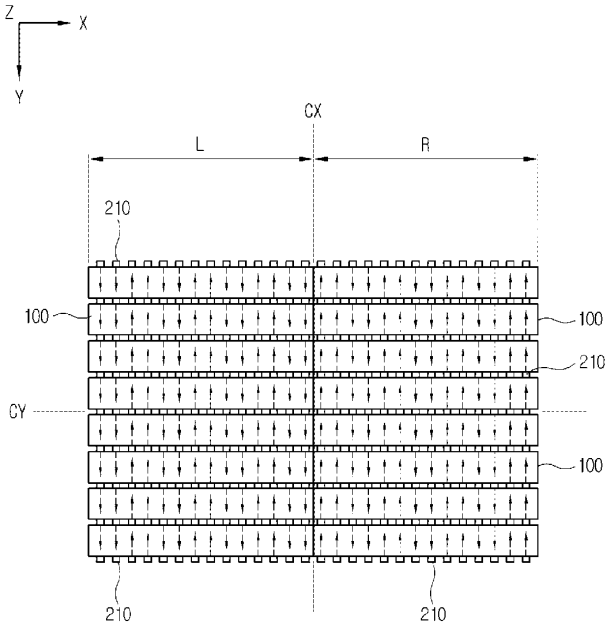


도면5

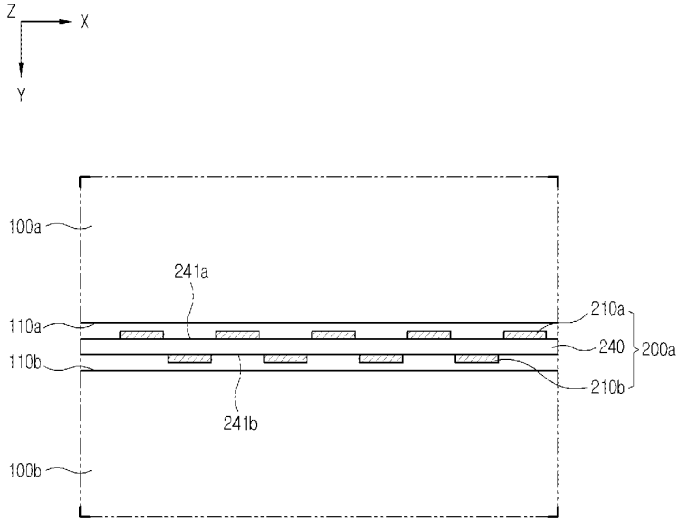


Microsoft Exhibit 1002 - Page 1346
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면6

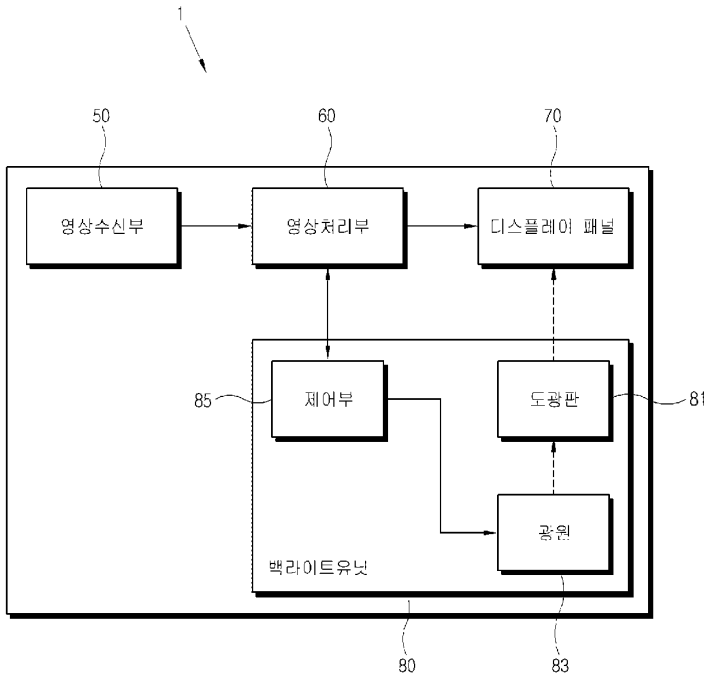


도면7



Microsoft Exhibit 1002 - Page 1347
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도면8



Microsoft Exhibit 1002 - Page 1348
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Espacenet

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Classification: - international: ***G02B27/22; G02F1/1335***
- cooperative: **G02B27/2214**; **G02B6/0053**; G02F1/133615

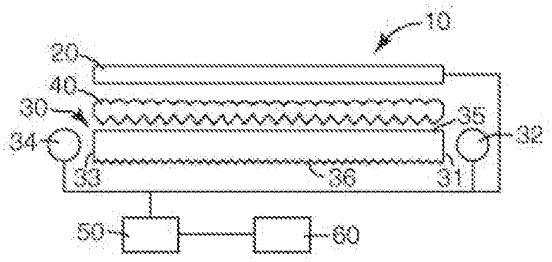
Application number: KR20117000775 20090515

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Abstract not available for KR20110017918 (A)
Abstract of corresponding document: US2009316058 (A1)

A stereoscopic 3D liquid crystal display module includes a liquid crystal display panel and a directional backlight positioned to provide light to the liquid crystal display panel. A double sided prism film is disposed between the liquid crystal display panel and the directional backlight. The prism film includes a first surface having a series of cylindrical lenses adjacent the liquid crystal display panel and a second surface, opposite the first surface, having a series of non-contiguous prisms adjacent the directional backlight. Each of the non-contiguous prisms is separated from adjacent prisms by a transmissive flat portion or an opaque portion.



Microsoft Exhibit 1002 - Page 1349
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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Microsoft Exhibit 1002 - Page 1350
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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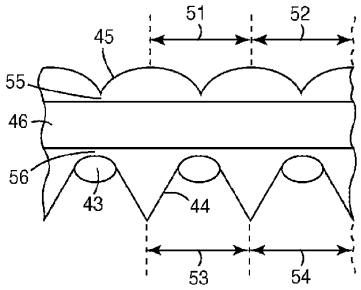
전체 청구항 수 : 총 16 항

(54) 무안경 입체 방식을 가능하게 하는 필름

(57) 요 약

입체 3D 액정 디스플레이 모듈은 액정 디스플레이 패널 및 광을 액정 디스플레이 패널에 제공하도록 배치된 지향성 백라이트를 포함한다. 양면형 프리즘 필름이 액정 디스플레이 패널과 지향성 백라이트 사이에 배치된다. 프리즘 필름은 액정 디스플레이 패널에 인접한 일련의 원통형 렌즈들을 갖는 제1 표면과, 제1 표면의 반대쪽에 있는, 지향성 백라이트에 인접한 일련의 비연속적인 프리즘들을 갖는 제2 표면을 포함한다. 비연속적인 프리즘들 각각은 평탄한 투과 부분 또는 불투명 부분에 의해 인접한 프리즘들로부터 분리된다.

대 표 도 - 도6



Microsoft Exhibit 1002 - Page 1351
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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Microsoft Exhibit 1002 - Page 1352
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

특허청구의 범위

청구항 1

액정 디스플레이 패널;

광을 액정 디스플레이 패널에 제공하도록 위치된 지향성 백라이트(backlight); 및

액정 디스플레이 패널과 지향성 백라이트 사이에 배치된 양면형 프리즘 필름을 포함하고,

프리즘 필름은 액정 디스플레이 패널에 인접한 복수의 원통형 렌즈를 갖는 제1 표면과, 지향성 백라이트에 인접한 복수의 비연속적인 프리즘을 갖는, 제1 표면의 반대쪽에 있는 제2 표면을 포함하는 입체 3D 액정 디스플레이 모듈.

청구항 2

제1항에 있어서, 비연속적인 프리즘들은 프리즘들 각각 사이에서 평탄한 투과 부분을 포함하는 디스플레이 모듈.

청구항 3

제1항에 있어서, 비연속적인 프리즘들은 프리즘들 각각 사이에서 불투명 부분을 포함하는 디스플레이 모듈.

청구항 4

제1항에 있어서, 비연속적인 프리즘들 및 원통형 렌즈들이 일정한 피치(pitch)를 갖는 디스플레이 모듈.

청구항 5

제1항에 있어서, 비연속적인 프리즘들 및 원통형 렌즈들이 차등적인 피치를 갖는 디스플레이 모듈.

청구항 6

제1항에 있어서, 프리즘들의 중심들은 원통형 렌즈들의 중심들과 정렬되는 디스플레이 모듈.

청구항 7

제1항에 있어서, 프리즘들의 중심들은 원통형 렌즈들의 중심들로부터 오프셋된 디스플레이 모듈.

청구항 8

액정 디스플레이 패널;

광을 액정 디스플레이 패널에 제공하도록 위치된 지향성 백라이트 - 지향성 백라이트는

제1 측면, 제1 측면의 반대쪽에 있는 제2 측면, 제1 측면과 제2 측면 사이에서 연장되고 광을 실질적으로 방향 전환시키는 제1 표면, 및 제1 표면의 반대쪽에 있고 광을 액정 디스플레이 패널로 실질적으로 투과시키는 제2 표면을 갖는 도광체(light guide),

도광체의 제1 측면을 따라 배치된 제1 광원, 및

도광체의 제2 측면을 따라 배치된 제2 광원을 포함함 - ;

제1 광원 및 제2 광원에 전기적으로 결합된 동기 구동 요소(synchronization driving element) - 동기 구동 요소는 제1 측면과 제2 측면 사이에서 교번하는 순서로 제1 광원 또는 제2 광원 각각을 켜거나 끄는 것을 동기화시킴 - ; 및

액정 디스플레이 패널과 지향성 백라이트 사이에 배치된 양면형 프리즘 필름 - 프리즘 필름은 액정 디스플레이 패널에 인접한 복수의 원통형 렌즈를 갖는 제1 표면과, 지향성 백라이트에 인접한 복수의 비연속적인 프리즘을 갖는, 제1 표면의 반대쪽에 있는 제2 표면을 포함함 - 을 포함하는 입체 3D 액정 디스플레이 장치.

Microsoft Exhibit 1002 - Page 1353
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

청구항 9

제8항에 있어서, 제1 광원 및 제2 광원 각각은 하나 이상의 발광 다이오드를 포함하는 디스플레이 장치.

청구항 10

제8항에 있어서, 제1 표면에 인접하여 위치된 반사 필름, 및 반사 필름에 부착된 히트 싱크(heat sink)를 추가로 포함하는 디스플레이 장치.

청구항 11

제8항에 있어서, 비연속적인 프리즘들은 프리즘들 각각 사이에서 평탄한 투과 부분을 포함하는 디스플레이 장치.

청구항 12

제8항에 있어서, 비연속적인 프리즘들은 프리즘들 각각 사이에서 불투명 부분을 포함하는 디스플레이 장치.

청구항 13

제8항에 있어서, 비연속적인 프리즘들 및 원통형 렌즈들이 일정한 피치를 갖는 디스플레이 장치.

청구항 14

제8항에 있어서, 비연속적인 프리즘들 및 원통형 렌즈들이 차등적인 피치를 갖는 디스플레이 장치.

청구항 15

제8항에 있어서, 프리즘들의 중심들이 원통형 렌즈들의 중심들과 정렬되는 디스플레이 장치.

청구항 16

제8항에 있어서, 프리즘들의 중심들이 원통형 렌즈들의 중심들로부터 오프셋된 디스플레이 장치.

명 세 서

배 경 기 술

[0001] 3D/입체는 빠르게 성장하고 있는 기술이다. 이 기술은 많은 방식으로 구현된다. 사용자가 부가의 장비를 착용할 것을 요구하는 입체 해결책은 셔터 안경(shutter glasses), 편광 안경, 및 기타를 포함한다. 부가의 장비를 요구하지 않는 무안경 입체(autostereoscopic) 해결책은 관심이 증가하는 것이지만, 공간 다중화(spatially multiplexed) 접근법은 열등한 시청 경험을 제공할 수 있고, 양호한 품질의 무안경 입체 디스플레이를 제공하기 위한 시도에 있어서 몇몇 기술들이 개발되었다.

[0002] 몇몇 무안경 입체 해결책은 양면 상에서 연속적인 특징부들을 갖는 양면형 필름을 사용한다. 그러나, 이러한 특정 유형의 필름은 몇몇 단점들을 가질 수 있다. 얇은 랜드(land) - 렌즈 특징부와 기재(substrate) 사이에, 또는 프리즘 특징부와 기재 사이에, 또는 둘 모두에 있음 - 는 두께가 광학계(optics)에 의해 설정되지만, 랜드의 예리한 코너(corner) 및 얇음은 탈층(delamination)을 야기할 수 있다. 게다가, 양면형 필름 상의 특징부들의 체적 및 구조의 차이는 필름 뒤틀림(warping)을 악화시킬 수 있다. 광학적 견지에서 볼 때, 연속적인 특징부들을 갖는 양면형 필름은 또한 바람직할 수 있는 것보다 더 넓은 수평 시청 범위를 갖는다.

발명의 내용

[0003] 본 발명에 따른 입체 3D 액정 디스플레이 모듈은 액정 디스플레이 패널 및 광을 액정 디스플레이 패널에 제공하도록 배치된 지향성 백라이트(backlight)를 포함한다. 양면형 프리즘 필름이 액정 디스플레이 패널과 지향성 백라이트 사이에 배치된다. 프리즘 필름은 액정 디스플레이 패널에 인접한 복수의 원통형 렌즈를 갖는 제1 표면과, 제1 표면의 반대쪽에 있는, 지향성 백라이트에 인접한 복수의 비연속적인 프리즘을 갖는 제2 표면을 포함한다.

[0004] 본 발명에 따른 입체 3D 액정 디스플레이 장치는 액정 디스플레이 패널 및 광을 액정 디스플레이 패널에 제공하

Microsoft Exhibit 1002 - Page 1354
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

도록 배치된 지향성 백라이트를 포함한다. 지향성 백라이트는 제1 측면, 제1 측면의 반대쪽에 있는 제2 측면, 제1 측면과 제2 측면 사이에서 연장되는 제1 표면, 및 제1 표면의 반대쪽에 있는 제2 표면을 갖는 도광체(light guide)를 포함한다. 도광체의 제1 표면은 광을 실질적으로 방향전환시키고, 제2 표면은 광을 액정 디스플레이 패널로 실질적으로 투과시킨다. 지향성 백라이트는 또한 도광체의 제1 측면을 따라 배치된 제1 광원 및 도광체의 제2 측면을 따라 배치된 제2 광원을 포함한다. 동기 구동 요소(synchronization driving element)가 제1 광원 및 제2 광원에 전기적으로 결합되고, 동기 구동 요소는 제1 측면과 제2 측면 사이에서 교번하는 순서로 제1 광원 또는 제2 광원 각각을 켜거나 끄는 것을 동기화시킨다. 이 장치는 또한 액정 디스플레이 패널과 지향성 백라이트 사이에 배치된 양면형 프리즘 필름을 포함한다. 프리즘 필름은 액정 디스플레이 패널에 인접한 복수의 원통형 렌즈를 갖는 제1 표면과, 제1 표면의 반대쪽에 있는, 지향성 백라이트에 인접한 복수의 비연속적인 프리즘을 갖는 제2 표면을 포함한다.

도면의 간단한 설명

[0005] 본 발명은 첨부 도면과 관련하여 본 발명의 다양한 실시예에 대한 하기의 상세한 설명을 고려하여 더욱 완전하게 이해될 수 있다.

도 1은 예시적인 디스플레이 장치의 개략 측면도.

도 2a 및 도 2b는 동작 중인 예시적인 디스플레이 장치의 개략 측면도.

도 3a는 3D 필름을 제조하는 공정에서 사용되는 공구의 도면.

도 3b는 공구 상에 흑색 재료를 코팅하는 것을 도시하는 도면.

도 3c는 흑색 재료를 경화시키는 것을 도시하는 도면.

도 3d는 비연속적인 프리즘을 형성하기 위해 공구 상에 광학 수지를 코팅하는 것을 도시하는 도면.

도 4는 광학 수지를 경화시키는 것을 도시하는 도면.

도 5는 광학 필름에 프리즘을 형성하도록 공구로부터 제거되어진 경화된 수지의 도면.

도 6은 비연속적인 프리즘들 사이에서 블투명 섹션을 갖는 3D 필름을 형성하도록 광학 필름에 부가된 렌즈의 도면.

도 7은 비연속적인 프리즘들 사이에서 투과 부분을 갖는 3D 필름의 도면.

도면은 반드시 축척대로 도시된 것은 아니다. 도면에 사용된 유사한 도면 부호는 유사한 구성요소를 지칭한다. 그러나, 주어진 도면에서 구성요소를 지칭하기 위한 도면 부호의 사용은 동일한 도면 부호로 표시된 다른 도면의 구성요소를 제한하고자 하는 것이 아님을 이해할 것이다.

발명을 실시하기 위한 구체적인 내용

[0006] 하기 설명에서, 본 명세서의 일부를 형성하며, 몇몇 특정 실시예가 예로서 도시되어 있는 첨부 도면을 참조한다. 다른 실시예가 고려되며 본 발명의 범주 또는 사상으로부터 벗어남이 없이 이루어질 수 있음이 이해되어야 한다. 따라서, 하기 상세한 설명은 제한하는 의미로 취해져서는 안 된다.

[0007] 본 명세서에 사용된 모든 과학적 및 기술적 용어는 달리 명시되지 않는 한 당업계에서 통상적으로 사용되는 의미를 갖는다. 본 명세서에 제공된 정의는 본 명세서에 빈번하게 사용되는 소정 용어들의 이해를 용이하게 하기 위한 것이며 본 발명의 범주를 제한하고자 하는 것은 아니다.

[0008] 달리 표시되지 않는 한, 본 명세서 및 특허청구범위에서 사용되는 특징부의 크기, 양 및 물리적 특성을 표현하는 모든 수는 모든 경우 용어 "약"에 의해 수식되는 것으로 이해되어야 한다. 따라서, 반대로 표시되지 않는 한, 전술한 명세서 및 첨부된 특허청구범위에 개시되는 수치 파라미터는 본 명세서에 개시된 교시 내용을 이용하여 당업자가 얻고자 하는 원하는 특성에 따라 달라질 수 있는 근사치이다.

[0009] 종점(endpoint)에 의한 수치 범위의 언급은 그 범위 내에 포함되는 모든 수(예를 들어, 1 내지 5는 1, 1.5, 2, 2.75, 3, 3.80, 4 및 5를 포함함)와 그 범위 내의 임의의 범위를 포함한다.

[0010] 본 명세서 및 첨부된 특허청구범위에서 사용되는 바와 같이, 단수 형태("a", "an" 및 "the")는 그 내용이 명백하게 다르게 지시하지 않는 한 복수의 지시 대상을 갖는 실시예를 포함한다. 본 명세서 및 첨부된 특허청구범

Microsoft Exhibit 1002 - Page 1355
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

위에서 사용되는 바와 같이, "또는"이라는 용어는 일반적으로 그 내용이 명백하게 다르게 지시하지 않는 한 "및/또는"을 포함하는 의미로 이용된다.

[0011] "무안경 입체"라는 용어는 사용자 또는 시청자 쪽에서 특수한 헤드기어(headgear) 또는 안경을 사용하지 않고서 볼 수 있는 3차원 이미지를 디스플레이하는 것을 지칭한다. 이들 방법은 이미지가 평판형 장치에 의해 생성되더라도 시청자를 위한 깊이 지각(depth perception)을 생성한다. 입체 3D라는 용어는 무안경 입체 장치의 분야를 포함하지만, 평판형 장치로부터 입체 3D를 보는 데에 특수한 헤드기어, 전형적으로는 셔터 안경을 필요로 하는 입체 3D 디스플레이 경우를 또한 포함한다.

[0012] 본 발명은 백라이트형 액정 디스플레이 장치, 및 특히 비연속적인 프리즘들을 구비한 3D 필름을 갖는 액정 디스플레이 장치를 사용하여 입체 3D 이미지를 디스플레이하는 것에 관련된다. 본 발명에 따른 실시예는 셔터 안경 입체 3D 디스플레이 모드 또는 무안경 입체 디스플레이 모드 중 어느 하나로 평판형 디스플레이로부터 3D 시각화 능력을 제공할 수 있는 단일 디스플레이로 조합될 수 있다. 본 발명은 이로 한정되지 않으며, 본 발명의 다양한 태양에 대한 이해는 이하에 제공된 예들의 논의를 통해 얻을 수 있다.

[0013] 3D 디스플레이

[0014] 액정 디스플레이는 임의의 특정 지점에서의 이미지가 그 지점 또는 픽셀이 전형적으로 1/60초 또는 그보다 빠른 시간 내의 그 다음 이미지 리프레시 시간에 업데이트될 때까지 안정되어 있게 되는 샘플/홀드 디스플레이 장치이다. 그러한 샘플/홀드 시스템에서, 디스플레이의 순차적인 리프레시 기간 동안에 상이한 이미지들, 구체적으로는 3D 디스플레이를 위한 교번하는 좌 및 우 이미지들을 디스플레이하는 것은, 예를 들어 좌안 광원이 우안에 대한 데이터의 디스플레이 동안에 켜지지 않도록 그리고 그 반대의 경우도 성립하도록 백라이트 광원들의 주의 깊은 시퀀싱을 필요로 한다.

[0015] 도 1은 예시적인 디스플레이 장치(10)의 개략 측면도이다. 디스플레이 장치는 액정 디스플레이 패널(20), 및 광을 액정 디스플레이 패널(20)에 제공하도록 위치된 지향성 백라이트(30)를 포함한다. 지향성 백라이트(30)는 우안 이미지 고상(solid state) 광원(32) 또는 복수의 제1 광원(32) 및 좌안 이미지 고상 광원(34) 또는 복수의 제2 광원(34)을 포함하며, 이 광원들은 많은 실시 형태에서 적어도 90 헤르츠(Hertz)의 레이트로 우안 이미지 고상 광원(32)과 좌안 이미지 고상 광원(34) 사이에서 변조될 수 있다. 양면형 프리즘 필름(40)이 액정 디스플레이 패널(20)과 지향성 백라이트(30) 사이에 배치된다.

[0016] 액정 디스플레이 패널(20) 및/또는 지향성 백라이트(30)는 임의의 유용한 형상 또는 구성을 가질 수 있다. 많은 실시예에서, 액정 디스플레이 패널(20) 및 지향성 백라이트(30)는 정사각형 또는 직사각형 형상을 갖는다. 그러나, 몇몇 실시예에서, 액정 디스플레이 패널(20) 및/또는 지향성 백라이트(30)는 4개 초과의 변을 갖거나 곡선 형상이다. 본 발명이 셔터 안경 또는 하나 초과의 도광체를 필요로 하는 것들을 포함하는 임의의 입체 3D 백라이트 및 관련 액정 디스플레이 패널에 관한 것이지만, 본 발명은 무안경 입체 디스플레이에 특히 유용하다.

[0017] 동기 구동 요소(50)가 지향성 백라이트(30), 복수의 제1 및 제2 광원(32, 34) 및 액정 디스플레이 패널(20)에 전기적으로 접속된다. 동기 구동 요소(50)는, 플리커-프리 스틸 이미지 시퀀스(flicker-free still image sequence), 비디오 스트림(video stream) 또는 렌더링된 컴퓨터 그래픽(rendered computer graphic)을 생성하기 위해 이미지 프레임이 액정 디스플레이 패널(20)에 많은 실시예에서 초당 90 프레임 또는 그 이상의 레이트로 제공될 때, 우안 이미지 고상 광원(32) 및 좌안 이미지 고상 광원(34)의 활성화 및 비활성화(즉, 변조)를 동기화시킨다. 이미지(예컨대, 비디오 또는 컴퓨터 렌더링된 그래픽) 소스(60)가 동기 구동 요소(50)에 접속되어 이미지 프레임(예컨대, 우안 이미지 및 좌안 이미지)을 액정 디스플레이 패널(20)에 제공한다.

[0018] 액정 디스플레이 패널(20)은 임의의 유용한 투과형 액정 디스플레이 패널일 수 있다. 많은 실시예에서, 액정 디스플레이 패널(20)은 16 밀리초 미만, 또는 10 밀리초 미만, 또는 5 밀리초 미만의 프레임 응답 시간을 갖는다. 10 밀리초 미만, 또는 5 밀리초 미만, 또는 3 밀리초 미만의 프레임 응답 시간을 갖는 구매가능한 투과형 액정 디스플레이 패널은, 예를 들어 도시바 마쯔시타 디스플레이(Toshiba Matsushita Display, TMD)의 광학 보상 휨(optically compensated bend, OCB) 모드 패널 LTA090A220F(일본 소재의 도시바 마쯔시타 디스플레이 테크놀로지 컴퍼니, 리미티드(Toshiba Matsushita Display Technology Co., Ltd.))이다.

[0019] 지향성 백라이트(30)는 많은 실시예에서 적어도 90 헤르츠, 또는 100 헤르츠, 또는 110 헤르츠, 또는 120 헤르츠, 또는 120 헤르츠 초과의 레이트로 우안 이미지 고상 광원(32)과 좌안 이미지 고상 광원(34) 사이에서 변조될 수 있는 임의의 유용한 백라이트일 수 있다.

[0020] 도시된 지향성 백라이트(30)는 복수의 제1 광원(32) 또는 우안 이미지 고상 광원(32)에 인접한 제1 측면 또는

Microsoft Exhibit 1002 - Page 1356
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1357
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

제1 광 입력 표면(31), 및 복수의 제2 광원(34) 또는 좌안 이미지 고상 광원(34)에 인접한 대향하는 제2 측면(33) 또는 제2 광 입력 표면(33)을 포함한다. 제1 표면(36)이 제1 측면(31)과 제2 측면(33) 사이에서 연장하며, 제1 표면(36) 반대편의 제2 표면(35)이 제1 측면과 제2 측면(33) 사이에서 연장한다. 제1 표면(36)은 광을 실질적으로 방향전환시키며(예컨대, 반사, 추출 등), 제2 표면(35)은 광을 실질적으로 투과시킨다. 많은 실시예에서, 고 반사성 표면이 제1 표면(36) 상에 또는 그에 인접하게 위치되어, 제2 표면(35)을 통해 나오는 광을 방향전환시키는 것을 보조한다.

[0021] 많은 실시예에서, 제1 표면(36)은, 예컨대 도시된 바와 같은 선형 프리즘 또는 렌즈형(lenticular) 특징부와 같은 복수의 추출 요소를 포함한다. 많은 실시예에서, 선형 프리즘 또는 렌즈형 특징부는 제1 측면(31) 및 제2 측면(33)에 평행한 또는 양면형 프리즘 필름(40)의 선형 프리즘 및 렌즈형 특징부에 평행한 방향으로 연장할 수 있다.

[0022] 고상 광원은, 예를 들어 적어도 90 헤르츠의 레이트로 변조될 수 있는 임의의 유용한 고상 광원일 수 있다. 많은 실시예에서, 고상 광원은, 예를 들어 니치아(Nichia) NSSW020B(일본 소재의 니치아 케미칼 인더스트리즈, 리미티드(Nichia Chemical Industries, Ltd.))와 같은 복수의 발광 다이오드이다. 다른 실시예에서, 고상 광원은 복수의 레이저 다이오드 또는 유기 발광 다이오드(즉, OLED)이다. 고상 광원은 적색, 청색 및/또는 녹색과 같은 많은 수의 가시광 파장들, 또는 파장들의 범위 또는 조합을 방출하여, 예컨대 백색 광을 생성할 수 있다. 지향성 백라이트는 양 단부에 광원을 갖는 광학적으로 투명한 재료의 단일 층이거나, 각각의 층에 대해 원하는 방향으로 우선적으로 광을 추출하는 각각의 층에 대한 광원을 갖는 광학적으로 투명한 재료의 2개(또는 그 이상)의 층일 수 있다.

[0023] 양면형 프리즘 필름(40)은 제1 면 상의 렌즈형 구조체 및 대향하는 면 상의 프리즘형 구조체를 갖는 임의의 유용한 프리즘 필름일 수 있다. 양면형 프리즘 필름(40)은 시청자가 디스플레이되는 이미지에서 깊이를 지각하도록 적절한 각도로 지향성 백라이트로부터 액정 디스플레이 패널(20)로 광을 투과시킨다. 유용한 양면형 프리즘 필름은, 둘 모두 마치 완전히 기재된 것처럼 본 명세서에 참고로 포함된 미국 특허 제7,224,529호 및 제7,210,836호에 기술되어 있다.

[0024] 이미지 소스(60)는, 예를 들어 비디오 소스 또는 컴퓨터 렌더링된 그래픽 소스와 같은 이미지 프레임(예를 들어, 우안 이미지 및 좌안 이미지)을 제공할 수 있는 임의의 유용한 이미지 소스일 수 있다. 많은 실시예에서, 비디오 소스는 50 내지 60 헤르츠 또는 그 이상의 이미지 프레임을 제공할 수 있다. 많은 실시예에서, 컴퓨터 렌더링된 그래픽 소스는 100 내지 120 헤르츠 또는 그 이상의 이미지 프레임을 제공할 수 있다.

[0025] 컴퓨터 렌더링된 그래픽 소스는 게임 컨텐츠, 의료 영상 컨텐츠, CAD(computer aided design) 컨텐츠 등을 제공할 수 있다. 컴퓨터 렌더링된 그래픽 소스는, 예를 들어 엔비디아(Nvidia) FX5200 그래픽 카드, 엔비디아 지포스(GeForce) 9750 GTX 그래픽 카드, 또는 랩톱 컴퓨터(laptop computer)와 같은 모바일 솔루션(mobile solution)의 경우에는 엔비디아 지포스 GO 7900 GS 그래픽 카드와 같은 그래픽 처리 장치를 포함할 수 있다. 컴퓨터 렌더링된 그래픽 소스는 또한, 예를 들어 오픈지엘(OpenGL), 다이렉트엑스(DirectX), 또는 엔비디아 독점(proprietary) 3D 스테레오 드라이버(stereo driver)와 같은 적절한 스테레오 드라이버 소프트웨어를 포함할 수 있다.

[0026] 비디오 소스는 비디오 컨텐츠를 제공할 수 있다. 비디오 소스는, 예를 들어 엔비디아 쿼드로(Quadro) FX1400 그래픽 카드와 같은 그래픽 처리 장치를 포함할 수 있다. 비디오 소스는 또한, 예를 들어 오픈지엘, 다이렉트엑스, 또는 엔비디아 독점 3D 스테레오 드라이버와 같은 적절한 스테레오 드라이버 소프트웨어를 포함할 수 있다.

[0027] 동기 구동 요소(50)는 플리커-프리 비디오 또는 렌더링된 컴퓨터 그래픽을 생성하기 위해 액정 디스플레이 패널(20)에 예컨대 초당 90 프레임 또는 그 이상의 레이트로 제공되는 이미지 프레임과 우안 이미지 고상 광원(32) 및 좌안 이미지 고상 광원(34)의 동기 활성화 및 비활성화(즉, 변조)를 제공하는 임의의 유용한 구동 요소를 포함할 수 있다. 동기 구동 요소(50)는 주문제작된 고상 광원 구동 회로에 결합되는, 예를 들어 웨스타(Westar) VP-7 비디오 어댑터(미국 미주리주 세인트 찰스 소재의 웨스타 디스플레이 테크놀로지즈, 인크.(Westar Display Technologies, Inc.))와 같은 비디오 인터페이스를 포함할 수 있다.

[0028] 도 2a 및 도 2b는 동작 중인 예시적인 디스플레이 장치(10)의 개략 측면도이다. 도 2a에서, 좌안 이미지 고상 광원(34)(즉, 복수의 제2 광원(34))이 조명되고 우안 이미지 고상 광원(32)(즉, 복수의 제1 광원(32))이 조명되지 않는다. 이러한 상태에서, 좌안 이미지 고상 광원(34)으로부터 방출된 광은 지향성 백라이트(30)를 통해,

양면형 프리즘 시트(40)를 통해 그리고 액정 패널(20)로 투과하여, 시청자 또는 관찰자의 좌안(1a)을 향해 지향되는 좌안 이미지를 제공한다. 도 2b에서, 우안 이미지 고상 광원(32)이 조명되고 좌안 이미지 고상 광원(34)이 조명되지 않는다. 이러한 상태에서, 우안 고상 광원(32)으로부터 방출된 광은 지향성 백라이트(30)를 통해, 양면형 프리즘 시트(40)를 통해 그리고 액정 패널(20)로 투과하여, 시청자 또는 관찰자의 우안(1b)을 향해 지향되는 우안 이미지를 제공한다. 우안 고상 광원(32)이 도광체의 우측에 배치되고 좌안 이미지 고상 광원(34)이 도광체의 좌측에 배치되어 있지만, 몇몇 실시예에서는, 우안 고상 광원(32)이 도광체의 좌측에 배치되고 좌안 이미지 고상 광원(34)이 도광체의 우측에 배치된다는 것을 이해하여야 한다.

[0029] 광원(32, 34)은 백라이트 도광체에 공기 결합(air coupled) 또는 굴절률 정합될 수 있다. 예를 들어, 패키징된 광원 소자(예컨대, LED)는 굴절률 정합 재료 없이 도광체에 에지-결합(edge-coupled)될 수 있다. 대안적으로, 패키징된 또는 베어 다이(bare die) LED가 효율 향상을 위해 도광부의 에지에서 굴절률 정합되고/되거나 봉지될 수 있다. 이러한 특징부는 입력 광을 효율적으로 전달하기 위해 도광체의 단부에 추가의 광학 특징부, 예를 들어 주입 웨지 형상부(injection wedge shape)를 포함할 수 있다. LED는 대안적으로 LED 광을 도광체의 내부 전반사(total internal reflection, TIR) 모드로 효율적으로 집광 및 시준하기 위해 적절한 특징부를 갖고서 도광체의 에지 또는 측면(31, 33)에 대립될 수 있다.

[0030] 액정 디스플레이 패널(20)은, 변동될 수 있지만 본 예의 목적을 위해서는 60 Hz 리프레시 레이트로 추정되는 리프레시 또는 이미지 업데이트 레이트를 갖는다. 이는 새로운 이미지가 매 1/60 초 또는 16.67 밀리초(msec)마다 시청자에게 제공된다는 것을 의미한다. 3D 시스템에서, 이는 시각 t=0에서 프레임 1의 우측 이미지가 제공되는 것을 의미한다. 시각 t=16.67 msec에서, 프레임 1의 좌측 이미지가 제공된다. 시각 t=2*16.67 msec에서, 프레임 2의 우측 이미지가 제공된다. 시각 t=3*16.67 msec에서, 프레임 2의 좌측 이미지가 제공되며, 이와 같이 이러한 과정이 반복된다. 유효 프레임 레이트는 보통의 영상 시스템의 프레임 레이트의 절반인데, 그 이유는 각각의 이미지에 대해 그 이미지의 좌안 및 우안 뷰(view)가 제공되기 때문이다.

[0031] 이러한 예에서, 시각 t=0에서 우측(또는 좌측) 이미지를 조명하도록 복수의 제1 광원을 켬으로써 각각 우측(또는 좌측) 이미지에 광이 제공된다. 시각 t=16.67 msec에서, 좌측 또는 우측의 제2 이미지가 제자리에 놓이기 시작한다. 이러한 이미지는 "시각 t=0 이미지"를 LCD 패널의 상부로부터 LCD의 하부로 대체하며, 이는 본 예에서 완료하는 데 16.67 msec가 걸린다. 비-스캐닝된 해결책은 복수의 제1 광원 모두를 끄고 이어서 복수의 제2 광원 모두를 켜며, 때때로 이러한 변이 중에 동상적으로 낮은 휘도의 디스플레이를 초래하는데, 그 이유는 3D 크로스토크(cross talk) 및 열등한 3D 시청 경험으로 이어질 수 있는 부정확한 광원으로 순차적 좌우 이미지가 조명되지 않는 경우 이미지 데이터가 전체 이미지에 걸쳐 안정되거나 적절히 그래야만 하기 때문이다.

[0032] 시청자에게 초당 적어도 45개 좌안 이미지 및 적어도 45개 우안 이미지를 제공하면(우안 이미지와 좌안 이미지 사이에 교번시키며, 이미지들은 가능하게는 이전 이미지 쌍의 반복임) 시청자에게 플리커-프리 3D 이미지를 제공하게 된다. 그에 따라, 광원(32, 34)의 스위칭과 동기화하여 디스플레이될 때, 컴퓨터 렌더링된 이미지 또는 스틸 이미지 카메라 또는 비디오 이미지 카메라로부터 획득된 이미지로부터 상이한 좌 및 우 시점 이미지 쌍을 디스플레이하는 것은 시청자가 2개의 상이한 이미지를 시각적으로 융합시켜 평판 디스플레이로부터 깊이를 지각할 수 있게 한다. 이러한 시각적 플리커-프리 동작의 한계는 전술한 바와 같이 액정 디스플레이 패널 상에 디스플레이되는 신규 이미지가 안정될 때까지 백라이트가 켜져서는 안된다는 것이며, 그렇지 않을 경우 크로스토크 및 열등한 입체 이미지가 지각될 것이다.

[0033] 본 명세서에 기술된 지향성 백라이트(30) 및 관련 광원(32, 34)은, 예를 들어 5 밀리미터 미만, 또는 0.25 내지 5 밀리미터, 또는 0.5 내지 4 밀리미터, 또는 0.5 내지 2 밀리미터와 같이 (두께 또는 직경이) 매우 얇을 수 있다.

[0034] 3D 필름

[0035] 본 발명의 실시예들은 연속적인 프리즘들을 갖는 특정 유형의 양면형 필름의 상기한 단점들을 감소시키는 데 도움을 준다. 프리즘의 피크가 양호한 무안경 입체 광학 효과를 정의하는 데 필수적인 요소이기 때문에, 본 발명의 실시예들은 프리즘들의 기부들 사이에 프리즘들을 비연속적으로 만드는 평탄부 또는 공간을 제공한다. 이러한 특징부는 랜드 두께를 증가시키며, 필름 기재 부근에서의 특징부의 예리함을 감소시키도록, 특히 프리즘과 랜드 사이의 급격한 전이보다 오히려 곡률을 제공하도록 맞춤될 수 있는데, 이는 필름의 기계적 안정성을 향상시키고 균열 및 탈층을 방지하고 필름 뒤틀림을 감소시킨다. 부가의 실시예는 축외(off-axis) 광을 감소시킬 수 있는, 흑색 또는 불투명(광 흡수) 특징부를 비연속적인 프리즘들 사이의 구조 내에 배치하는 것을 포함한다.

Microsoft Exhibit 1002 - Page 1358
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

[0036] 도 3a와 도 3b 및 도 4는 비연속적인 프리즘을 갖는 양면형 3D 프리즘 필름을 제조하는 공정을 도시한다. 도 3a는 3D 필름을 제조하는 공정에서 사용되는 공구의 일부분의 도면이다. 공구는 일련의 비연속적인 절두 프리즘(41)들을 포함한다. 예시 목적을 위해 단지 하나의 프리즘만이 도시되어 있지만, 공구는 3D 필름을 제조하는 데 필요한 또는 요구되는 만큼 많은 비연속적인 프리즘 특징부들을 갖는다. 프리즘(41)의 절두 부분은 웰(well, 42) 또는 평탄부를 형성할 수 있거나, 프리즘을 절단하는 데 사용되는 공정은 프리즘들 사이에 전형적으로 평탄한 원래의 공구 표면을 남길 수 있다. 공구는, 예를 들어, 마치 완전히 기재된 것처럼 본 명세서에 참고로 포함된 PCT 공개 출원 WO 00/48037호에 기술된 일반적인 다이아몬드 선삭 기술을 사용하여 제조될 수 있다.

[0037] 도 3b는 공구(41) 상에 일 유형의 보조 재료인 불투명 재료를 코팅하는 것을 도시하는 도면이다. 키스(kiss) 코팅 공정에서 각각의 프리즘(41)의 절두 부분(42) 상에 불투명 재료(43)가 도포된다. 3D 필름에 사용하는 불투명 재료의 일례는 하기를 포함한다: 바람직하게는 안료로서 카본 블랙을 갖고 결합제로서 광 경화성 아크릴레이트를 갖는 흑색 안료 충전된 경화성 결합제; 흑색 또는 원하는 파장의 임의의 흡수성 색상을 포함하는 잉크; 안료 충전된 수지; 및 카본 블랙이 로딩된(loaded) UV 경화성 아크릴레이트. 불투명 재료에서, 계면 반사를 최소화하기 위해 결합제 굴절률이 결합제가 부착되는 층의 굴절률과 정합하는 것이 바람직할 수 있다. 다른 실시예들에서, 다른 원하는 광학 효과를 달성하기 위해 결합제 굴절률이 결합제가 부착되는 층의 굴절률과 상이한 것이 바람직할 수 있다.

[0038] 도 3c에 도시된 바와 같이, 코팅된 불투명 재료(43)는 이어서 경화된다. 도 3d는 공구 상에 광학 수지를 코팅하는 것을 도시하는 도면이다. 불투명 재료(43)가 경화된 후에, 광학 수지 재료(44)가 공구 상에 코팅되어 프리즘(41)을 덮는다. 코팅 후에, 도 4에 도시된 바와 같이 광학 수지 재료가 경화되고, 이어서 공구(41)로부터 제거된다.

[0039] 도 5는 불투명 재료에 의해 분리된 비연속적인 프리즘(44)들을 갖는 광학 필름의 일면을 형성하도록 공구로부터 제거되어진 경화된 광학 수지의 도면이다. 완전한 양면형 프리즘 필름을 형성하기 위해, 도 6에 도시된 바와 같이, 원통형 렌즈(45)가 광학 필름의 반대쪽 표면에 부가된다. 렌즈는 원통형 홈을 갖는 다른 공구를 사용하여 광학 필름의 반대쪽 면에 코팅되고 이어서 경화되며 상기 다른 공구로부터 제거되도록 부가될 수 있다. 3D 필름을 위한 렌즈 및 프리즘은, 예를 들어 연속 캐스트 및 경화(continuous cast and cure, 3C)와 같은 미세복제 공정을 사용하여 제조될 수 있다. 3C 공정의 일례가, 모두 마치 완전히 기재된 것처럼 본 명세서에 참고로 포함된 하기의 특허들에 기술되어 있다: 미국 특허 제4,374,077호, 제4,576,850호, 제5,175,030호, 제5,271,968호, 제5,558,740호, 및 제5,995,690호. 둘 모두 마치 완전히 기재된 것처럼 본 명세서에 참고로 포함된 미국 특허 제7,165,959호 및 제7,224,529호에 기술된 바와 같이, 렌즈는 반대 표면들 상에서 미세복제된 정렬된 패턴들을 갖는 광학 필름을 제조하는 방법을 사용하여 3D 필름에서 프리즘과 정렬될 수 있다. 미세복제된 구조물이 생성되게 하는 액체는 전형적으로 경화성 광중합성 재료, 예를 들어 UV 광에 의해 경화가능한 아크릴레이트이다. 다른 코팅 재료, 예를 들어 중합성 재료가 사용될 수 있고, 재료의 선택은 미세복제된 구조물에 대해 요구되는 특정 특성에 의존할 수 있다. 이 공정에서 사용하기 위한 경화 방법의 예에는 반응성 경화, 열경화, 또는 방사선 경화가 포함된다. 전술된 바와 같이, 프리즘들 사이의 보조 재료가 불투명할 수 있지만, 프리즘들 사이에 다른 유용한 특성, 예를 들어 상이한 굴절률, 복굴절, 기계적 탄성 등을 갖는 재료를 부가함으로써 유용한 광학 효과가 얻어질 수 있다.

[0040] 전술된 바와 같이 미세복제된 특징부를 형성하는 공구 상에 보조 재료가 또한 도포될 필요가 없다. 예를 들어, 상기 재료가 증발성 담체(carrier) 내로 로딩될 수 있고, 담체 및 재료가 양면형 필름의 원하는 면 상에 코팅될 수 있으며, 담체가 증발될 수 있다. 이 기술은 도 5 및 도 6에 도시된 바와 같이 보조 재료의 침착물을 형성할 수 있는, 로딩된 재료의 잔류물을 남길 것이다.

[0041] 도 6은 비연속적인 프리즘들 사이에서 불투명 섹션을 갖는 양면형 프리즘 필름을 형성하도록 광학 필름에 부가된 렌즈의 도면이다. 도 6에 도시된 바와 같이, 3D 필름은 기재 부분(46), 기재(46)의 일면 상에 있는 일련의 렌즈(45)들, 및 기재(46)의 반대쪽 면에 있는, 불투명 부분(43)들에 의해 분리된 일련의 비연속적인 프리즘(44)들을 포함한다. 렌즈 면 상의 랜드 부분(55) 및 렌티큘러(lenticular) 면 상의 랜드 부분(56) 각각은 기계적 및 광학적 요건에 대해 조절될 수 있다.

[0042] 특정 구현에 기초하여 렌즈 및 프리즘의 피치(pitch)가 조절될 수 있다. 렌즈와 관련하여 "피치"라는 용어는, 거리(51, 52)로 나타낸 바와 같이, 인접한 렌즈들의 중심들 사이의 거리를 말한다. 프리즘과 관련하여 "피치"라는 용어는, 거리(53, 54)로 나타낸 바와 같이, 인접한 프리즘들의 중심들 사이의 거리를 말한다.

Microsoft Exhibit 1002 - Page 1359
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

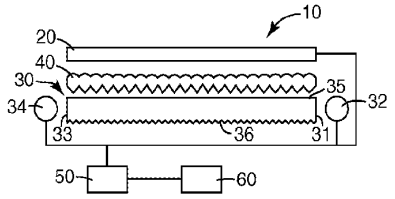
[0043] 대안적인 실시예는 비연속적인 프리즘들 사이에서 투과 부분을 갖는 3D 필름을 포함한다. 도 7에 도시된 바와 같이, 이러한 대안적인 실시예의 양면형 프리즘 필름은, 기재 부분(46), 기재(46)의 일면 상에 있는 일련의 렌즈(45)들, 및 기재(46)의 반대쪽 면에 있는, 투과 부분(47)들에 의해 분리된 일련의 비연속적인 프리즘(44)들을 포함한다. 이 필름은, 불투명 재료가 없이 경화된 광학 수지의 부분들에 의해 프리즘들이 분리되도록 도 3b 및 도 3c에 도시된 단계들이 생략될 수 있다는 것을 제외하고는, 도 6에 도시된 필름과 유사한 방식으로 제조될 수 있다. 게다가, 프리즘을 형성하는 공구는 비연속적인 프리즘(44)들 사이에서 실질적으로 평탄한 투과 부분을 형성하기 위해 웰(42)보다는 오히려 실질적으로 평탄한 상부를 포함할 수 있다. 도 7에 도시된 필름에서, 렌즈 면에 있는 랜드 부분(55) 및 렌티큘러 면에 있는 랜드 부분(56) 각각은 기계적 및 광학적 요건에 대해 조절될 수 있다. 도 6 및 도 7에서 렌즈들이 연속적인 것으로 도시되어 있지만, 렌즈들은 대안적으로 비연속적으로 제조될 수 있다.

[0044] 도 6 및 도 7의 3D 필름에서, 렌즈들 및 프리즘들은 일정한 피치 또는 차등적인(differential) 피치를 가질 수 있다. "일정한 피치"라는 용어는 렌즈들의 피치가 프리즘들의 피치와 동일하도록 설계된다는 것, 예를 들어 가능하게는 제조 공정에 기초한 용인가능한 허용범위 내에서 거리(51, 52)가 거리(53, 54)와 실질적으로 동일하다는 것을 의미한다. "차등적인 피치"라는 용어는 렌즈들의 피치가 프리즘들의 피치와 상이하도록 설계된다는 것, 예를 들어 거리(51, 52)가 거리(53, 54)와 동일하지 않다는 것을 의미한다. 또한, 피치에 기초하여, 프리즘들의 중심들이 렌즈들의 중심들과 정렬되도록, 또는 대안적으로 프리즘들의 중심이 렌즈들의 중심으로부터 오프셋되도록, 렌즈와 프리즘 사이의 정렬을 설계하는 것이 가능하다. 상기한 특허들에서의 미세복제된 정렬된 패턴을 갖는 필름을 제조하는 공정에 의해 어느 쪽의 유형의 정렬도 달성될 수 있다.

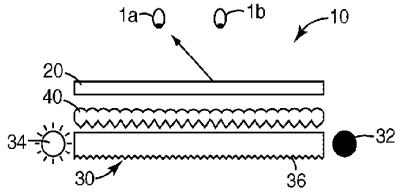
[0045] 렌즈들 및 프리즘들의 피치에 대한 바람직한 치수는 보통, 예를 들어 3D 필름을 포함하는 LCD 패널에서 무아레(moire) 패턴을 제거하거나 감소시킬 피치를 선택함으로써 결정된다. 피치는 또한 제조성(manufacturability)에 기초하여 결정될 수 있다. 3D 필름을 위한 예시적인 피치 치수는 하기를 포함한다: 26 마이크로미터, 29 마이크로미터, 29.5 마이크로미터, 70.5 마이크로미터, 및 52 마이크로미터. LCD 패널이 상이한 픽셀 피치로 제조될 때, 상이한 픽셀 피치를 수용하기 위해 3D 필름의 피치를 변경하는 것이 요구될 수 있다. 3D 필름에 유용한 피치 범위의 일례는 10 마이크로미터 내지 80 마이크로미터이다.

도면

도면1

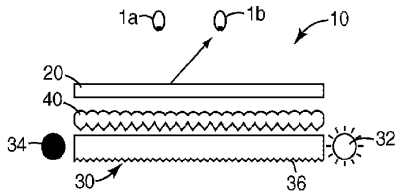


도면2a

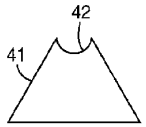


Microsoft Exhibit 1002 - Page 1360
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

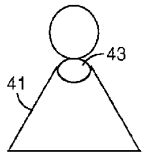
도면2b



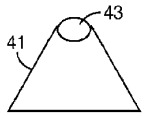
도면3a



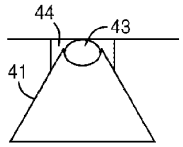
도면3b



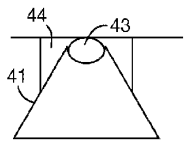
도면3c



도면3d

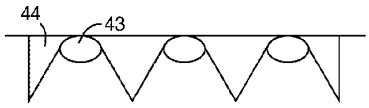


도면4

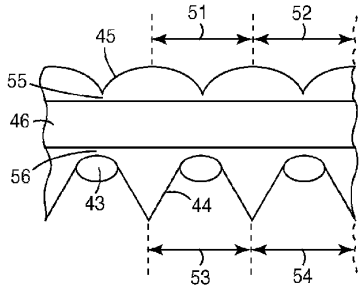


Microsoft Exhibit 1002 - Page 1361
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

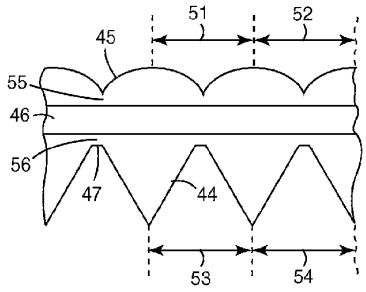
도면5



도면6



도면7



Microsoft Exhibit 1002 - Page 1362
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

KR 10-2012-0049890 A

Title: EFFICIENT COLLIMATION OF LIGHT WITH OPTICAL WEDGE

DWPI Abstract

Novelty: The collimator has an optical waveguide/wedge (100) having a viewing surface (150) that comprises a second light interface extending between the thin and thick ends (110,120). The viewing surface has a critical angle of internal reflection with respect to a normal of the viewing surface. A back surface opposing the viewing surface is reflective to internally incident light at the critical angle of internal reflection. A collimating end reflector (125) arranged at the thick end of the optical waveguide, which comprises a faceted lens structure.

Use: Optical collimator e.g. lenses or curved mirror in flashlight or car headlamp for use as backlight for LCD.

Advantage: Allows reduction in size of the volume between a light source and wedge surface with increased optical efficiency of the optical wedge.

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(85) 번역문제출일자 2012년02월20일
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(87) 국제공개번호 WO 2011/022625
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12/621,399 2009년11월18일 미국(US)
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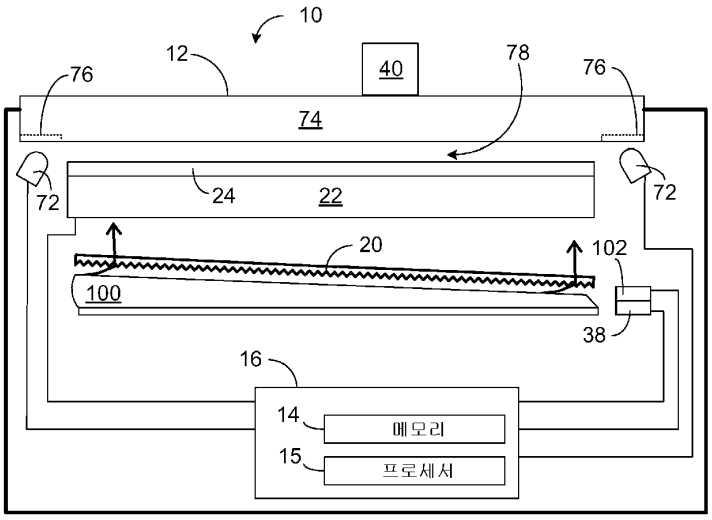
전체 청구항 수 : 총 15 항

(54) 발명의 명칭 **광학 웨지에 의한 효율적인 광 콜리메이션**

(57) 요 약

광 콜리메이터의 실시예들이 개시된다. 예를 들어, 개시된 일 실시예는, 제 1 말단, 제 1 말단을 대향하는 제 2 말단, 제 1 말단 및 제 2 말단 사이에 적어도 부분적으로 연장된 관찰면, 및 관찰면을 대향하는 후면을 가진 광 도파관을 포함한다. 관찰면은 제 1 내부 반사 임계각을 포함하고, 후면은 제 1 내부 반사 임계각에서 반사하도록 구성된다. 또한, 말단 반사경은 광 도파관의 제 2 말단에 배치되고, 제 1 말단에 균일광이 주입될 때 관찰면의 대부분이 균일하게 조명되고, 또한 주입된 광의 대부분이 관찰면을 빠져나가게 하기 위해 패싯화된 렌즈 구조를 포함한다.

대 표 도



Microsoft Exhibit 1002 - Page 1364
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

(72) 발명자

에머튼 네일

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Microsoft Exhibit 1002 - Page 1365
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1366
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

특허청구의 범위

청구항 1

광 도파관을 포함하는 광 콜리메이터에 있어서,

상기 광 도파관은

제 1 광 인터페이스를 포함하는 제 1 말단,

상기 제 1 말단 반대편의 제 2 말단,

상기 제 1 말단 및 제 2 말단 사이에 적어도 부분적으로 연장된 제 2 광 인터페이스를 포함하고, 자신의 법선에 대한 제 1 내부 반사 임계각(first critical angle of internal reflection)을 가진 관찰면,

상기 관찰면에 대향하는 후면 - 상기 후면은 상기 제 1 내부 반사 임계각에서 내부적으로 입사된 광을 반사하도록 구성됨 -,

상기 광 도파관의 상기 제 2 말단에 배치된 말단 반사경을 포함하고,

상기 말단 반사경은, 상기 제 1 말단에 균일광이 주입될 때 상기 관찰면의 대부분이 균일하게 조명되게 하고 또한 상기 주입된 광의 대부분이 상기 관찰면을 빠져나가게 하도록 경사진 복수의 패싯들을 포함하는 패싯화된 렌즈 구조(faceted lens structure)를 포함하는

광 콜리메이터.

청구항 2

제 1 항에 있어서,

상기 광 도파관의 상기 제 1 말단은 얇은 말단이며, 상기 광 도파관의 상기 제 2 말단은 두꺼운 말단인 광 콜리메이터.

청구항 3

제 1 항에 있어서,

상기 말단 반사경은 구형으로 곡선을 이루는 광 콜리메이터.

청구항 4

제 1 항에 있어서,

상기 말단 반사경의 패싯화된 렌즈 구조의 복수의 패싯들은 상기 관찰면을 바라보는 복수의 패싯들과 상기 후면을 바라보는 복수의 패싯들을 포함하고, 상기 관찰면을 바라보는 각 패싯이 상기 후면을 바라보는 패싯과 인접하여 배치되는 광 콜리메이터.

청구항 5

제 4 항에 있어서,

상기 관찰면을 바라보는 각 패싯은 90 도와 상기 제 1 임계각 간의 차이의 3/8인, 상기 말단 반사경의 표면 법선에 대한 각도를 형성하는 광 콜리메이터.

Microsoft Exhibit 1002 - Page 1367
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

청구항 6

제 4 항에 있어서,

상기 후면을 바라보는 각 패싯은 90 도와 상기 제 1 임계각 간의 차이의 3/8과 동일한, 상기 말단 반사경의 표면 법선에 대한 각도를 형성하는 광 콜리메이터.

청구항 7

제 4 항에 있어서,

상기 관찰면을 바라보는 각 패싯의 높이가 500 미크론(micron)보다 작고, 상기 후면을 바라보는 각 패싯의 높이가 500 미크론보다 작은 광 콜리메이터.

청구항 8

제 1 항에 있어서,

상기 후면은, 상기 반사시키는 후면의 법선에 대한 제 2 내부 반사 임계각을 포함하고, 상기 제 2 반사 임계각은 상기 제 1 반사 임계각보다 작은 광 콜리메이터.

청구항 9

제 1 항에 있어서,

상기 광 도파관의 상기 관찰면이 피복재를 포함하는 광 콜리메이터.

청구항 10

제 1 항에 있어서,

상기 광 도파관의 상기 후면이 피복재를 포함하는 광 콜리메이터.

청구항 11

제 1 항에 있어서,

상기 후면이 거울을 포함하는 광 콜리메이터.

청구항 12

제 1 항에 있어서,

상기 광 도파관은 제 1 반사 측면 및 제 2 반사 측면을 더 포함하고, 상기 제 1 반사 측면은 상기 제 2 반사 측면의 반대편에 있고, 상기 각 반사 측면은 상기 제 1 말단으로부터 상기 제 2 말단까지 또한, 상기 관찰면으로부터 상기 후면까지 연장된 광 콜리메이터.

청구항 13

광 도파관을 통해 광을 콜리메이션하는 방법에 있어서,

상기 광 도파관은 제 1 말단, 상기 제 1 말단 반대편의 제 2 말단, 말단 반사경, 상기 제 1 말단 및 제 2 말단

사이에서 연장되는 관찰면 및 상기 관찰면에 대향하는 후면을 포함하고,

상기 방법은

상기 광 도파관의 제 1 말단에 광을 주입하는 단계,

내부 전 반사를 통해 상기 말단 반사경에 상기 광을 전달하는 단계,

상기 말단 반사경으로부터 광을 내부적으로 반사시키는 단계,

광의 제 1 부분을 반사 임계각에서 상기 관찰면으로부터 방출하는 단계,

광의 제 2 부분을 상기 반사 임계각과 동일한 각도로 상기 후면으로부터 내부적으로 반사시키고, 상기 후면에서 광의 상기 제 2 부분이 내부적으로 반사된 후, 상기 관찰면으로부터 광의 상기 제 2 부분을 방출하는 단계를 포함하는 방법.

청구항 14

제 13 항에 있어서,

상기 말단 반사경으로부터 광을 반사시키는 단계는 제 1 패싯 집합과 제 2 패싯 집합으로부터 광을 반사시키는 단계를 포함하고, 상기 제 1 패싯 집합의 각 패싯은 적어도 부분적으로는 상기 관찰면을 향하는 법선을 포함하고, 상기 제 2 패싯 집합의 각 패싯은 적어도 부분적으로는 상기 후면을 향하는 법선을 포함하는 방법.

청구항 15

제 14 항에 있어서,

상기 제 1 패싯 집합의 각 패싯은 90 도와 상기 반사 임계각 간의 차이의 3/8인 각도를 갖고, 상기 제 2 패싯 집합의 각 패싯은 90 도와 상기 반사 임계각 간의 차이의 3/8인 각도를 갖는 방법.

명 세 서

배 경 기 술

[0001] 광 콜리메이터(optical collimator)는 전구 또는 LED(light emitting diode)과 같은 점광원(point source of light)으로부터의 광선들을 모아서 이들 광선이 표면과 평행하게 나오게 하는 장치이다. 콜리메이터의 예로 손전등이나 자동차 전조등에서 볼 수 있는 렌즈 또는 곡면 거울(curved mirrors)을 들 수 있다. 이러한 예에서, 점광원과 콜리메이션된 광선이 나오는 표면 사이에 공간이 존재한다. 몇몇 사용 환경에서는, 이러한 공간이 콜리메이터를 이용하는 광학 장치의 전체적인 크기를 증가시키기 때문에 곤란할 수 있다.

발명의 내용

과제의 해결 수단

[0002] 따라서, 광 콜리메이터에 관련된 다양한 실시예들이 본원에 개시된다. 예를 들어, 개시된 일 실시예에서 광 콜리메이터가 제공되며, 광 콜리메이터는 제 1 광 인터페이스를 포함하는 제 1 말단, 제 1 말단을 대향하는 제 2 말단, 제 1 말단 및 제 2 말단 사이에 적어도 부분적으로 연장된 제 2 광 인터페이스를 포함하는 관찰면 및 관찰면을 대향하는 후면을 가진 광 도파관을 포함한다. 관찰면은 자신의 법선에 대한 제 1 내부 반사 임계각을 포함하고, 후면은 제 1 내부 반사 임계각에서 반사하도록 구성된다. 또한, 말단 반사경은 광 도파관의 제 2 말단에 배치되고, 제 1 말단에 균일광이 주입될 때 관찰면의 대부분이 균일하게 조명되고, 또한 주입된 광의 대부분이 관찰면을 빠져나가게 하기 위해 경사진 복수의 패싯들을 포함하는 패싯화된 렌즈 구조를 포함한다.

[0003] 본 요약은 아래의 상세한 설명에서 추가적으로 설명되는 일련의 컨셉을 간략한 형태로 소개한다. 본 요약은 특허 청구된 대상의 핵심 특징이나 필수 특징을 밝히기 위한 것이 아니며, 특허 청구된 대상의 범위를 제한하기

Microsoft Exhibit 1002 - Page 1368
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

위해 사용된 것도 아니다. 또한, 특허 청구된 대상은 본 명세서에서 언급된 일부의 또는 전부의 단점을 해결하는 구현에 한정되지 않는다.

도면의 간단한 설명

[0004] 도 1은 광학 장치 및 그 광학 장치 내에 배치된 광학 웨지의 실시예를 도시한다.

도 2는 광학 웨지의 실시예를 도시하는 개략적인 평면도이다.

도 3 및 4는 도 2의 실시예의 단면도를 통해 광선 추적(ray traces)에 대해 도시한다.

도 5는 도 2의 실시예의 말단 반사경의 개략적인 확대 단면도를 도시한다.

도 6 및 7은 도 2의 실시예의 모형들의 더미를 통과하는 경로로써 도 2의 광선 추적을 도시한다.

도 8 및 9는 반사 측면을 포함하는 광학 웨지의 실시예의 사시도를 통해 광선 추적에 대해 도시한다.

도 10은 광을 콜리메이션하는 방법의 실시예를 도시한다.

발명을 실시하기 위한 구체적인 내용

[0005] 웨지 모양의 광 가이드(light guides)나 또는 광학 웨지(optical wedges) 형태의 광 콜리메이터의 다양한 실시예가 본원에 개시된다. 광학 웨지는, 내부 전반사(total internal reflection)를 통해 웨지의 끝에 있는 광 인터페이스와 웨지의 앞면에 있는 다른 광 인터페이스 간에 광을 전도하는 광 가이드이다. 본원에 개시된 실시예 각각에서는, 접혀진 광경로(folded optical path)를 사용하여, 광이 콜리메이션되기 전에 원하는 크기까지 펼쳐지게 되어, 광원과 콜리메이션된 광이 존재하는 표면(예컨대, 웨지 앞면) 간 공간의 부피가 줄어들게 된다. 이러한 광학 웨지는 액정 디스플레이(liquid crystal display)용 백라이트(backlight)를 포함하며, 그러나 이에 제한되지 않고, 다양하게 사용될 수 있다.

[0006] 이제부터, 예시를 통해 또한 특정 실시예와 관련하여 본 개시의 대상이 설명된다. 첨부된 도면에서, 도시된 실시예들의 도면은 일정한 비율로 그려진 것이 아니며, 몇몇 특징들의 형상비(aspect ratios)는 선택된 특징이나 관계를 보다 쉽게 볼 수 있도록 과장된 것일 수 있다.

[0007] 도 1은 대형 터치 감지 디스플레이 표면(large-format, touch-sensitive display surface, 12)을 통해 제어기(16)에 디스플레이 및 입력 기능을 제공하도록 구성된 광학 시스템(optical system, 10)의 일 실시예이다. 제어기(16)는 광학 시스템에 디스플레이 데이터를 제공하고 입력 데이터를 수신하도록 구성된 임의의 장치일 수 있다. 몇몇 실시예에서, 제어기는 컴퓨터의 전부 또는 일부를 포함하고, 다른 실시예에서는, 제어기가 유선 또는 무선 통신 링크를 통해 컴퓨터에 연결되어 동작하는 임의의 장치일 수 있다. 제어기(16)는 메모리(14) 및 프로세서(15)를 포함한다. 메모리(14)는 광학 시스템(10)을 제어하는 루틴(routines)을 포함하는, 프로세서(15)에 의해 실행되는 인스트럭션들을 저장하는 데에 사용될 수 있다.

[0008] 디스플레이 기능을 제공하기 위해서, 광학 시스템(10)은 터치 감지 디스플레이 표면(12)에 가시 이미지(visible image)를 투사시키도록(project) 구성될 수 있다. 입력 기능을 제공하기 위해서는, 광학 시스템은 손가락, 전자 장치, 종이 카드, 음식 또는 음료수 등의 터치 감지 디스플레이 표면에 놓인 물체의 적어도 부분적인 이미지를 캡쳐하도록 구성될 수 있다. 따라서, 광학 시스템은 이러한 물체를 조명하고(illuminate), 그 물체로부터 반사된 광을 탐지하도록 구성될 수 있다. 이러한 방식으로, 광학 시스템은 터치 감지 디스플레이 표면에 놓인 임의의 적절한 물체의 위치, 풋프린트(footprint) 및 다른 특징들을 기록할 수 있다.

[0009] 광학 시스템(10)은 광학 웨지(100), 광 디렉터(light director, 20), 광 밸브(light valve, 22), 산광기(diffuser, 24) 및 광원(102)을 포함한다. 광원(102) 및 광 밸브(22)는 제어기(16)에 연결되어 동작하고, 터치 감지 디스플레이 표면(12)에 비주얼(visual) 디스플레이 이미지를 제공하도록 구성될 수 있다. 예컨대, 광원(102)은 하나 이상의 LED(light emitting diodes)와 같이 가시 광선을 내보낼 수 있는 임의의 발광체(illuminant)일 수 있다. 광원(102)의 광은 광학 웨지(100)를 통해 투사되어, 광 디렉터(20)를 거쳐 광 밸브(22)를 향한다. 몇몇 실시예에서, 광 디렉터(20)는 광이 광 밸브(22)에 수직인 방향을 향하도록 구성된 프리즘막(film of prisms)을 포함할 수 있다. 광 디렉터(20)로부터의 광을 색상 및 강도에 대해 변조하기 위해 광 밸브(22)에 수많은 광 게이팅 요소들(light-gating elements)이 사용될 수 있다. 몇몇 실시예에서, 광 밸브는 액정 디스플레이 장치를 포함할 수 있으며, 다른 광 변조 장치들이 사용될 수도 있다. 이러한 방식으로, 광원과

Microsoft Exhibit 1002 - Page 1369
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

광 밸브가 함께 디스플레이 이미지를 생성할 수 있다. 디스플레이 이미지는 산광기(24)를 통해 투사되어, 터치 감지 디스플레이 장치(12)에 제공되게 된다.

[0010] 또한, 광학 시스템(10)은 제어기(16)에 입력 기능을 제공하도록 구성될 수 있다. 따라서, 도시된 광학 시스템은 탐지기(detector, 38), 적외선 방출기(infrared emitters, 72) 및 조명 광 가이드(illuminating light guide, 74)를 포함한다. 예를 들어, 탐지기(38)는 적외선 감지 디지털 카메라와 같은 카메라 또는 기타 임의의 적절한 이미지 감지 장치를 포함할 수 있다. 적외선 방출기(72)는 예를 들어, 하나 이상의 적외선 LED 또는 기타 임의의 적절한 광원을 포함할 수 있다. 조명 광 가이드는 하나 이상의 입구(entry zones, 76)에서 주입되는 적외선을 수신하고, 디스플레이 스크린을 터치한 물체로부터 반사된 적외선을 출구(exit zone, 78)를 통해 보내도록 구성된 임의의 광학 물체일 수 있다.

[0011] 예를 들어, 적외선 광은 적외선 방출기(72)에 의해 조명 광 가이드(74)의 입구(76)로 주입될 수 있다. 적외선 광은 내부 전반사를 통해 조명 광 가이드(74)를 통과하고, 물체(40)와 같이 터치 감지 디스플레이 표면(12)에 접촉하고 있는 하나 이상의 물체에 부딪칠 때까지 (예컨대, 터치 감지 디스플레이 표면(12)을 따라 배열된 도시되지 않은 확산 엘리먼트(diffusing elements)로 인해) 터치 감지 디스플레이 표면(12)을 따라 유출될 수 있다. 적외선 광의 일부는 하나 이상의 물체에 반사되어, 출구(78)에서 조명 광 가이드(74)를 빠져나올 수 있다. 적외선 광은 출구(78)로부터 산광기(24)와 광 밸브(22)로 이동하여 광학 웨지(100)의 표면에 부딪치며, 이로 인해 입사 적외선 광(incident infrared light)이 탐지기(38)를 향하도록 구성될 수 있다. 그러나, 다른 수많은 조명 구성이 가능하며, 이는 본 개시의 범위 내에 속한다.

[0012] 도 2를 참조하면, 광학 웨지(100)는, 그 광학 웨지(100)의 얇은 말단(thin end, 110) 가까이에 배치된 광원(102)으로부터의 광을 콜리메이션시켜서, 도 2의 광선 추적에서 볼 수 있듯이, 콜리메이션된 광이 광학 웨지(100)의 관찰면(viewing surface, 150)을 빠져나오도록 구성될 수 있다. 용어 "관찰면"은, 관찰면(150)이 그 반대쪽인 후면(back surface)(도 2에서는 보이지 않음)보다 관찰자에게 더 가까이에 있음을 나타낸다. 관찰면과 후면은 각각 측면(130, 140), 얇은 말단(110) 및 두꺼운 말단(thick end, 120)에 의해 경계지어진다. 도 2에서, 관찰면(150)은 페이지의 관찰자를 마주보고, 후면은 광학 웨지(100)의 이러한 시야로부터 감추어진다.

[0013] 광학 웨지(100)는 얇은 말단(110)의 광 인터페이스로 주입되는 광선이 말단 반사경(end reflector, 125)을 포함하는 두꺼운 말단(120)에 다가갈수록 펼쳐지도록 구성된다. 광선은 관찰면(150) 및 후면의 내부 전반사를 통해 말단 반사경(125)에 전달된다. 바람직한 실시예에서, 말단 반사경(125)은 곡률 중심(center of curvature, 200)을 갖고 일정한 곡률 반지름으로 곡선을 이루며, 광원(102)은 말단 반사경(125)의 초점에 광을 주입하고, 초점은 곡률 반지름의 중간 지점에 위치한다. 두꺼운 말단(120)에서, 광선 각각은 다른 광선과 평행하게 말단 반사경(125)에서 반사된다. 광선은 두꺼운 말단(120)으로부터 관찰면(150)의 반사 임계각(critical angle of reflection)으로 관찰면(150)을 교차할 때까지 얇은 말단(110) 쪽으로 이동하고, 광선은 콜리메이션된 광으로 빠져나오게 된다. 다른 실시예에서는, 말단 반사경(125)이 포물선 모양이거나(parabolic), 또는 광을 콜리메이션하기 위한 다른 적절한 곡률을 가질 수 있다.

[0014] 다른 실시예에서, 복수의 광원이 얇은 말단(110)을 따라 그 근처에 배치될 수 있다. 복수의 광원을 사용하면 단일 광원을 사용하는 것과 비교하여, 관찰면(150)을 빠져나오는 콜리메이션된 광의 밝기(brightness)를 증가시킬 수 있다. 이러한 실시예에서, 상면 만곡 및/또는 구면 수차(field curvature and/or spherical aberration)를 교정하기 위해서, 광학 웨지(100)의 측면(130 및 140)을 조금 짧게 하여 광원이 중심선(center line, 210)의 양쪽에 대해 말단 반사경(125)의 초점에 머무르게 하는 것이 바람직할 것이다. 곡선(115)에 의해 도시되는 바와 같이, 측면(130 및 140)을 단축시키는 것은 얇은 말단(110)을 볼록하게(convex) 만들 수 있다. 광선이 얇은 말단(110) 근처의 초점에 닿을 때까지, 광학 웨지(100)의 관찰면(150)의 반사 임계각의 광선들을 광학 웨지(100)를 거슬러 추적하는 광선 추적 알고리즘을 사용하여 적절한 곡률을 찾을 수 있다.

[0015] 도 3 및 4는 광학 웨지(100)의 개략적인 단면도를 통해 광선 추적에 대해 도시한다. 도 3은 광학 웨지(100)를 통과하는 제 1 광선(300)의 경로를 도시하고, 도 4는 광학 웨지(100)를 통과하는 제 2 광선(400)의 경로를 도시하며, 광선들(300 및 400)은 광학 웨지(100)의 얇은 말단(110)에 입력되는 광추(cone of light)의 반대편들에 위치하는 광선들을 나타낸다. 도 3 및 4에서 볼 수 있듯이, 광선(300)은 광학 웨지(100)의 얇은 말단(110)에 가까운 관찰면(150)을 빠져나오는 반면, 광선(400)은 광학 웨지(100)의 두꺼운 말단(120)에 가까운 관찰면(150)을 빠져나온다.

[0016] 광선들(300 및 400)이 관찰면(150)의 법선에 대해 내부 반사 임계각보다 작거나 같은 각으로 관찰면(150)과 교차하면, 이 광선들(300 및 400)은 관찰면(150)을 빠져나오게 된다. 본원에서 이러한 임계각은 "제 1 임계각"이

Microsoft Exhibit 1002 - Page 1370
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1371
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

라고 한다. 마찬가지로, 광선들이 관찰면(150)의 법선에 대해 내부 반사 임계각보다 큰 각으로 관찰면(150)과 교차할 때, 광선들은 광학 웨지(100)에서 내부적으로 반사된다. 또한, 광선들이 후면(160)의 법선에 대해 내부 반사 임계각보다 큰 각으로 후면(160)과 교차할 때, 이 광선들은 광학 웨지(100)에서 내부적으로 반사된다. 본원에서 이러한 임계각은 "제 2 임계각"이라고 한다.

[0017] 제 1 임계각으로 후면(160)에 입사하는 광이 관찰면(150)을 향해 다시 반사되도록 제 1 임계각과 제 2 임계각은 서로 다른 것이 바람직하며, 이는 도 5와 관련하여 아래에서 보다 상세하게 설명될 것이다. 따라서, 후면(160)을 통과하는 광손실을 막는 데 도움이 되어, 광학 웨지(100)의 광효율(optical efficiency)이 증가할 수 있다. 제 1 임계각은 광학 웨지(100)의 굴절률(refractive index) 및 관찰면(150)에 접한 물질(예컨대, 공기 또는 피복재(cladding))의 굴절률의 함수인 반면, 제 2 임계각은 광학 웨지(100) 및 후면(160)에 인접한 물질의 굴절률의 함수이다. 몇몇 실시예에서는, 도 3 및 4에 도시된 바와 같이, 후면(160)에만 피복재 층(170)이 도포되고, 관찰면(150)은 공기와 접하게 된다. 다른 실시예에서는, 관찰면(150)이 후면(160)과는 다른 굴절률을 가진 피복재 층(도시되지 않음)을 포함할 수 있다.

[0018] 광학 웨지의 관찰면 및/또는 후면에 대해 원하는 내부 반사 임계각을 얻기 위해 피복재 층에 적절한 임의의 물질 혹은 물질들이 사용될 수 있다. 일 실시예에서, 광학 웨지(100)는 굴절률 1.492의 폴리메틸 메타크릴레이트(polymethyl methacrylate), 또는 PMMA로 형성된다. 공기의 굴절률은 대략 1.000이다. 따라서, 피복재가 없는 표면의 임계각은 대략 42.1 도이다. 다음으로, 피복재 층의 일례로 굴절률 1.33의 비정질 불소 중합체(amorphous fluoropolymer)인 테플론(Teflon) AF(델라웨어 주 윌밍톤의 EI Dupont de Nemours & Co.)를 들 수 있다. 테플론 AF가 피복된 PMMA 표면의 임계각은 63.0 도이다. 이러한 예시들은 설명 목적으로 기술된 것으로, 어떤 경우에든 제한하기 위한 것은 아니다.

[0019] 다른 실시예에서, 후면(160)은 거울을 포함할 수 있다. 비제한적인 예로써, 거울은 후면(160)에 반사막(reflective coating)을 도포함으로써 형성되거나, 또는 후면(160) 가까이에 거울을 배치함으로써 형성될 수 있다. 이런 식으로, 후면(160)은 그 후면(160)에 교차하는 입사광을 반사시킬 수 있다. 후면(160)이 입사광 일부 혹은 전부를 반사시키도록 구성될 때, 본원에서는 그 후면(160)을 "반사 후면(reflective back surface)"이라고 한다. 반사 후면의 비제한적인 예시로, 경면(mirrored surface), 후면 가까이에 놓인 거울을 가진 후면, 제 1 반사 임계각보다 작은, 후면의 법선에 대한 제 2 내부 반사 임계각을 가진 후면, 또는 후면이 제 1 내부 반사 임계각으로 내부적으로 입사하는 광을 반사시키는 임의의 다른 구성이 포함된다.

[0020] 광학 웨지(100) 및 말단 반사경(125)은, 얇은 말단(110)에 균일광(uniform light)이 주입될 때 관찰면(150)의 대부분이 균일하게 조명되도록, 또한 주입된 광의 대부분이 관찰면(150)을 빠져나가도록 구성될 수 있다. 앞서 언급한 대로, 얇은 말단(110)에 주입된 광선들이 내부 전반사를 통해 말단 반사경(125)까지 이동할 수 있도록, 광학 웨지(100)는 그 길이를 따라 점점 가늘어진다(tapered). 말단 반사경(125)은 관찰면(150) 및 후면(160) 각각의 법선에 대한 광선 각도를 감소시키도록 구성된 패싯화된 렌즈 구조(faceted lens structure)를 포함한다. 또한, 두꺼운 말단(120)에서부터 얇은 말단(110)까지 광학 웨지(100)의 줄어드는 두께로 인해, 광선이 얇은 말단(110)을 향해 이동할수록 광선 각도가 각 표면의 법선에 대해 줄어들게 된다. 광선이 제 1 임계각보다 작은 각도로 관찰면(150)에 입사될 때, 광선은 관찰면(150)을 빠져나오게 될 것이다.

[0021] 몇몇 실시예에서, 광원(102)은 말단 반사경(125)의 초점에 배치될 수 있다. 이러한 실시예에서, 말단 반사경(125)은 광학 웨지(100)의 길이의 두 배인 곡률 반경으로 곡선을 이룰 수 있다. 도 3 및 4의 실시예에서, 두꺼운 말단(120)과 관찰면(150)의 모서리가 직각이 되고, 두꺼운 말단(120)과 후면(160)의 모서리가 직각이 되도록 광학 웨지(100)의 테이퍼 각(taper angle)이 구성된다. 얇은 말단(110)이 말단 반사경(125)의 초점에 있을 때, 얇은 말단(110)은 두꺼운 말단(120)의 두께의 절반이 된다. 다른 실시예에서는, 이러한 구조들이 각각 임의의 다른 적절한 구성을 가질 수 있다.

[0022] 도시된 실시예에서, 말단 반사경(125)은 측면(130)에서 측면(140)까지, 관찰면(150)에서 후면(160)까지 구형으로(spherically) 곡선을 이룬다. 다른 실시예에서, 말단 반사경(125)은 관찰면(150)에서 후면(160)까지 일정한 곡률 반경과, 연장된다면 관찰면(150)과 후면(160)이 만나게 되는 곡률 중심으로 원통형으로(cylindrically) 곡선을 이룰 수 있다. 원통형으로 곡선을 이루는 말단 반사경은 구형으로 곡선을 이루는 말단 반사경(125)에 비해 휘어짐에 강하게 저항하고, 이는 대형 애플리케이션에서 유용할 수 있다. 예를 들어, 포물선형과 같이, 다른 적절한 곡률이 말단 반사경(125)에서 사용될 수 있다. 또한, 측면(130 및 140)에 수직인 평면에서 말단 반사경(125)의 곡률은 측면(130 및 140)에 평행한 평면에서의 말단 반사경(125)의 곡률과 다를 수 있다.

[0023] 앞서 언급한 바와 같이, 관찰면(150)과 후면(160)의 반사 임계각은 서로 다른 것이 바람직하다. 이는, 도 2 내

지 4의 광학 웨지 실시예의 말단 반사경(125)의 개략적인 확대 단면도를 나타내는 도 5 에 도시된 바와 같이, 후면(160)을 통한 광손실 방지를 도울 수 있다. 말단 반사경(125)는 두꺼운 말단(120)에 대한 특정 각도로 배열된 복수의 패싯들을 포함하는 패싯화된 렌즈 구조를 포함한다. 복수의 패싯들은 패싯(530)과 같이 관찰면(150)을 바라보는 패싯들과, 패싯(540)과 같이 후면(160)을 바라보는 패싯들이 번갈아 가며 배열된다. 말단 반사경(125)은 곡률 중심을 향해 연장되는 말단 반사경 법선(542) 및 말단 반사경 법선(532)을 가진, 전술한 바와 같은 일반적인 곡률을 따른다. 복수의 패싯들 각각은 말단 반사경의 표면 법선에 대한 특정 높이와 각도를 갖게 된다. 예를 들어, 관찰면(150)을 바라보는 어느 하나의 패싯은 말단 반사경 법선(532) 및 패싯 법선(facet normal, 534)에 대한 특정 높이(538) 및 각도(536)를 가진다. 또 다른 예를 들면, 후면(160)을 바라보는 어느 하나의 패싯은 말단 반사경 법선(542) 및 패싯 법선(544)에 대한 특정 높이(548) 및 각도(546)를 가진다.

[0024] 복수의 패싯들 각각의 높이는 관찰면(150)을 빠져나오는 콜리메이션된 광의 균일성(uniformity) 및 밝기에 영향을 줄 수 있다. 예를 들어, 큰 패싯들은 이상적인 초점 거리(focal length)와는 다른 광경로를 만들어, 프레넬 밴딩(Fresnel banding)을 야기시킬 수 있다. 따라서, 이러한 밴딩이 문제를 일으킬 수 있는 실시예에서는, 예컨대, 복수의 패싯들 각각의 높이를 500 미크론(micron)보다 작게 하여, 이러한 밴딩이 덜 보이도록 하는 것이 바람직할 것이다.

[0025] 마찬가지로, 복수의 패싯들 각각의 각도 또한 관찰면(150)을 빠져나오는 콜리메이션된 광의 균일성 및 밝기에 영향을 줄 수 있다. 광선(500)은 패싯 각도가 광학 웨지(100)를 통과하는 광선 경로에 어떤 영향을 미치는 지에 대해 도시한다. 광선(500)은 얇은 말단(110)에 주입되고, 광학 웨지(100)를 통과하여 말단 반사경(125)에 부딪친다. 광선(500)의 절반은 관찰면(150)을 바라보는 패싯(530)에 부딪친다. 패싯(530)에 부딪치는 광선(500)의 일부는 관찰면(150)을 향하는 광선(510)처럼 반사된다. 광선(510)은 관찰면(150)의 법선에 대한 제 1 내부 반사 임계각보다 작거나 같은 각도로 관찰면(150)과 교차하여, 광선(512)와 같이 관찰면(150)을 빠져나간다.

[0026] 광선(500)의 나머지 절반은 후면(160)을 바라보는 패싯(540)에 부딪친다. 패싯(540)에 부딪치는 광선(500)의 일부는 후면(160)을 향하는 광선(520)처럼 반사된다. 관찰면(150)과 후면(160)의 임계각의 차이로 인해, 광선(520)은 후면(160)의 법선에 대한 제 2 내부 반사 임계각보다 큰 각도로 후면(160)을 교차하고, 따라서 관찰면(150)을 향하는 광선(522)처럼 반사된다. 그 후, 광선(522)은 관찰면(150)의 법선에 대한 제 1 내부 반사 임계각보다 작거나 같은 각도로 관찰면(150)과 교차하여, 광선(524)와 같이 관찰면(150)을 빠져나간다. 이러한 방식으로, 말단 반사경(125)에서 반사되는 광의 대부분(및 몇몇 실시예에서는, 실질적으로 전부)이 관찰면(150)을 빠져나간다.

[0027] 관찰면(150)을 바라보는 패싯들과 후면(160)을 바라보는 패싯들에서 따로따로 반사되는 광으로 인해, 관찰면(150)에 머리에서 꼬리 방향으로(head-to-tail orientation) 배열된, 오버래핑되고 중첩된 제 1 및 제 2 이미지들이 형성될 수 있다. 이들 이미지 간의 오버래핑 정도는 패싯들(530 및 540)의 각도에 의해 결정될 수 있다. 예를 들어, 각 패싯이 90 도와 제 1 반사 임계각 간의 차이의 3/8인, 말단 반사경의 표면 법선에 대한 각도를 가질 때, 두 이미지들이 완전히 오버래핑되며, 이는 아래에서 보다 상세하게 설명될 것이다. 본 예시에서, 광학 웨지(100)로 들어가는 실질적으로 모든 광이 관찰면(150)을 빠져나온다. 이 값으로부터 패싯들을 변화시킴으로써 이미지 간의 오버래핑되는 양이 줄어들며, 패싯들의 각도가 90 도와 제 1 반사 임계각 간의 차이의 1/4 또는 1/2일 때, 두 이미지 중 어느 한쪽만이 디스플레이된다. 또한, 90 도와 제 1 반사 임계각 간의 차이의 3/8로부터 패싯들의 각도를 변화시킴으로써, 관찰면(150)이 아닌 광학 웨지(100)의 얇은 말단으로부터 일부의 광이 빠져나오게 된다. 패싯들의 각도가 90 도와 제 1 반사 임계각 간의 차이의 1/4 또는 1/2일 때, 관찰면이 균일하게 조명될 수 있지만, 광의 절반이 광학 웨지(100)의 얇은 말단으로 빠져나오게 되어, 손실된다. 원하는 사용 환경에 따라, 90 도와 제 1 반사 임계각 간의 차이의 3/8이 아닌 패싯 각도를 사용하여 콜리메이션된 광을 얻는 것이 적절함을 이해할 것이다. 이러한 사용 환경은 (오버래핑 영역에 비해 강도가 낮은 것으로 보이는) 광이 오버래핑되지 않는 임의의 영역이 사용자의 관찰 시야 내에 있지 않은 환경을 포함하며, 그러나 이에 제한되지는 않을 것이다.

[0028] 다른 실시예에서, 말단 반사경(125)의 패싯화된 렌즈 구조는 회절 격자(diffraction grating)를 포함할 수 있다. 제공된 입사각 및 제공된 광파장(wavelength of light)에 대한 회절 각도를 계산하기 위해 격자 방정식이 사용될 수 있다. 회절 각도는 광파장에 달려있으므로, 주입되는 광이 단색(monochromatic)일 때, 회절 격자를 포함하는 말단 반사경이 바람직하다.

[0029] 도 6 및 7은 도 5에 도시된 컨셉을 추가적으로 설명하기 위해, 각각의 광학 웨지가 광학 웨지(100)의 실시예의

Microsoft Exhibit 1002 - Page 1372
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1373
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

모형인, 광학 웨지들의 더미를 통과하는 광선의 경로로써, 광학 웨지(100)를 가로지르는 광의 이동을 도시한다. 광학 웨지의 모형들의 더미를 통과하는 광선을 추적하는 것은 광학 웨지 내의 광선 경로를 추적하는 것과 광학적으로 동등하다. 따라서, 이러한 방식으로, 광선의 각각의 내부 반사는 하나의 광학 웨지로부터 인접 광학 웨지로의 경계를 통과하는 광선 통로로써 보여진다. 도 6에서, 관찰면은 광학 웨지들(600)의 더미의 맨 위에 있는(topmost) 웨지의 관찰면(620)이다. 후면은 광학 웨지들(600)의 더미의 맨 아래에 있는(bottommost) 웨지의 후면(630)이다. 광학 웨지들(600)의 더미의 두꺼운 말단들은 합쳐져서, 모든 표면들이 수렴하는 축(610)에 중심을 둔 거의 곡선(640)에 가까운 것을 형성한다. 도 6에서, 각 웨지의 두꺼운 부분은 동일한 일반적인 곡률을 가진 것으로 도시된다. 그러나, 각 웨지의 두꺼운 부분이 임의의 적절한 다른 곡률을 가질 수도 있음을 이해할 것이다.

[0030] 또한, 도 6은 광학 웨지 더미(600)의 얇은 말단에 주입되는 광추의 양쪽 반대편에 위치하는 두 광선들(650 및 660)을 도시한다. 각 광선(650 및 660)이 말단 반사경에서 반사된 후에, 광선의 절반은 실선(652 및 662)으로 표시된 것과 같이 광학 웨지 더미(600)의 관찰면에서 (따라서, 재시된 광학 웨지로부터) 나오고, 광선의 절반은 점선(654 및 664)으로 표시된 것과 같이 광학 웨지 더미의 후면으로부터 나오게 된다. 이들 양 극단 사이에 임의의 각도로 주입되는 광선은 말단 반사경에서 패싯 패턴에 의해 쪼개지고, 유사한 방식으로 광학 웨지의 관찰면과 후면으로부터 나오게 된다. 광선들(652 및 662)와 평행하게 관찰면(620)을 빠져나오는 광선들은 음영처리된 영역(602)으로 표시된다. 앞서 언급한 바와 같이, 광학 웨지의 후면(630)을 통해 방출되는 것으로 도시되는 광선들은 그 대신에, 광학 웨지의 관찰면에 사용되는 피복재(도시되지 않음)보다 작은 굴절률을 가진 피복재(도시되지 않음)를 광학 웨지의 후면에 이용함으로써, 후면에서 반사된 후 관찰면을 빠져나올 수 있다. 이런 방식으로, 이 광학 웨지의 얇은 말단으로 주입되는 실질적으로 모든 광이 광학 웨지의 관찰면으로부터 방출될 수 있다.

[0031] 관찰면이 균일하게 조명되기 위해(예컨대, 패싯들(530 및 540)에서 반사되는 이미지들이 완전하게 오버래핑되는 곳에서), 얇은 말단에 주입되어 말단 반사경을 향해 수평으로 이동하며, 말단 반사경의 법선과 일치하는 광선은, 관찰면을 바라보는 패싯에서 반사되어 관찰면의 중심을 향해 이동하고, 관찰면의 임계각으로 관찰면과 교차한다. 도 7은 광학 웨지 더미(700)를 통과하는 광선의 경로에 대해 개략적으로 보여준다. 광선(710)은 광학 웨지의 얇은 말단(702)에 주입되고, 광선(715)처럼 말단 반사경(704)에서 반사된다. 광선(715)은 관찰면(706)의 중심을 향해 이동하고, 관찰면 법선(720) 대한 반사 임계각(730)으로 관찰면(706)에 교차하게 된다. 각도(732 및 734)의 합은 90 도와 반사 임계각(730)의 차이와 같다. 광학 웨지의 얇은 말단이 광학 웨지의 두꺼운 부분의 두께의 절반일 때, 웨지의 중심점은 광학 웨지의 두께의 3/4가 된다. 근축 근사(paraxial approximation)를 사용하면, 각도(732)는 90 도와 반사 임계각(730)의 차이의 3/4가 된다. 수평선(722)는 주입되는 광선(710)에 평행하므로, 각도(740)은 각도(732)와 동일하다. 반사 법칙에 의하면, 입사각은 반사각과 동일하므로, 패싯 각도는 각도(740)의 절반이 될 것이다. 따라서, 관찰면이 균일하게 조명되기 위해서, 관찰면을 바라보는 각 패싯이 90 도와 반사 임계각(730) 간의 차이의 3/8인, 말단 반사경의 표면 법선에 대한 각도를 형성할 수 있다.

[0032] 광학 웨지(100)에 광을 주입하기 위해 임의의 적절한 광원이 사용될 수 있다. 예시로써 LED(light emitting diodes)를 포함하나, 이에 제한되지는 않는다. 맨 LED(bare LED)로부터 람베르시안 패턴(Lambertian pattern)으로 광이 방사됨을 알 것이다. 그러나, 맨 LED 보다 광학 효율을 향상시키기 위해, 모든 광선들이 도 6에 도시되는 두 실선 광선들(650 및 660) 사이의 각도에 있도록, 즉, 0 도와, 90 도에서 임계각을 뺀 차이의 절반 사이에 있는 광학 웨지의 수평면에 대한 각도에 있도록 광이 광학 웨지에 주입되는 것이 바람직하다. 따라서, LED는, 그 출구 두께가 웨지의 얇은 말단의 두께와 거의 같고, 그 방출 각도의 범위가 광선들(650 및 660)에 의한 범위와 거의 동일하도록 설계된 집광기(concentrator)의 초점에 배치될 수 있다.

[0033] 몇몇 실시예에서, 출력 콜리메이션된 광의 강도를 증가시키기 위해 복수의 광원이 광학 웨지의 얇은 말단을 따라 그 근처에 배치될 수 있다. 이러한 광원 어레이(array)의 광학 웨지(100)로부터의 출력은 각각의 광원을 분석하여, 중첩 원리(superposition principle)를 통해 그 결과들을 결합함으로써 분석될 수 있다. 이는, 예시된 광학 웨지를 통과하는 광선의 경로에 대한 개략도를 보여주는 도 8 및 9에서 도시된 바와 같이, 광원 어레이를 사용하여 콜리메이션된 균일한 광을 만드는 시스템의 설계를 도울 수 있다. 도 8 및 9의 광학 웨지(100)는 얇은 말단(110), 두꺼운 말단(120), 측면(130 및 140) 및 중심선(850)이 있는 관찰면(150)을 포함한다. 두꺼운 부분(120)은 말단 반사경(125)을 포함한다. 측면(130 및 140)은 반사면일 수 있다. 광원들(802 및 902)은 얇은 말단(110) 가까이에 중심선(850)으로부터 같은 거리에 배치된다.

[0034] 도 8에서, 광선들(810 및 830)이 경계를 이루는 광추는 광원(802)에 의해 얇은 말단(110)에 주입된다. 광선

(830)은 말단 반사경(125)에서 교차하여, 광선(840)처럼 반사된다. 광선(810)은 말단 반사경(125)에서 교차되고, 측면(140)에서 추가적으로 반사된 후에 광선(820)과 같이 반사된다. 도 8에 도시된 바와 같이, 이러한 구성에서 관찰면(150)으로부터 방출되는 콜리메이션된 광은 균일하지 않을 수 있다. 예를 들어, "반사(Reflection)"라고 표시된 광선(820)과 측면(140) 사이의 영역은, 광선(820) 및 측면(140) 사이의 영역에 말단 반사경(125)으로부터 직접 반사되는 광선에 더해서 측면(140)에서 반사된 광선들이 관찰면으로부터 방출되기 때문에, 광선(820)과 측면(130) 사이의 영역보다 밝을 수 있다. 또한, "그늘(Shadow)"이라고 표시된 측면(130)과 광선(840) 사이의 영역은 측면(130)에서 반사된 광선(840)에 의해 생기는 그림자로 인해 광선(840) 및 측면(140) 사이의 영역보다 더 어두울 수 있다.

[0035] 도 9에서, 광원(902)과 광원(802)은 중심선(850)으로부터 같은 거리에, 그러나 중심선(850)의 반대편에 배치된다. 광선들(910 및 930)이 경계를 이루는 광추는 광원(902)에 의해 얇은 말단(110)에 주입된다. 광선(930)은 말단 반사경(125)에서 교차하여, 광선(940)처럼 반사된다. 광선(910)은 말단 반사경(125)에서 교차되고, 측면(130)에서 추가적으로 반사된 후에 광선(920)과 같이 반사된다. 도 8과 관련하여 전술한 바와 같이, 이러한 구성에서 관찰면(150)으로부터 방출되는 콜리메이션된 광은 균일하지 않을 수 있다. "반사"라고 표시된 광선(920)과 측면(130) 사이의 영역은, 광선(920) 및 측면(140) 사이의 영역보다 밝을 수 있다. 또한, "그늘"이라고 표시된 측면(140)과 광선(940) 사이의 영역은 광선(940) 및 측면(140) 사이의 영역보다 더 어두울 수 있다.

[0036] 광원들(802 및 902)이 중심선(850)에서 비슷한 거리에 위치할 때, 도 8의 "반사" 영역의 경계는 도 9의 "그늘" 영역의 경계과 일치할 수 있다. 마찬가지로, 도 8의 "그늘" 영역의 경계는 도 9의 "반사" 영역의 경계와 일치할 수 있다. 각 광원에 의해 얇은 말단(110)에 주입되는 광이 유사한 밝기와 균일성을 갖도록 광원들(802 및 902)의 밝기가 유사한 경우, 그늘 및 반사 영역은 서로 상쇄될 수 있다.

[0037] 도 10은 광 도파관(optical waveguide)을 통해 광을 콜리메이션하는 방법의 일례(1000)를 도시한다. 광 도파관은 제 1 말단, 제 1 말단 반대편의 제 2 말단, 복수의 패싯을 포함하는 말단 반사경, 제 1 말단과 제 2 말단 사이에서 연장된 관찰면, 및 관찰면을 대향하는 후면을 포함할 수 있다. 관찰면은 제 1 반사 임계각을, 후면은 제 2 반사 임계각을 갖고, 여기서 제 1 및 제 2 반사 임계각은 다르다. 일 실시예에서, 광 도파관은 도 2의 광학 웨지이며, 광학 웨지의 얇은 말단이 광 도파관의 제 1 말단이고, 광학 웨지의 두꺼운 말단이 광 도파관의 제 2 말단이다. 다른 실시예에서, 광 도파관은 일정한 두께일 수 있으며, 예를 들어, 제 1 말단 및 제 2 말단이 동일한 두께일 수 있다. 광 도파관은 제 1 말단 및 제 2 말단 사이에서 선형으로 변하는 굴절률을 가진, 관찰면 및/또는 후면의 피복재를 포함할 수 있다. 광 도파관의 제 1 말단에 광이 주입될 때, 본 실시예는 광학 웨지와 유사하게 동작할 것이다. 또 다른 실시예에서, 광 도파관은 일정한 두께와, 제 1 말단 및 제 2 말단 사이에서 선형으로 변하는 굴절률과, 일정한 굴절률을 가진 관찰면 및/또는 후면의 피복재를 가질 수 있다. 또한, 광 도파관의 제 1 말단에 광이 주입될 때, 본 실시예는 광학 웨지와 유사하게 동작할 것이다.

[0038] 다시 도 10을 참조하면, 1010에서 광 도파관의 제 1 말단에 광이 주입되고, 1020에서 내부 전반사를 통해 말단 반사경으로 광이 전달된다. 1030에서, 광은 말단 반사경으로부터 내부적으로 반사된다. 말단 반사경으로부터 내부적으로 반사된 광은 제 1 패싯 집합과 제 2 패싯 집합으로부터 반사되고, 제 1 패싯 집합의 각 패싯은 적어도 부분적으로는 관찰면을 향하는 법선을 갖고, 제 2 패싯 집합의 각 패싯은 적어도 부분적으로는 후면을 향하는 법선을 가지게 된다. 또한, 몇몇 실시예에서, 제 1 패싯 집합의 각 패싯은 90 도와 반사 임계각 간의 차이의 3/8인 각도를 가지며, 제 2 패싯 집합의 각 패싯은 90 도와 반사 임계각 간의 차이의 3/8인 각도를 가질 수 있다. 다른 실시예에서, 패싯은 광도(light intensities)에 부적절한 변화를 일으키지 않는 다른 적절한 각도를 가질 수 있다.

[0039] 말단 반사경의 패싯이 경사진 각도로 인해, 1040에서, 광의 제 1 부분이 관찰면으로부터 방출되고, 광의 제 1 부분은 제 1 반사 임계각으로 관찰면을 교차하게 된다. 1050에서, 제 2 반사 임계각이 제 1 반사 임계각보다 작을 때, 광의 제 2 부분은 제 1 반사 임계각과 같은 각도로 후면으로부터 내부적으로 반사된다. 1060에서, 광의 제 2 부분은 후면으로부터 내부적으로 반사된 후에 관찰면에서 방출된다.

[0040] 이러한 평면 콜리메이터(flat panel collimator)의 잠재적인 사용에는 액정 패널(liquid crystal panel)을 조명하는 것이 있다. 액정 디스플레이는 비디오를 디스플레이하기 위한 저렴한 방법으로, 백라이트가 후방에 배치된 액정 패널을 포함한다. 과거의 웨지 백라이트는 두꺼운 말단을 따라 광원이 다련된 얇은 투명 웨지와, 디스플레이된 이미지를 볼 수 있도록 액정 패널을 통해 시청자에게 광을 보내는 필름들을 이용해 왔다. 백라이트로부터의 방출이 충분하게 확산되어, 디스플레이된 이미지를 넓은 시야에서 볼 수 있게 하기 위해 상당한 노력이 필요하다. 예를 들어, 과거의 몇몇 웨지들은 산란 사이트(scattering sites)로 채워져 있었다. 그러나, 확

Microsoft Exhibit 1002 - Page 1374
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Microsoft Exhibit 1002 - Page 1375
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

산 조명(diffuse illumination)으로는, 액정 패널을 종래의 디스플레이가 아닌 다른 방식으로 사용하기 힘들다.

[0041] 비디오 이미지의 투사가 필요한 많은 애플리케이션이 있다. 이를 위해 액정 디스플레이 앞에 렌즈를 배치할 수도 있다. 그러나, 조명이 확산되면, 렌즈는 커져야만 하고 따라서 비싸지게 된다.평면 콜리메이터는 작은 투사 렌즈를 통해 집광되는 콜리메이션된 광으로 작은 액정 패널이나 기타의 공간 광 변조기를 조명하는 슬림한(slim) 방식일 수 있다. 공간 광 변조기가 반사를 하면, 디지털 마이크로미러(micromirror) 장치에서와 같이, 빔 스플리터(beam splitter)나 기타의 조명을 위한 공간이 필요하지 않다. 따라서, 투사 렌즈는 광 변조기에서 원하는 만큼 가까이에 오게 할 수 있다.

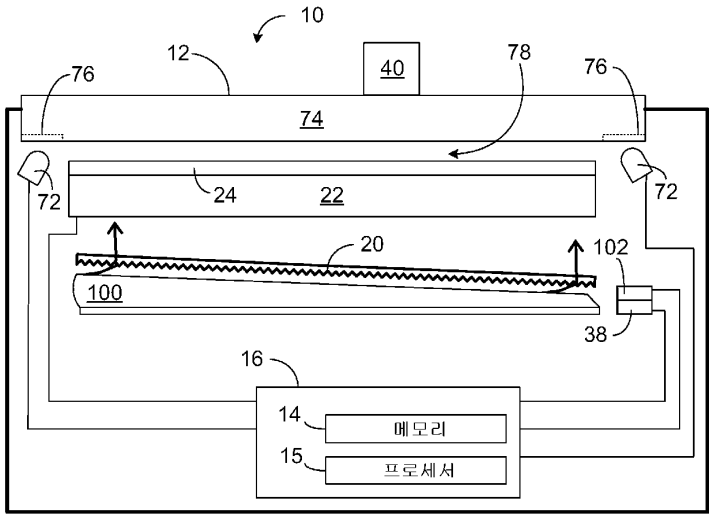
[0042] 몇몇 실시예에서, 단지 스크린 앞 수 밀리미터에서 이미지를 투사하는 것이 바람직할 수도 있다. 이는 태양이 지면에 나무의 그림자를 투사하는 것과 같은 방식으로 행해질 수 있고, 즉, 콜리메이션된 광으로 큰 액정 패널을 조명하면, 그 그림자, 예컨대, 이미지가 액정 패널에서 수 밀리미터 떨어져 있는 산광기에 형성될 수 있다. 한 가지 애플리케이션은 키보드의 모든 키에 특정 비디오 이미지가 요구될 때이다. 각각의 키보드 키에 개별 디스플레이 스크린이 형성된다면, 다수의 작은 디스플레이들의 비용은 엄청나게 비쌀 수 있다. 그러나 전술한 바와 같은 콜리메이션 광학 웨지 백라이트를 사용하면, 투명 키들은 확산 표면을 갖게 되고, 또한 콜리메이션된 백라이트가 마련된 액정 패널 상에 배치될 수 있다. 이러한 방식으로, 단일 대형의 저비용 패널의 다른 영역으로부터 이미지가 각각의 키에 투사될 수 있다.

[0043] 그림자 투사(shadow projection)의 다른 애플리케이션 일례로, 산광기를 터치하는 손가락이나 물체가 후방 적외선 카메라로 감지되는 산광기에 이미지를 투사하는 것을 들 수 있다. 워싱톤 주 레드몬드의 마이크로소프트 코포레이션에서 개발하여 판매하는 마이크로소프트 서피스(Microsoft's SURFACE)와 같은 장치는 비디오 프로젝터, 적외선 램프, 카메라 및 산광기를 포함한다. 프로젝터는 산광기에 비디오 이미지를 생성하고, 램프는 가까이에 있는 물체들을 조명하여 산광기에서 떨어질 때는 흐릿해, 터치 순간에는 선명하게 보이게 한다. 전술한 실시예와 같이, 광학 웨지를 통해 산광기에 카메라를 조준함으로써 영상 광학기(imaging optics)가 슬림하게 만들어질 수 있다. 액정 디스플레이가 확산광(diffuse light)에 의해 조명되면, 투사된 이미지는 산광기와 공간적으로 분리되어 흐리게 보일 수 있다. 따라서, 산광기에 흐릿하지 않은 가시 이미지가 형성되도록, 전술한 바와 같이 액정 패널이 콜리메이션된 광으로 조명될 수 있다. 몇몇 실시예에서, 콜리메이션된 가시 조명을 제공하고 적외선 이미지를 탐지하는 패널이 동일하며, 말단 반사경은 가시광을 반사하고 적외선 광을 전달하는 본 개시에 따른 각도의 패싯들을 포함하며, 그 너머에는 적외선 광을 반사하고 또한, 선명한 단일 이미지를 형성하기 위해 경사진 패싯들 또는 그 등가물이 배치된다.

[0044] 본원에 기술된 구성 및/또는 접근 방법은 예시적인 것으로, 다양한 변형이 가능하기 때문에, 이런 구체적인 실시예 또는 예시들은 제한적인 것으로 간주되어서는 안 된다는 점을 이해할 것이다. 본 개시의 대상은 본원에 개시된 다양한 프로세스, 시스템 및 구성, 및 기타 특징, 기능, 액트 및/또는 특성의 모든 신규하고 비자명한 조합 및 서브콤비네이션뿐만 아니라, 임의의 그리고 모든 등가물도 포함한다.

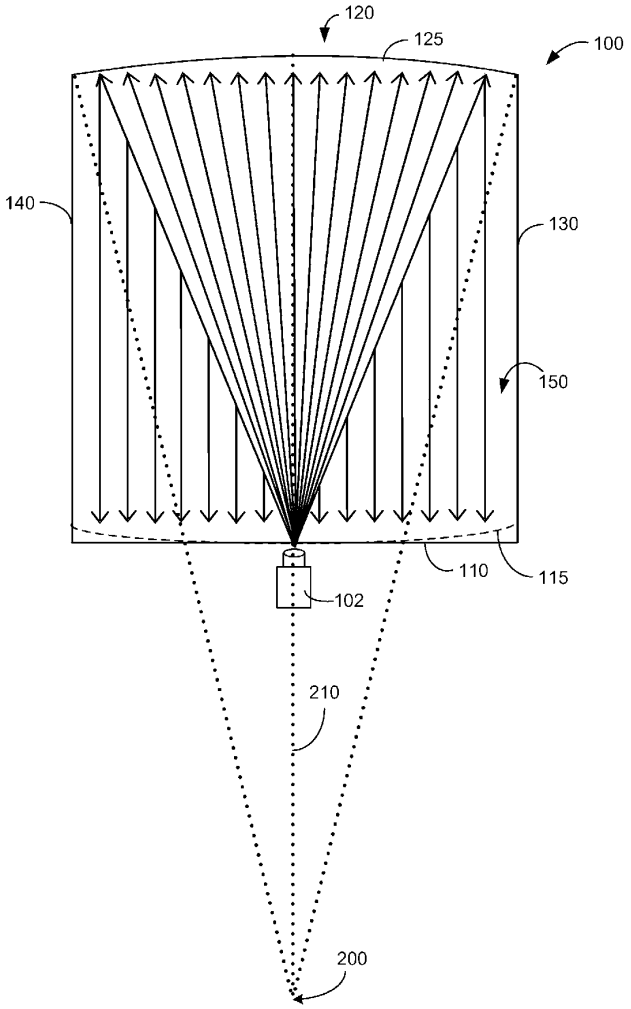
도면

도면1

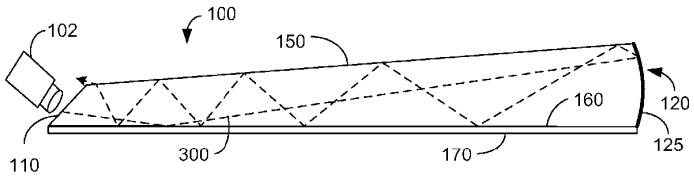


Microsoft Exhibit 1002 - Page 1376
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

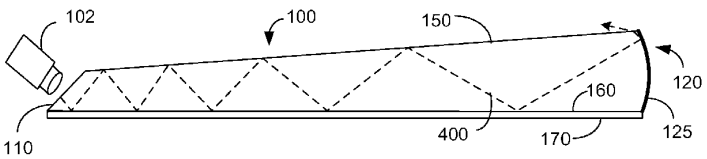
도면2



도면3

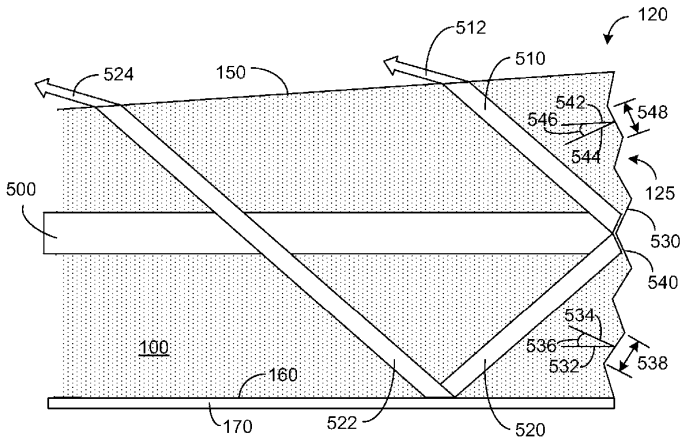


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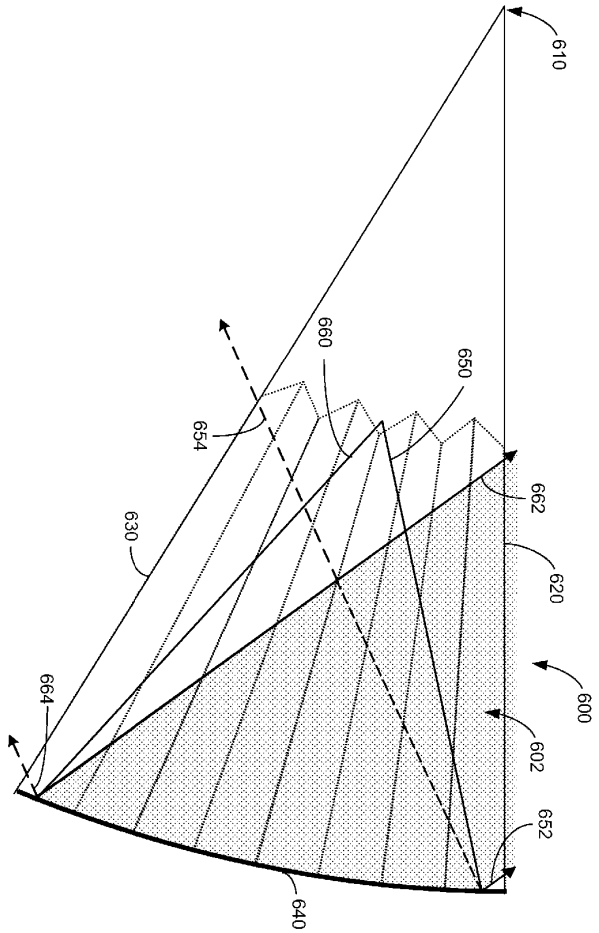


Microsoft Exhibit 1002 - Page 1377
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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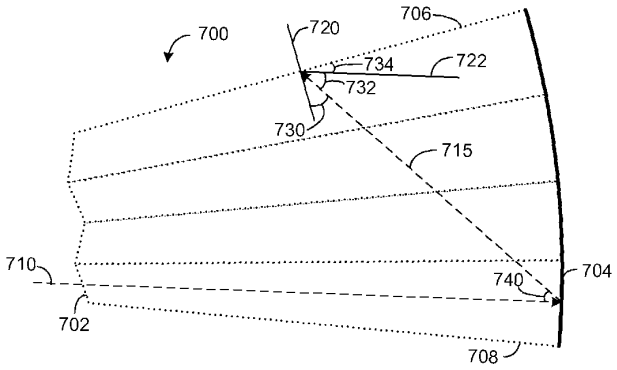


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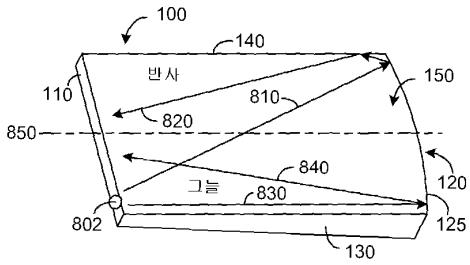


Microsoft Exhibit 1002 - Page 1378
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

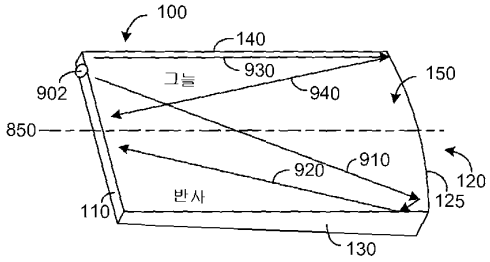
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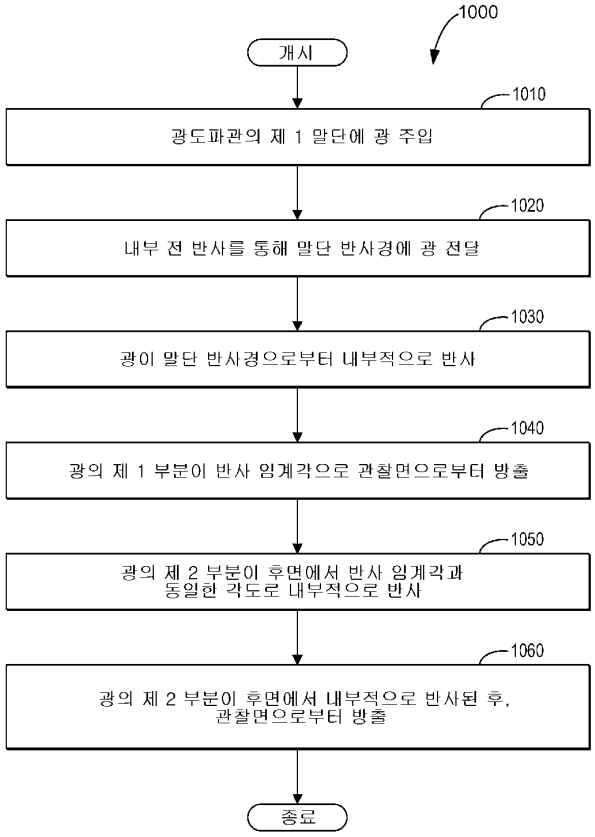


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Microsoft Exhibit 1002 - Page 1379
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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Microsoft Exhibit 1002 - Page 1380
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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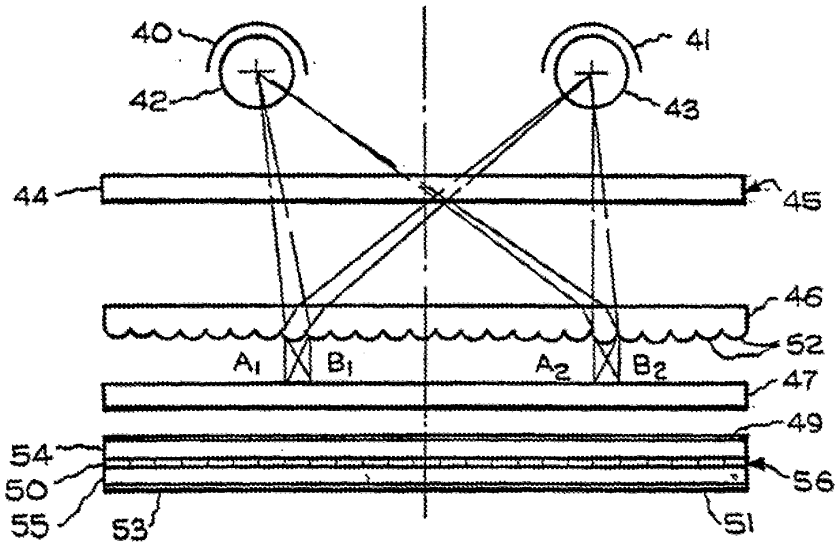
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(57) Abstract

In a flat panel autostereoscopic display full resolution equal to the number of pixels in the two-dimensional light valve array, which serves to generate images, is achieved by incorporating an illumination system (40-47) which makes use of stroboscopic light 5 sources or continuously lit light sources in combination with electro-optical shutter means (56). The lighting system when used in conjuction with a 2-D flat panel display, achieves image resolution exceeding several times the pixel resolution of the light valve array.

Microsoft Exhibit 1002 - Page 1381
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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Microsoft Exhibit 1002 - Page 1382
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

STROBOSCOPIC ILLUMINATION SYSTEM FOR VIDEO DISPLAYS

BACKGROUND

1. Field of the Invention

This invention relates to illumination systems designed to improve image resolution and permit look-around viewing in liquid crystal and similar flat panel transmissive three dimensional (3-D) displays and enhanced resolution and color two dimensional (2-D) displays, for use in computers, television and the like viewing apparatus.

2. Prior Art

Several display systems are on the market today which are capable of generating three-dimensional images based on the use of stereopairs, i.e., complementary images, which when directed to the appropriate eye of the observer, produce a perception of three-dimensionality. Two of such

Microsoft Exhibit 1002 - Page 1383
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

systems, one made by Stereographics, Inc., the other by Tektronix Corp., utilize cathode ray tubes in conjunction with liquid crystal light valves designed to direct the appropriate half of the stereopair to the left or right eye of the observer. Both of these systems require the observer to wear special glasses. In addition, in order to achieve full resolution, these displays operate at frame rate twice the standard television (TV) scanning rates.

A third system made by Dimension Technologies Inc. is autostereoscopic, i.e., it permits the observer to perceive 3-D without the need to wear glasses. The system uses a transmissive image generating liquid crystal panel (LCD) and is disclosed in US-A- 4,717,949; 4,829,365 and 5,040,878. In this system a multiplicity of parallel, equidistant, thin, bright, vertical light lines is generated using an optical device termed the "reflection plate" which carries on its one surface opposite the planar surface facing the LCD, a series of parallel ridges equal in numbers to the number of said light lines. The ridges, triangular in cross-section, are designed to intercept light rays tangentially projected by a cylindrical lens onto said ridge-bearing surface of said reflection plate from a linearly configured light source disposed on the vertical side of the LCD. This method for generating a lattice of lines is specifically described in US-A-5,040,878. An image-generating LCD is situated parallel to and in front of a reflection plate, separated by a small fixed distance of, say, 3 mm, such that the observer, due to the parallax effect of vision, sees with his left eye the light lines through the odd-numbered pixel columns of the LCD, and the even-numbered pixel columns with his right eye. Thus, an illusion of depth is created, albeit by sacrificing one half of the pixel resolution in the 3-D image.

Another optical configuration for the generation of lines for an autostereoscopic display has been disclosed in US-A-5,036,385, which employs a lenticular lens or fly's eye lens to generate a lattice of light lines. This

Microsoft Exhibit 1002 - Page 1384
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

configuration allows multiple sets of light lines in different locations to be made to flash on and off in sequence, allowing for the display of full resolution autostereoscopic images that can be viewed in correct perspective from across a wide angle. These configurations also allow the generation of multiple sets of light lines or points for the display of two dimensional images with resolution greater than that provided by the pixels of the LCD by means explained in US-A-5,036,385.

Accordingly, it is an object of this invention to provide illumination systems for imaging devices, such as disclosed in US-A-5,036,385, which will be effective, economical and convenient for implementation of full resolution 3-D displays, look around 3-D displays, and enhanced resolution 2-D displays.

Another object of this invention is the use of fluorescent lamps for the illumination system.

A further object of this invention is to utilize stroboscopic gas filled arc lamps for said illumination systems.

Yet another object of this invention is to use electro-optical shutters in conjunction with the appropriate light source for said illumination systems.

Still another object of this invention is to utilize high-brightness projection type cathode ray tubes as the means for generating appropriate light patterns for use in said illumination systems.

An additional object of this invention is to use two-dimensional matrices of high-brightness light-emitting diodes (LEDs) of any one or any combination of at least three different colors as the means for generating appropriate light patterns for use in said illumination systems.

Microsoft Exhibit 1002 - Page 1385
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

A further object of this invention is to use an electro-luminescent or AC plasma display as light sources for generating appropriate light patterns for use in said illumination systems.

Yet another object of this invention is to provide electronic control systems to control the timing of on-off states of said light sources and said electro-optical shutters in synchronization with the raster scanning of said flat panel displays for the purpose of formation of 3-D and 2-D images.

Still a further object of this invention is the implementation of said illumination systems using a plurality of light sources emitting light of different colors in conjunction with a monochromatic flat panel light valve displays for the purpose of generating full resolution 3-D and enhanced resolution 2-D color images without image breakup being apparent to the user.

It is also an object of this invention to provide a device which can sense the position of a single observer's head, and position the optics within the stereo display so that the central viewing zone is automatically aligned on the observers head, and remains aligned on it as the person moves their head back and forth and sideways.

A further object of this invention is to provide a device that allows an observer a wide latitude for head movement and body position when using an autostereoscopic display.

Another object of this invention is to provide a device which uses head position data to alter the operation of a software program, so that the program always displays images on a screen with a perspective appropriate to the observer's eye positions.

Microsoft Exhibit 1002 - Page 1386
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Yet another object of this invention is to achieve the above objectives without the use of moving parts within the display.

Still other objects will be apparent to those skilled in the art upon reference to the following detailed description and the claims.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided in both autostereoscopic and non-autostereoscopic high resolution displays, the improvement in illumination system comprising a plurality of linear or point like light sources, an electronic means for controlling the on and off states of said light sources in synchronization with the process of image generation on an electronically controllable light valve, a lenticular or fly's eye lens sheet spaced apart from and in front of said light emitting sources so as to focusing the light into patterns of lines, line segments, or point like areas, said light patterns illuminating selected portions of the light valve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram which illustrates the basic optical concepts of the invention.

FIG. 2 is a schematic view from above of another embodiment of this invention, an illumination system employing two stroboscopic light sources.

FIG.s 3a - 3c are a timing diagram which illustrates the timing involved between the address of pixels an the generation of images due to changes in pixel states after address and the flashing of the various lamps of FIG. 2.

FIG. 4 is another timing diagram which illustrates the

Microsoft Exhibit 1002 - Page 1387
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

relation between the generation of video fields in the display and the timing of the light pulses from the stroboscopic light sources.

FIG. 5 is a portion of the system of FIG. 2 demonstrating the effect of varying the distances between the elements of the optical system.

FIG. 6 is a schematic optical layout, as seen from above, in which a plurality of stroboscopic light sources are employed operating in synchronism with the image generation using column by column addressing of the liquid crystal panel.

FIG. 6A is an arrangement that can be used to generate four sets of light lines for a four zone display.

FIG. 7 shows schematically the configuration of a display using the illuminating system of FIG. 6.

FIG. 8 is an autostereoscopic display utilizing segmented light sources for generating light lines of partial length to provide further improvement in the method for using stroboscopic means to increase resolution of autostereoscopic and 2-D displays where the liquid crystal display is addressed row by row.

FIG. 8A illustrates a lamp arrangement capable of producing four sets of light lines.

FIG. 9 is a schematic diagram of an optical layout for using electro-optical shutter means in conjunction with linear geometry light sources in another version of an illumination system of the present invention.

FIG. 10 is a schematic diagram of a top view of an optical layout for implementing the illumination system using a cathode ray tube.

Microsoft Exhibit 1002 - Page 1388
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

FIG. 11 is a schematic diagram of a top view of an optical layout for using an electro-luminescent device or an AC plasma display as a light source in the illumination system.

FIG. 12 is a schematic diagram of an optical layout for using light emitting diodes as light sources in the illumination system.

FIG. 13 is a schematic diagram of an optical layout of an enhanced resolution 2-D display in which light emitting diodes of different colors are used as light sources and a fly's eye lens is employed as the optical means for directing and focussing light.

FIG. 14 is a schematic diagram of a top view of an optical layout and control electronics for implementing both 2-D and 3-D displays using light sources of different colors.

FIG. 15 diagrams an alternate illumination configuration using a large number of lamps and a suitable fly's eye lens to achieve the same effect as the illumination system in FIG. 2, but which occupies a smaller volume.

FIG.s 16a - 16c diagrams the timing involved between the address of the LCD, changes in pixel states after address, and flashing of the various lamps shown in FIG. 15.

FIG. 17 is a magnified view of a section of an LCD illustrating how subregions of pixels can be illuminated by red, green, and blue light in a certain spatial pattern and in a certain temporal sequence.

FIG. 18 diagrams an illumination system that can be used to create the spatial patterns and temporal sequence illustrated in FIG. 17.

Microsoft Exhibit 1002 - Page 1389
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

FIG. 19 is a magnified view of an LCD showing an alternate spatial pattern of colored illuminated subregions that can be illuminated in a certain temporal sequence.

FIG. 20 is a drawing of part of an illumination system that can be used to create the spatial pattern and temporal illumination sequence shown in FIG. 19.

FIG. 21 is a magnified view of part of an LCD showing how a larger number of subregions in a certain spatial pattern can be illuminated within each pixel in a certain temporal sequence.

FIG. 22 is a magnified view of part of an LCD illustrating a larger spatial pattern of colored subregions within a larger number of pixels.

FIG. 23 is a magnified view of part of an LCD illustrating how linear subregions of pixels can be illuminated in a certain spatial pattern and in a certain temporal sequence.

FIG. 24 is a magnified view of part of an illumination system that can be used to generate the pattern of FIG. 23.

FIG. 25 is a top view of a head tracking system.

FIG. 26 is a close up of the lenticular lens of FIG. 6, with a slide mechanism and motor that can cause the lens, and thus the light lines and autostereoscopic viewing zones, to move sideways.

FIG. 27 is a light valve and illumination system that produces two independently controllable sets of lines, which can be used to cause viewing zones to move sideways without moving parts.

FIG.s 28a through 28c are a magnified view of how the embodiment of FIG. 27 looks to an observer's eye while the

Microsoft Exhibit 1002 - Page 1390
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

system is in use.

FIG. 29 is another specific embodiment that causes the viewing zones to move sideways using three sets of light emitting lines.

FIG.s 30a through 30c are a top view of the system of FIG. 29.

FIG.s 31a through 31c are a magnified view of how the embodiment of FIG. 29 looks to an observer's eye while the system is in use.

FIG. 32 is a top view showing the various viewing zones formed by the three sets of light lines shown in FIG. 29, and how they overlap.

FIG. 33 is a top view of a variation of the illumination system, similar to that of FIG. 6, which can create more than one set of lines and cause the sets to independently turn on and off.

FIG. 34 illustrates how the head tracking system operates with a hysteresis feature added.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The basic concept of displays using the stroboscopic illumination systems object of this invention is explained with reference to FIG. 1 which depicts schematically a general configuration of autostereoscopic and 2-D displays incorporating the system. A two dimensional light valve array 6, such as a liquid crystal panel (LCD) or a similar imaging device, is used to generate images by electronically scanning the array 6 which is comprised of rows and columns of individual pixels. The operation of such imaging devices is well known to those skilled in the art. Information is inputted to the LCD 6 via an input 10 which is usually a ribbon cable.

Microsoft Exhibit 1002 - Page 1391
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

The illumination of the LCD 6 is provided by the stroboscopic or non-stroboscopic light source means 3, which is described in its several versions in the following, can consist of several different types of light sources, some in combination with electro-optical shutters. The emitting regions of the light sources will generally be long, thin, and vertically oriented or will be small and point like, as described in US -A-5,036,385. Light source means 3 is controlled and driven by signals through input 9 from the electronic control module 1. Control module 1 receives its timing signals through input 8 and generates a sequence of light flashes appropriately synchronized with the generation of an image on LCD 6. In addition to light sources or combination of light sources and electro-optical shutters, the light source means 3 contains appropriate reflectors, mechanical supports, cooling means, and means for adjusting the position of said light sources to achieve a desired geometry of the illumination system. An opaque flat black non-reflective barrier 96 blocks the area between and to the sides of the light sources 3, so as not to allow light to exit the light source 3 or be reflected from the light source 3 from points other than the light source 3. Barrier 96 can be a flat black metal plate with slots or holes cut in its surface in front of the light source 3.

A system of baffles (not shown) consisting of opaque barriers extending out from the barrier 96 can be placed in the system to prevent light from light source 3 from reaching points on the lenticular lens far from the area directly in front of the light source 3. These barriers generally reduce the amount of scattered light in the system, and reduce the brightness of ghost images - that is, images intended for the right eye which seen faintly by the left eye and vice versa - which are caused by scattered light which strikes the diffuser 5 in the area between the light lines.

Optical means 4, such as a lenticular lens or fly's eye

Microsoft Exhibit 1002 - Page 1392
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

lens, focuses the light from said light source means 3 onto a weakly diffusing transparent panel 5, the purpose of which is to slightly broaden the angle from which these light lines can be seen though the LCD 6. The panel 5 typically consists of a clear substrate of a certain thickness, with a thin layer of diffusing material bonded to its rear most surface. A glass or plastic panel 7 with an antireflection (AR) thin film coating 11 on its front surface is disposed of in, or bonded to the front of the LCD 6 so as to reduce disturbing reflections from the ambient light sources.

This generic system, when certain details are added and when it is operated in different ways, can be used to create one or more sets of light lines or light points in different positions and control which of the sets of light lines or points is on at a given time, as are necessary for several advanced types of displays that are described in US-A-4,717,949, 4,829,365 and 5,036,385.

If only one set of steadily shining light source lines is used, the system can be used to generate the steadily shining vertically oriented light lines, or arrays of light points, behind an LCD, as described in US-A-4,717,949 and 4,829,365. This system will produce autostereoscopic images with less resolution than the LCD itself. In some embodiments it will also create certain position restrictions for an observer - the observer must position himself so that his eyes are located within certain viewing zones within which right eye and left eye images are seen.

If multiple sets of independently controllable, steadily shining light sources are used, with each set capable of being turned off and another turned on upon command of a device which senses the position of an observer's head, then the viewing zones within which the autostereoscopic images are seen can be made to move to follow the observer's head as it moves, thus removing the position restrictions associated with the devices described in US-A-4,717,949 and 4,829,365. The operation of this type

Microsoft Exhibit 1002 - Page 1393
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

of system is described in detail later in this application.

As described in detail in US-A-5,036,385, the doubling of the pixel resolution of a 3-D image generated using an autostereoscopic display is achieved by rapidly generating partial images on the LCD 6 and stroboscopically illuminating the appropriate section on LCD 6 in synchronism with the image generation using appropriate fast flashing light systems. In this manner it is possible to use the same sets of pixel columns to display left and right halves of the stereopair, thus doubling the resolution of the display, as compared to earlier schemes, e.g., see US-A-4,717,949. If said partial images are generated and illuminated at a rate above the fusion frequency of vision, no flicker is perceived.

The look-around capability in autostereoscopic displays, as described in US-A-5,036,385, makes it possible for the observer to sees the 3-D image from several perspectives, not unlike a hologram. To implement this function several images representing the different perspective views of the object or a scene are interlaced with one another and are scanned in sequentially into the LCD 6 and the stroboscopic illumination is synchronized such that the different perspective views appear in different viewing zones, so that as the head of the observer moves with respect to the screen of the display, appropriate views, corresponding to the perspective appear. Such images of actual scenes or objects can be generated in real time using a number of TV camera pairs, or computer-generated images can be presented using one of several available image rotation programs.

A similar approach can be used to increase the resolution of non-stereoscopic (2-D flat) images to several times beyond the physical pixel resolution of an LCD. In this case, different subsections of each pixel are sequentially illuminated, while each pixel varies its transparency to correspond to different sub sections of a

Microsoft Exhibit 1002 - Page 1394
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

high resolution image, such that a detailed total image can be observed because of vision persistence with resolution several times greater than the pixel resolution of the LCD 6. In this latter case, the light lines are so positioned with respect to the pixel columns in the LCD 6 that at any given instant the observer sees only a part of a given pixel. Thus, the complete high resolution image is built up sequentially but fast enough to avoid flicker.

Some of the choices of components available for use in the illumination system when used for these various display configurations are described below.

In the present embodiment of the autostereoscopic display 2 the light source 3 is a bank of aperture fluorescent lamps, i.e., a fluorescent lamp with a narrow transparent slit parallel to its major axis, internally scribed into the light-emitting phosphor. The configuration allows for very bright light to be emitted by the lamp through said slit.

In place of said fluorescent lamp a short filament incandescent lamp has been used in conjunction with a fiber optic device which converts the image of the short filament into a long line of light which is then directed in a similar manner onto said lenticular lens sheet.

Intense illumination, and consequently bright images, can be generated using linear gas filled arc stroboscopic lamps, such as xenon flash lamps, as the light sources 3 in the above described light line generation scheme. The stroboscopic lamps operate at a rate considerable above the fusion frequency threshold of human vision (24 - 30 Hz), so that no flicker is perceived. Gas filled DC arc lamps can also be used.

Another method of illumination is to use a very bright point like incandescent lamp situated at some distance behind the lenticular lens 4. This method of illumination

Microsoft Exhibit 1002 - Page 1395
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

produces exceptionally bright 3-D images.

Xenon flash lamps and light emitting diodes (LEDs) light sources have also been experimentally utilized.

Other possibilities for light sources for this illumination system are projection type cathode ray tubes (CRT), electro-luminescent and AC plasma display panels

The pixels on these types of displays generally can be made to emit their light in strobe fashion when addressed, and thus can be used as light sources for the type of illumination systems described in this application.

Because in the present autostereoscopic display referenced above one half of the pixel columns of the LCD are used to display one half of the stereopair, the resolution of 3-D images with this type of display is one half of the pixel resolution of the LCD.

A top view of an embodiment of the invention using two stroboscopic light sources is shown schematically in FIG. 2. Light sources 42, 43 have linear geometry and are operated sequentially in a stroboscopic mode. The light sources 42, 43 can be any of the types of light sources described above. Reflectors 40, 41 can be used to increase the intensity of light projected toward the front of the display.

The light lines required in this embodiment to make it possible for the observer to perceive an illusion of a full resolution 3-D image are generated by means of the lenticular lens 46 which is a large array of thin, evenly spaced cylindrical lenslets forming a part of a transparent substrate. The geometry of the illumination system is so designed that light source 42, when it is on, generates a set of vertical light lines of which two, B1 and B2, are indicated in the drawing, to the right of the centers of the lenslets 52; and source 43 generates a set of vertical light lines, A1 and A2, to the left of the center of the lenslets

Microsoft Exhibit 1002 - Page 1396
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

52. Only one set of light lines can be seen at a time because these light sources 42 and 43 operate sequentially. More lamps can be used to generate multiple sets of light lines for the full resolution displays with look around capability.

The lenticular lens 4 is a transparent plate which has on its one surface an array of very narrow vertically disposed parallel cylindrical lenslets. The number of said lenslets is equal to one half of the number of pixel columns of LCD 6 or less. The fly's eye lens version uses a two dimensional array of spherical lenses of circular or square outline on the same type of transparent plate. It can be used to image thin, vertically oriented light sources into light lines or it can be used to image smaller, more point like light sources into light spots. The various means of illumination described above can be utilized with these lenses.

It is desirable in many applications to be able to switch between 3-D image display, in which each eye sees different pixels on the LCD, and 2-D image display, in which both eyes see all the pixels. A commercially available electrically controlled diffuser 44 is diffuse when 2-D images are being displayed. When 3-D presentation is desired, the diffuser 44 is actuated by applying a voltage via input 45 such that it changes its state from strongly diffusing to transparent thus changing the nature of illumination from the type of uniform, diffuse illumination as required for 2-D images to one in which the light sources 42 and 43 are imaged by the lenticular lens 46 to generate a lattice of light lines for 3-D imaging. Such diffusers are made by Polytronics and Raychem in the United States, and other companies overseas.

It is generally desirable that the lenticular lens 4 and electronically controlled diffuser 44 have anti reflective coatings on their front most and rear most surfaces, that any non diffusing surface of weakly diffusing

Microsoft Exhibit 1002 - Page 1397
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

transparent panel 47 has an anti-reflective coating, and that the rear most surface of the LCD has an anti reflective coating. As an alternative, the front most surface of diffuser 5 can be bonded to the rear most LCD surface with an optically clear bonding agent, achieving the same effect of greatly reducing reflections at these surfaces.

The lenslets 52 focus the images of the active parts of the light sources 42 and 43 on the weakly diffusing transparent panel 47, the purpose of which is to slightly widen the angle from which said light lines are visible to the observer, i.e., to widen the zone of observation and also make the brightness of the illumination appear to be more uniform across the display. In the case of 3-D autostereoscopic imaging, locating the diffuser at the plane where the lines are focused is the only placement that works well. However, in the 2-D high resolution imaging case, the light lines or spots will ideally be located at the liquid crystal pixel layer itself, which is in the middle of the LCD glass where typically no diffuser can be placed. In the 2-D case, good results in terms of even illumination can be obtained with a weak diffuser placed practically anywhere in the available space between a plane several millimeters in front of the light source and the front of the LCD. However, the viewing angle is broadened only if the diffuser is placed on the front of the LCD. In the case of 2-D high resolution imaging, one also has the option of focusing the light spots or points through the LCD pixels and onto a diffuser mounted in front of the LCD.

The observer sees the light lines through the LCD 53 which comprises a two-dimensional array of cells 50 filled with a liquid crystal substance, and sandwiched between two sheets of glass 54 and 55 which are coated with polarizing film 49 and 51. The driving signals to control image generation on said LCD 53 are fed though the input 56.

Most embodiments that move the viewing zones to follow the observer's head require multiple sets of steadily

Microsoft Exhibit 1002 - Page 1398
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

shining lamps. Such a system is described below.

FIG. 33 (another top view) shows how a lenticular lens and linear lamp arrangement can be used to produce two, three, or many sets of independently controlled light emitting lines. In FIG. 33 independently controllable sets of lamps 470, 471, 472 are spaced behind a lenticular lens sheet or fly's eye lens sheet 473 with lenticular lenses or fly's eye lens columns 474 parallel to the lamps and oriented in a vertical direction parallel to the lamps. A lenticular diffuser 475 is again placed at the distance from the lenses where light from lamps 470, 471, and 472 are focused, and at a certain distance behind the pixel layer 482 of LCD 481. Baffles 476, barriers 477, and anti-reflective coatings are again used to minimize scattered and reflected light. The lenticular lenses 474 image the light from lamps 470 - 472 onto the diffusion layer along different sets of lines 478 - 480, each set being at a different position on diffuser 475. The light from lamps 470 along lines 478, the light from lamp 471 along lines 479, and the light from lamps 472 along lines 480. By turning lamps 470 - 472 on and off independently, it is possible to cause light line sets 478 - 480 to independently turn on and off. Note that the number of different sets of light lines formed with this arrangement can be equal to the number of independently controllable sets of lamps. Although three sets of lamps and light lines are shown here, any number can, in theory, be used.

An electronic means 483 would be provided to turn one and only one lamp on at any given time through operation of lamp power supply electronics 484. In this embodiment of the invention, the electronics switch between the lamps according to information received from a observer's head position sensing device to be described. Electronic means 483 is typically a microprocessor based device that is capable of turning different lamps on and off according to input in the form of X, Y and Z Cartesian coordinate head position information. As before fluorescent lamps or arc

Microsoft Exhibit 1002 - Page 1399
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

strobe lamps would be ideal for this application.

This illumination system is, of course, not the only way to produce either single, stationary, sets of light emitting lines or multiple sets of light emitting lines in different locations that can be turned on and off independently. Other possible systems include the embodiments using a special side illuminated reflector plates described in US-A-5,040,878.

Other methods of producing different sets of light lines in different positions behind an LCD with light from different sources, as well as variations of the systems described above, will be apparent to those skilled in the art. For example, variations on the system described above include the use of a fly's eye lens array instead of the lenticular lens, and use of columns of point like light sources instead of linear vertical oriented light sources.

FIG. 25 illustrates a head tracking system that can be used with displays employing the illumination systems described above. As a representative example of a head position sensing device, three ultrasonic transducers 420a, 420b, 421 are positioned along the top of the display case 430 of FIG. 25. In practice, such position sensors are not limited to ultrasonic transducers. A number of different types of sensors can provide information on the head position, to be used by the mechanical or electro-optic methods described above to shift the position of the light lines. For example, the Polhemus Company makes an electro-magnetic sensor which, combined with an element that can be worn on the body or head, is capable of determining the location of the element to a high degree of accuracy. The Polhemus system is particularly effective in situations where a helmet is worn, since the element can be mounted unobtrusively on or within the helmet. Another type of sensor uses infrared light reflected off the head to determine the head's location. Origin Instruments makes such a sensor, which reflects infrared light off of a small

Microsoft Exhibit 1002 - Page 1400
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

reflective spot attached to the forehead or glasses. Another infrared system described by Pund in US-A-4,649,425, reflects light directly off the head and does not require the user to wear any reflective device. Those familiar with the art will be aware of other types of head position sensors and other variations of the types just described.

In the ultrasound system of FIG. 25, an electronic pulse generator 422 causes the middle transducer 421 to periodically send pulses of ultrasound into the environment. The other two transducers 420a, 420b mounted near the sides of the display, listen for return echoes. Generally, all the transducers will be located at the back of horn reflectors 423 to concentrate the outgoing beam in a forward direction, and shield the listening transducers 420a, 420b from sound coming from anywhere but the forward direction.

Upon receiving ultrasonic energy, receiving transducers 420a, 420b send a signal to electronic interface 424 whose amplitude is proportional to the intensity of ultrasonic wave being detected at any given moment. Electronic interface 424 contains a filter which notes the time at which the first signal above a certain intensity is received. This signal will be a signal from the closest point on the closest object to the transducers.

A computing device 425, such as a microprocessor, uses the times measured between the emitted pulse from the central transducer 421 and the received echo from the two receivers 420a, 420b to calculate the position of the object, presumably the observer's head 427, which is causing the echo. A variation of the ultrasound device places the central transducer 421 on a clip on device worn by the user, instead of mounting it on the display 430. This can be attached to the users clothing directly below the center of his or her face. The transducer 421 should ideally be powered by a battery so that no cords or other devices are needed between the observer 427 and the display or other power source.

Microsoft Exhibit 1002 - Page 1401
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

All of the head position sensors described above have in common the ability to determine the position of the head 427 in at least one dimension namely the horizontal direction parallel to the screen surface. Ideally, the head position in the other two dimensions, forward and back from the screen, and vertically, can also be determined. The Polhemus device can determine head position in all three dimensions, and the Origin Instruments and Ultrasound device described can determine position in the Y (side to side, horizontal) and Z (toward and away from the display) dimensions. In certain situations it may be desirable to use more than one of such sensing devices in combination, in order to determine the observer's positions in all coordinates.

Information on the head's 427 position is used by the microprocessor 425 to change the position of the light emitting lines behind the display, thus causing the viewing zones to move sideways, to stay centered on the observer's head 427.

A method of accomplishing this with the illumination system shown in FIG. 6 is shown in the magnified view in FIG. 26. Here, a motor 419 is attached to a slide mechanism 426 within which the lenticular lens 69 of FIG. 6 is held. Signals from the microprocessor 425 cause the stepping motor 419 to extend or retract its shaft 341, causing the slide mechanism to move. As the slide moves, the illuminating lines 413 formed on the diffuser 417 move sideways relative to the pixels 404 on the LCD 401 (not shown), and the viewing zones shift position. For example, in FIG. 26 if the lenslets 412 are shifted to positions shown in dotted lines 427 the lines 413 shift from positions 413 to new or second positions 428, and the viewing zones move horizontally, as shown by the change in direction of the arrows from the light lines 213 through the boundaries 229 of the pixels 404 in the liquid crystal layer 417 of LCD.

Microsoft Exhibit 1002 - Page 1402
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

The motor 419 used is ideally a stepper motor, but can also be a continuous motor with a reduction gear system which moves a shaft only a small amount per revolution of the motor armature.

The distance that the lines must shift in order for the viewing zones to follow a person's head 427 across a distance D_h is equal to $S(D_h/Z)$, where S is the distance between the light lines and the image forming pixels, D_h is the distance that the person's head moves, and Z is the distance from the person's head to the image forming pixel layer.

FIG. 26 illustrates a method of moving the line that requires moving parts. However, it is possible to perform head tracking without moving parts by using different sets of lines that turn on and off, using an illumination system similar to that shown in FIG. 33, which can form multiple sets of light emitting lines in different positions by turning lamp sets on and off as was described earlier. A head tracking system without moving parts has advantages over a moving parts system including superior ability to keep the zones positioned on the observers eyes, and superior reliability under adverse conditions such as the high gravity forces and vibrations encountered within an aircraft.

A method of doing this with two sets of lines is illustrated in FIG. 27. A surface, such as a diffuser 342, upon which two sets of light emitting lines 432 and 433 can be displayed is spaced behind LCD 401 as shown. Each set of lines can be turned on and off independently, and furthermore circuitry is provided to turn one set off whenever the other set is on and visa versa. Such independently controllable sets of light emitting lines can be formed by the lenticular lens arrangement of FIG. 33 if two independently controlled sets of lamps are used.

FIG.s 28a - 28c illustrate how the arrangement of FIG.

Microsoft Exhibit 1002 - Page 1403
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

27 looks to the left eye of an observer sitting in front of the display. Light line set 432 is assumed to be on. As the observer moves to the right, line set 432 seems to get closer and closer to the boundary between the odd pixel columns 434 and the even pixel columns 435, as shown in FIG. 28a. At some point before the line appears to reach the boundary, line set 432 is turned off and line set 433 is turned on, as shown in FIG. 28b. Line set 433 is seen to still be well away from the pixel boundary, so the observer can continue moving to the right without crossing a zone. At some point after the line set 432 has crossed the boundary, but before line set 433 reaches the boundary, set 433 is turned off and set 432 is turned on again, as shown in FIG. 28c. Since line set 432 is now seen to be behind the even pixel columns by the left eye, the computer must simultaneously switch the left eye view image on the odd columns over to the adjacent even columns, and switch the right eye view to the odd columns. This can be accomplished by writing a new image with the right eye view on the even columns and a left eye view on the odd columns.

As the observer continues to move, it is possible to repeat the process illustrated in FIG. 26 as the lines appear to move across successive pixel columns. If the observer then moves to the left, the process is repeated in reverse.

FIG. 29 illustrates a light line illumination arrangement that can accomplish this process without an image flip when three or more lines are used. Here, three line sets 441, 442 and 443 are shown spaced on the diffuser 342 behind the LCD 401. Each set can be turned on and off independently. Furthermore, electronic means are provided to cause one set of lines to turn on at any given time.

FIG.s 30a - 30c show how the viewing zones formed by the light lines in FIG. 29 move sideways as the light lines change position. When the lines 41 are on, the central left and right viewing zones are formed in positions 444 and 445,

Microsoft Exhibit 1002 - Page 1404
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

with the borders of the two central viewing zones defined by imaginary lines between the light lines and the boundaries 429 of the odd and even pixel columns of the light valve, as shown in FIG. 30a, according to the principles described in US-A-4,717,949. As described in that patent, there are a number of such zones spaced evenly across a plane parallel to the display. Only two are shown here for clarity. When lines 442 are on, the viewing zones move to positions 446 and 447 in FIG. 30b. When lines 443 are on, the zones move to positions 448 and 449 in FIG. 30c.

FIG.s 31a - 31c illustrate how this arrangement looks to an observer's left eye. Line set 441 is assumed to be on. As the observer moves to the right, line set 441 appears to approach the boundary between the pixel columns as shown in FIG. 31a. Before this occurs, set 41 is turned off and set 442 is turned on. As the observer continues to move, set 442 seems to approach the pixel boundary as shown in FIG. 31b. Before it crosses the boundary, set 442 is turned off and set 443 is turned on. As the observer continues to move, set 443 will eventually be seen to approach the boundary as shown in FIG. 31c. Before it crosses the boundary, set 443 is turned off and set 441 is turned back on. When set 441 is turned on again, the observer has moved so that his or her eyes are now in the two viewing zones adjacent to the central pair of zones where the observer started. This process can be repeated continuously as the observer moves, without any image flip between columns being necessary. If the observer moves to the left, the process can be repeated in reverse.

When more than three sets of light lines are used, the process is identical, with one light set coming on after its neighbor as the observer moves, except that since a larger number of light line sets with smaller space between them is used, more viewing zone positions are produced and the centers of the viewing zones can be more closely matched to the positions of the observer's eyes.

Microsoft Exhibit 1002 - Page 1405
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

When only three sets of light lines are used, an image flip at every light line change may still be used to good effect, since it can allow the viewing zones centers to remain closer to the observer's eyes.

Use of an image flip with three lamp sets is illustrated in FIG. 32. Here, lamps 490, 491, 492 create light line sets 493, 494 495. In turn the light lines 493 shining through the LCD pixels create viewing zones 496, 497; light lines 494 create viewing zones 498, 499 and light lines 495 create viewing zones 350, 351. Each of the even numbered zones is assumed to be a left eye zone, and each of the odd numbered zones is assumed to be a right eye zone. They are marked in FIG. 32 with an "L" for left or "R" for right, respectively. Although the three sets of zones are shown to be spaced at slightly different distances from the display, this is only done to provide clarity. The horizontal lines 360, representing the ideal viewing plane where the zones are widest, are in reality coincident. The ideal viewing plane is explained in US-A-4,717,929.

When no image flip is used, the system will have to switch lamps when the observer's eyes are in regions such as region 352 where two left eye or two right eye zones overlap. These overlap regions are rather narrow. If, however, and image flip is used every time a lamp is switched, the switch can occur whenever the eyes are in wider regions 353, where left eye zones overlap with right eye zones. The overlap distance between these sets of zones is twice as large as the overlap between the others, as can be seen in the drawing.

Operation of the three lamp system with an image flip during observer movement is shown in FIG. 32. The observer's eyes are initially in zones 496, 497 and the observer is assumed to be moving left. As the eyes reach the horizontal positions 354, lamp set 490 turns off and lamp set 491 turns on, forming new zones 498 and 499. Normally, this would put the left eye in a right eye zone

Microsoft Exhibit 1002 - Page 1406
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

and vice versa, However, simultaneously, the images switch between columns, causing zones 498 to become right eye zones and zones 499 to become left eye zones, thus keeping the right eye image visible to the right eye and the left eye image visible to the left eye.

If the observer continues to move left, to the positions 355, lamps 491 now turn off and lamps 492 come on, causing the zones to move to positions 351 and 352. Once again, an image flip occurs. If the observer still continues to move, lamp set 491 can come on again when the eyes have reached point 356. By continuously turning the lamp sets on and off in the order 490, 491, 492, 490 .... and flipping the images between columns after every lamp change, one can cause the zones to track the observers eye positions as the observer moves to the left. If the observer moves to the right, the order of turn on and turn off of the lamps is reversed, and an image flip still occurs at every lamp switch. Note that the order in which the lamps turn on is the reverse order in which they turn on when no image flip is used with the three lamp system.

In any of the previous arrangements, if the observer stops at or near the location that causes the line sets to switch, the systems just described may cause the lines sets to switch on and off and the images to flip continuously. This will likely be annoying to the viewer. To prevent this problem, hysteresis can be introduced into the control system. This is illustrated in FIG. 34.

In FIG. 34, as the observer 427 moves to the right, there will be certain points, 450 which when crossed will cause the controller to switch line sets and or flip images. The controller can be programed so that, when the observer stops and moves back to the left, the switching back to the original state does not occur until the observer gets to the points 451. Thus if the observer stops at or near any of the points 450 or 451, a single line switch and or image flip will occur, and the system will stay in that state

Microsoft Exhibit 1002 - Page 1407
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

until the observer has moved a considerable distance one way or the other.

When the systems described above use an image flip between pixel columns, then it is desirable, when switching between one set of lamps and the next, to keep both lamps off during all or most of the short period when the pixels on the LCD are changing to flip the positions of the left and right eye images. Otherwise, a double image become visible for an instant, during the short time the pixels of the display are changing from one state to the next. If strobe lamps are used, the short time interval between lamp flashes can be timed to occur at the end of the address of the LCD, and be of such a length that the pixel complete all or most of their change by the time the next lamp flash occurs.

It is desirable in many applications to be able to switch between 3-D image display, in which each eye sees different pixels on the LCD and 2-D image display, in which both eyes see all the pixels. In a system with three or more sets of lamps, this can be accomplished simply be turning on all the lamps at once. With all the lamps on, light lines are seen behind all the pixels by each eye, and thus full resolution 2-D images can be viewed. A switch can be provided for this purpose. At one position, the switch allows only one set of lamps to be on at any given time. In the other position it turns all the lamp sets on. Note that if a large number of lamp sets are used, it is not necessary to turn on all of them in order for a light line to become visible behind every pixel. It is generally desirable, when turning on multiple lamp sets on for 2-D viewing, to turn down the power provided to each lamp, so that the overall brightness of the display remains roughly constant, even though many more lamps are on. The variable diffuser 416 of FIG.s 32 and 33 can also be used to good effect for 2-D viewing in a multiple lamp set system. If the variable diffuser is turned to its diffuse condition when multiple lamp sets are turned on for 2-D viewing, very

Microsoft Exhibit 1002 - Page 1408
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

even illumination will result.

With any of the multiple line set or mechanically moving line set methods described above, it is possible to add a so called look around feature through the use of the proper image generating software and interface between the software and the head tracker. When the observer is in a certain position directly in font of the screen, a stereoscopic image made up of two perspective views of some scene is shown on the screen. The actual images of the scene on the display surface are two projections of the points on the imaginary 3-D objects onto the screen surface along lines running between the points in imaginary space and the observer's two eye locations. The drawing of images in this way is well known to those familiar with the art of computer graphics as applied to stereoscopic and autostereoscopic displays.

As the observer moves sideways or back and forth, the computer continuously redraws the scene so that the perspective views are drawn as projections toward the observer's new eye locations. Thus, the observer will always see perspective views of the scene that are identical to the views that would be perceived of real objects in space as viewed from the observers current location. Thus the observer will be able to move her head to look around corners or behind objects and so forth, and perhaps more importantly, will always see a 3-D image with minimal distortion. This will greatly enhance the apparent realism of the scene. Origin Instruments sells a software package that performs this function on simple images when used with their infrared head position sensing system.

In some applications, however, a different scheme would be more desirable for elimination of the distortion in the image when seen from off axis. For example, in some avionics applications the pilot sees a representation of an imaginary path in the sky to follow, which extends from near the display out to infinity. If displayed in 3-D, this path

Microsoft Exhibit 1002 - Page 1409
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

will be seen as if through a small window at the display surface. Obviously, if the pilot moves his or her head to the side when the look around software described above is in use, all but the nearest parts of the pathway will disappear behind the edge of the window, as distant objects always do because of perspective. This would be very undesirable.

If no look around software of the type described is used, the image will stay the same on the screen and the observer will still be able to see all of it as he moves around, but it will appear to be distorted when viewed from all positions except one, as is well known to those familiar with stereoscopic display systems.

A much more desirable arrangement would be to use software that continuously redraws the image as projected to two eye points coincident with the pilot's eyes, as before, and simultaneously causes the scene image to rotate around an imaginary point at the center of the display in such a way that the same axis within the image space is always pointed at the spot between the observer's eyes. Thus, the pilot would always see an undistorted image of the pathway that seems to extend directly away into the distance, but does not become hidden behind the edges of the display. Note that with either system, the image redraws can be performed to accommodate observer movement along any direction, up and down, in and out as well as sideways, provided that the head position sensor provides information on the head position in these dimensions.

With any of the light line moving systems described above, it is desirable to provide a means by which an observer can initially position the viewing zones to center them precisely on his or her eyes when he or she is seated in the most comfortable position. This will correct for any erroneous positioning caused by variables such as posture, eye separation, echoes from headgear and the like. For this purpose, a switch may be provided, ideally located on the display case, and ideally being a spring loaded three

Microsoft Exhibit 1002 - Page 1410
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

position rocker switch. In the left position, the switch would cause a mechanical or electro-optic optic mechanism to take the actions necessary to shift the viewing zones to the left one step at a time. In the middle position, to which the switch would return when not pressed, nothing would occur - this would be a neutral position. When pressed into the right position, the switch would cause electrical connections which caused the light line repositioning system to move the lines to the left, thus moving the viewing zones to the right one step at a time.

When multiple users are observing the display, it will be desirable to turn the head tracker off, since the tracking schemes just described can only track and follow one person's head. The zone movements necessary to track this person's head will not be appropriate for the other users, since their heads will more than likely be undergoing different motions than the tracked user. Thus a switch should be provided to turn the head tracker on and off independently of the display.

In the head tracking systems described above it is desirable, but not absolutely necessary, to coordinate the lamp turn ons and turn offs with the completion of the LCD addresses necessary to form the next image or flip images between columns. However, in the full resolution 3-D, full resolution 3-D with look around, and increased resolution 2-D embodiments, it is critical that the turn on and turn off of various lamp sets be timed precisely in relation to the address and change of the pixels on the LCD. An explanation of this timing is provided here prior to a description of how the stroboscopic versions of the present illumination system work.

The timing sequence of LCD scan (during which all pixels are addressed), pixel transmittance changes to form the next image component, and light source turn on and turn off when a small number of lamps is used for full resolution 3-D imaging as in FIG. 2 is shown in FIG.s 3a - 3c.

Microsoft Exhibit 1002 - Page 1411
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

The timing diagram is shown in FIG.s 3a - 3c. FIG. 3a depicts the repeated address of LCD rows starting at the top row and proceeding to the bottom row. FIG. 3b shows the change from "off" or opaque state to "on" or clear state (or vice versa) of the first and the last pixels in a video field, after these pixels have been addressed, and the flashing of the first light emitting point or lamp 42 shown in FIG. 2. In the case of TFT and Ferroelectric LCDs, when a pixel is turned on during the scan of an LCD, it stays on until turned off, in this case until the scan of the entire LCD to display one video frame is completed, and the last pixels have had time to change their state.

As shown in FIG. 3a the time period between the start of one LCD scan and the start of the next is divided into three periods during which three actions occur: a first period 22 during which the LCD is scanned and its rows sequentially addressed usually starting at the top row 20 and ending at the bottom row 21 causing the pixels to change state in order to display the next image, a pause or waiting period 23 during which nothing happens, and an optional blanking period 24 of beneficial effect in some LCDs in which the LCD is scanned again and all the pixels are addressed and made to change state to either full on or full off depending on LCD configuration, to completely erase the previous image. Typically, all the pixels of a given row are addressed at the same time.

The signal to change the states of the first row pixels is given to the LCD 6 at time t_0. For illustrative purposes, it is assumed that a delay of about 3.5 ms occurs before the pixel completes its change to a new state in response to the applied signal - it begins to turn on at time t_1 and completes the change in its state between opaque and clear at time t_2 as shown in FIG. 3b. Although in FIG. 3b pixels are shown turning between full off and full on it is understood that typically some will be turning from on to off and others will turning between one intermediate gray

Microsoft Exhibit 1002 - Page 1412
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

state and another. The last pixel starts its state change at time t_3 after it is addressed at time t_2 and completes it at time t_4. At this instant the video frame is complete and the light source 7 flashes, as shown in FIG. 3c, thus transferring the information in the first field to the observer. As seen in FIG. 3a a pause period 23 during which no addressing of the LCD happens is inserted in order to give all the pixels time to change to their new state before the lamp is fired. If the time it takes a pixel to change state is long enough, or the time required for a scan is short enough, a second scan can occur during the pause period. During the second scan the same image information is transferred to the LCD as in the first scan. The optional blanking scan can then occur followed by the next address of the LCD during which the pixels are addressed in order to create the second image field. The sequence in the second frame is the same as in the first frame except that lamp 43 flashes. Likewise, the timing of events is identical in subsequent frames, the only difference being the information written to the LCD and which of the lamps flashes.

Again as shown in FIG.s 3a - 3c, the pixels take a certain period of time to change state once they are addressed. In this case 3.5 ms is shown for illustration, that being the period typical of a custom pixel LCD being made by an LCD development lab for Dimension Technologies Inc. The time required to turn off from full on may be different than the time required for full on to full off, or the time required to change between various intermediate gray levels. In such cases, the longest time period required to change between two states is most relevant, and must be accommodated so that all pixels, regardless of which states the change to or from, can complete their change before a lamp is fired.

Lamps, of course, never flash instantaneously, but rather emit light for a short time and then turn off. The duration that the lamp is emitting light depends on the lamp, and can be controlled with some lamps, such as LEDs.

Microsoft Exhibit 1002 - Page 1413
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

In general, the lamp should emit light only during the time period between the completion of the last pixel's change and the beginning of the next address scan. However, if a blanking scan is used, and the LCD is blanked to a dark state, the lamps may emit light during the blanking period without significant image degradation. However, if the LCD is blanked to the bright or transparent state, the lamps should stop emitting light before the blanking period begins. Otherwise, contrast will be lessened considerably.

A total of 16.7 ms has elapsed from the time the turn on signal has been applied to the first pixel to the completion of the change in state of the last pixel and flash of the light source, and blanking at all the pixels, and beginning of the next scan. Thus, there are 60 fields per second or 30 images (video frames) per second. This frame frequency will result in a nearly flickerless image in this particular configuration given typical screen sizes and brightness levels. Other configurations in which more than two sets of light lines or spots are created may require higher frame frequencies to avoid flicker. This scanning, changing, and flash sequence proceeds continuously, as subsequent image frames, each consisting of two sequential fields made visible to the observer by means of two lamp flashes, are displayed. The two image fields each consist of interleaved right and left eye members of a stereopair image as described in US-A-5,036,385.

FIG. 4 depicts the relation of the flashes of light sources 42 and 43 to the field generation on the LCD 53. As is shown, time is divided into periods numbered consecutively on the diagram starting with 1. During the odd periods, labeled 1, 3, etc., the LCD is scanned and all the rows of pixels are addressed. These correspond to the time period T_0 to T_3 in FIG.s 3a - 3c. The even periods, labeled 2, 4, etc., are waiting periods during which no addressing action is taken, and all the pixels on the LCD, including the very last ones addressed, are allowed to change to their new state after being addressed. These

Microsoft Exhibit 1002 - Page 1414
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

periods correspond to the time period T_3 to T_4 in FIG.s 3a - 3c. The spikes represent the flashes for light sources 42,43.

The two periods are shown as being roughly equal in FIG. 4, but the wait periods can be shorter or longer than the scan periods, depending on how fast the Liquid Crystal material in the LCD can change its state. If the periods can be equal, that is, if the LC material changes state in about the same amount of time as it takes to scan the LCD, then an extra scan can be performed during the even time periods, during which the information of the previous odd field is scanned onto the LCD a second time. This will result in a slightly brighter, more uniform image with greater contrast when a conventional TFT LCD is used. The reason for this is that charge slowly leaks across an LCD pixel cell after it changes state and is waiting for the next address, causing its transmittance to drop slightly during the remainder of the scan and wait periods. A second scan will cause the pixel transmittance to stop falling and return, at least partially, to its proper value by the time the lamp flashes.

By changing the distances between the light sources 30 and the lenticular lens 32 as indicated in FIG. 5, it is possible to vary the pitch between the light lines imaged on the weakly diffusing panel 33. It is also possible to adjust the width of the left and right eye viewing zones in this manner, to match the interpupillary spacing of the observer and provide the maximum amount of lateral head movement for that observer. In this way it is possible to adjust the illumination system to the pixel geometry on an LCD. In addition, by also varying the distance between the lenticular lens 32, said diffusing panel 33, and the LCD, it is possible to vary the best viewing distance from the LCD to the observer.

A version of the illumination system of FIG. 2 is illustrated as a top view in FIG. 6. In this system instead

Microsoft Exhibit 1002 - Page 1415
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

of two a plurality of light sources 61 through 68 are positioned such that each pair of light sources illuminates one vertical section of the lenticular lens 69. The light sources 61 through 68 can be fluorescent lamps or gas filled arc lamps, such as those filled with Xenon gas. Baffles 73 through 77 prevent light from one pair of the light sources shine on another section of the lenticular lens 69 other than the section in front of each lamp. The lenticular lens 69 images the light sources 61 through 68 on to the weakly diffusing panel 70 generating a lattice of thin, bright, vertical lines the purpose of which is as explained earlier. In this example, the column of the LCD pixels are addressed sequentially, during each field, starting with the left most column, and proceeding to the right most column.

Lamps 61, 63, 65 and 67 flash in sequence at predetermined intervals synchronized with the build up of one half of a stereopair image on the LCD 72. The first half image displayed during the first field is made up of the odd columns of the left eye image displayed on the odd columns of the LCD 72 and of the even columns of the right eye image, which are displayed on the even columns of the LCD 72, as is explained in US-A-5,036,385. After the section of the first half image in front of lamp 61 is generated, (i.e. the pixels in that section complete their change of state) light source 61 flashes, thus transferring the video information to the observer. The process is sequentially repeated by light sources 63, 65 and 67 until light source 67 flashes when the last pixel in the last section of the first half of the stereopair is addressed or changes its state. The second half of the stereo image is scanned in the same manner into the same set of pixels, thus achieving full resolution of the stereo image, and the set of light sources 62, 64, 66 and 68 flash in sequence and synchronism with the build up of the image on LCD 72 oriented as shown in FIG. 6.

The main advantage of this embodiment of this invention is that most of the wait period or pause period, where one is waiting for all the pixels, including the very last ones,

Microsoft Exhibit 1002 - Page 1416
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

to complete their change is shortened. Each of the smaller sections is illuminated as soon as the pixels within that section complete their change, which may occur while another part of the LCD is still being addressed. Indeed, if the pixels can complete their change in a period of time less that the interval between the address of the last column of their section and the next address of the first column of their section, the LCD can be addressed continuously, without any pause period between fields.

Although FIG. 6 shows eight light sources, it is understood that any number of light sources, constrained in their number only by the physical dimensions of the display and the dimensions of the light sources themselves, could be used in this illumination scheme.

Given the arrangement of FIG. 6, the lamps do not necessarily have to flash in a very short interval. They can remain on for the duration of the period between the time when the pixels of the last addressed column of section in front of them complete their change to the time when the pixels in the first addressed column are addressed again during the next scan.

It is possible to use essentially the same illumination system and timing sequence, as explained above, to generate 2-D images with resolution several times that of the pixel resolution of the LCD, given appropriate optics and light source configurations already known to those skilled in the art.

The forgoing diagram and explanation has used the case of an autostereoscopic full resolution display for illustrative purposes. This type of display requires two sets of interleaved light lines, each set positioned halfway between the member of the other set. The display generates two full resolution images, forming a stereo pair, that are visible from a series of left and right eye viewing zones spaced across a viewing region in front of the display.

Microsoft Exhibit 1002 - Page 1417
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

US-A-5,036,385 also describes a multiple perspective view full resolution display providing a look around effect, which generates several different full resolution perspective views of a scene, each of which is visible from within a different viewing zone, several of which are spaced across a viewing area in front of the display. This type of display relies on multiple sets of flashing light lines.

As an example, the arrangement and flashing sequence of FIG. 6 can be used to generate four sets of light lines for a four zone display if a total of 16 lamps were used instead of 8. The lamps are shown in FIG. 6A. Lamps 101, 105, 109, and 111 flash on as the first of four images (consisting of interleaved parts of four perspective views, as described in US-A-5,036,385) is built up on the LCD. Next lamps 102, 106, 110, and 114 would flash on in sequence as the next image is built up, then lamps 103, 107 111, and 115, would flash on as the third image is built up, then lamps 104, 108, 112, and 116 would flash on as the fourth image is built up.

As shown in FIG. 7 said LCD 72 is rotated 90 degrees against its commonly used orientation, i.e., its long dimension is vertical. This is called the "portrait format", and is useful in many applications. Because of this orientation the rows of pixels are used as columns and the columns are used as rows. The reason for this format is that all commonly available LCD drive circuits are designed to scan the LCD in a raster format, row-by-row; this configuration, consequently, takes advantage of this process.

Similar illumination systems can be used in a configuration of autostereoscopic and enhanced resolution 2-D displays in which the longer side of the LCD is horizontal, the so-called "landscape" format. Such a system is depicted in FIG. 8. A plurality of light sources 81 - 88 and 91, 92, etc. are also used in this scheme. However, in contrast to the illumination system described with reference to FIG. 6, light sources 81 - 88 do not extend over the

Microsoft Exhibit 1002 - Page 1418
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

entire height of the display, but are divided into vertical sections of equal heights. While FIG. 8 shows two such sections 81 - 88 it is understood that more than two sections could be used, constrained in their number only by the physical dimensions of the display and the physical dimension of the light sources. Said light sources can be fluorescent lamps or gas filled arc lamps, such as those filled with Xenon gas, operating in stroboscopic mode. Arrays of small lamps such as LEDs can be used to good effect, as can addressable flat panel emissive displays such as EL and plasma displays.

This illumination system operates as follows: the first half image is progressively scanned in on the LCD 95 starting with the top (first) row until in this case, the scan of the upper half of the LCD 95 screen is completed and the pixels in the upper half have made their change to form the image (the scan, meanwhile, can continue through the lower half of the LCD). At this instant light sources 81, 83, 85 and 87 flash, thus transferring the video information on the top half of the screen to the observer. The scan of the LCD 95 proceeds until the lower half of the screen is completed. As soon as the pixels on the lower half complete their change, the lower set of light sources 91, etc., is triggered to flash, causing the video information on the LCD 95 screen to be transferred to the observer. Now, the process is repeated in the identical manner for the next interleaved half image, using first the light sources 92, 94, 96, 98, then the light sources 92, etc., in this manner transferring the remainder of the image to the observer, and thus, because of the vision phenomenon of image retention, generating the illusion of a non-flickering full resolution three-dimensional image.

While the pixels of the lower half of the first half image are being allowed to change their state, the upper half of the next half image can begin to be scanned in. Again, if the pixels change their state fast enough so that all the pixels in each half have completed their change

Microsoft Exhibit 1002 - Page 1419
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

before the scan of the other half is complete, the LCD can be scanned continuously and no pause period will be required.

Lenticular lens 93 generates images of vertical light lines on the weak diffusing panel 94. In the configuration illustrated in FIG. 8 the light lines are about one half the height of the LCD 95. The height of the light lines in a particular display configuration depends on the number of sets of light sources, and thus the number of rows of light sources. Likewise, any number of columns might be used. The number of columns would be constrained only by the width of the lamps and the required width of the illuminating area.

This illumination system with different lamps and optics can be also used to generate enhanced resolution 2-D images by successively illuminating different subsections of the LCD, as described above. As an example of the 2-D case, FIG. 15 illustrates a lighting arrangement that could be used to increase the resolution of an LCD by a factor of 4, according to the principles explained in US-A-5,036,385.

FIG. 15 shows a configuration using an array 230 of a large number of light sources placed at a shorter distance behind the fly's eye lens sheet 211 and LCD 206. FIG.s 16a -16c is a timing diagram showing how lamps in different rows of the array are turned on and off in synchronization with LCD scans and pixel changes.

The array shown in FIG. 15 has 8 rows of light source groups 231 -238. Each group consists of four light sources 239 - 242. Each row of light source groups illuminates a horizontal section of the LCD 243 - 250 of roughly 1/8th the LCD's height. The LCD is assumed to be addressed row by row, starting from the top, as is typical of LCDs. Since each light source only illuminates a 1/8th horizontal section of the LCD, one must wait only for the pixels in a given 1/8th section to be addressed and complete their change before turning on the lamps behind it.

Microsoft Exhibit 1002 - Page 1420
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

For example, in FIG.s 16a, 16b the address and pixel response of the last rows of sections 243 - 250 are shown. Again, the LCD is operated at 120 times per second, and the pixels take 3.5 ms to respond. As soon as the pixels of the last row of section one are through changing, the lamps marked 239 in the row of lamp groups 231 in FIG. 15 are turned on. Their brightness curve 231 is shown in FIG. 16c. They may remain on until the first rows of section 243 are addressed again, and start changing. FIG. 16c shows the lamps turning off at this point in time. The light from these lamps is imaged by the fly's eye lens into the upper left quadrants of each pixel. Likewise, as soon as the pixels of section 44 are through changing, the lamps 239 of row 232 are turned on. These, likewise do not turn off until the first row of section 44 is addressed again. The address and turn on sequence continues for section 245 - 250.

After the last section 250 is addressed, the scan can immediately proceed to address the LCD again, starting at the top. The lamps behind section 243, of course, will ideally turn off before the next scan of section 243 begins. After the first section 243 is addressed again, and its pixels have had a chance to change, lamps 240 in row 231 are turned on, providing illumination to the upper right hand quadrants of the LCD pixels of section 243. The remaining lamps 240 of rows 232 - 238 turn on in succession, as the pixels of the sections 244 - 250 in front of them complete their change to a new transparency state.

Likewise, on the next scan in the sequence, lamps 241 flash on and off, and then on the next scan after that the lamps 242 flash on and off. Thus, within four scans, a complete high resolution image is presented to the observer. During the next four scans, the next frame of the high resolution image is created in the same way using the same scan and lamp flash timing sequence shown in FIG.s 16a - 16c.

Microsoft Exhibit 1002 - Page 1421
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Although FIG. 15 shows four sets of light sources arranged in groups of four lamps each, it is understood that any number of light sources or groups of light sources, constrained in their number only by the physical dimensions of the display, the dimensions of the light sources themselves, and the address and pixel response speed of the LCD, could be used in this illumination scheme.

For the look around case, more lamp sets would again have to be used. A lamp arrangement capable of producing four sets of light lines is illustrated in FIG. 8A. The lamps are arranged in 16 columns of two lamps each. Here the top members of lamp columns 121, 125, 129, and 133 would flash on all at the same time after the top half of the first image had formed, and then the bottom members of lamp columns 121, 125, 129, and 133 would flash on when the bottom half of that image had formed. Likewise with the top and bottom members of lamp columns 122, 126, 130, and 134 would flash on as the second part of the image was formed, then the top and bottom members of lamps 123, 127, 131, and 135 as the third image was formed and finally the top and bottom members of lamp columns 124, 128, 132, and 136.

The image formation concepts, as explained with reference to FIG.s 2 through 8, can be implemented in a display configuration illustrated schematically in FIG. 9. The illumination system in this configuration does not employ flashing light sources; rather, the light sources 101 through 109 mounted on the base 100 are constantly lit. Such light sources, could be, preferably, fluorescent lamps. The light from said light sources is diffused by the strong diffuser 110 to produce homogeneous illumination of the electro-optical shutter array 111 preferably employing fast acting liquid crystal valves.

At the present time, typical shutters of this type will have low contrast when viewed from off angle. This means that when in the off state they do not efficiently block light that is passing though them at various high off axis

Microsoft Exhibit 1002 - Page 1422
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

angles. Baffles, similar to those shown in FIG. 2, and be employed to block this light and prevent it from scattering within the system and causing ghost images to be visible.

It is generally desirable, when the shutters employed are LC devices that require front and rear polarizers, to use linear polarizers whose polarization angles whose directions of polarization are in the vertical and horizontal directions. In that configuration, light blockage tends be most efficient at angles far from normal in both the vertical and horizontal directions, allowing the display to be viewed from far off axis in these directions without ghost images becoming a problem. It is desirable, of course, to also make the polarization directions of the front shutter polarizer and the rear LCD polarizer to be parallel, thus maximizing light transmission. It is also desirable, if the rear polarizer of the LCD is of optimal type for use with the shutter LC material, and if its polarization direction is vertical or horizontal, to leave off the front polarizer from the shutter, and simply rely on the LC rear polarizer to perform the light blocking function in the shutter off state. This results in slightly greater light transmission in the on state.

The on-off, i.e. clear and opaque, states of the individual shutters 115 through 124 etc., 131, 132 etc. of the electro-optical shutter array 111 illustrated in FIG. 9 are controlled in synchronism with the scanning of the LCD 114 and are turned on in a sequence, similarly to the sequence of light sources flashes in the display shown in FIG. 8. As scanning and pixel change on the LCD 114 proceeds from top to bottom, and completes 1/3 of the LCD's height, light shutters 115, 117, 119 and 121 are turned on momentarily allowing the light to pass to the lenticular lens 112 which generate the first set of light lines on the diffusing panel 113 and, consequently transfers the first part of the interleaved image to the observer. Next the second third of the one half of the image is scanned in and light shutters 123, etc. are turned on when this part of the

Microsoft Exhibit 1002 - Page 1423
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

image is scanned in, followed by the last third of the image.

While the pixels in the last third of the first half image are changing their state, the first third of the next half image can be being scanned into the upper third of the LCD 114 and transferred to the observer by momentarily turning on the shutters 115, 117, 119, 121. In this manner fast and efficient transfer of video information is achieved.

FIG. 10 depicts yet another illumination system for autostereoscopic and enhanced resolution 2-D displays. In this system a high intensity projection type CRT 190 is used to generate patterns of light lines or points in synchronism and an appropriate sequence with the scanning on the LCD 193. The light lines are projected onto a strong diffusing panel 192 by the focussing lens 191. The sequence of LCD scanning and light line generation can be as described with reference to the description of the illumination systems of FIG.s 2, 5, 7, 8 and 9, or another suitable sequence where the lines or points projected on to the diffuser 192 replace the lamps indicated in the figures. Stereoscopic or enhanced resolution 2-D images are generated as already described.

The system shown in FIG. 11 makes use of an electroluminescent or plasma panel 194 which has a predetermined pattern of addressable lines or pixels that are actuated in an appropriate sequence in synchronism with the scanning of the LCD 197. In some cases, customized EL or plasma displays of the type normally used for information display can be employed. As in previously described systems, a lenticular or fly's eye lens 195 images lines or points generated on the panels onto the weakly diffusing panel 196, and the stereoscopic or enhanced resolution 2-D images are produced as described above.

Yet another method of creating the illumination required for generation of stereoscopic or enhanced

Microsoft Exhibit 1002 - Page 1424
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

resolution 2-D images can take advantage of light emitting diodes (LEDs) as light sources. Such devices are increasingly commercially available in a variety of colors and with high brightness. FIG. 12 shows one version of a display utilizing LEDs.

A two-dimensional array 140 is comprised of a large plurality of LEDs 144, 145, 146 etc. Such LEDs can all be of one color, say, green, for monochromatic displays, or can be a set of three primary colors, red, blue and green, for color displays.

Since the brightness of blue LEDs is not as high as that of red and green devices, a greater number of blue LEDs could be used in each LED cluster in the LED array 140.

The LEDs can be discrete packaged devices mounted in a array on a base, or chips mounted on a suitable substrate.

The LEDs individually or in light-pattern on color generating sets are turned on and off in synchronism with the scanning of the LCD 143. The light generated by said LEDs is focused by the lenticular lens 141 onto the weakly diffusing panel 142 to form the light lines or points necessary for observation of stereoscopic or enhanced resolution images on the LCD 143.

For color displays, a sequence of red, blue and green components of the images can be generated on a monochrome LCD which are fused by the vision of the observer in to a color image, as described in US-A-5,040,878. As an example an optical configuration of an LED-based color illumination system for 2-D displays is depicted in FIG. 13 which shows a much enlarged partial perspective view of said system. Here also a monochromatic (black and white) LCD is utilized. As in the system explained with reference to FIG. 12, LED's which emit light of at least three primary colors are used. Such LEDs can be, for example, 174 (red), 175 (green), 176 and 177 (blue) (two blue LEDs to compensate for

Microsoft Exhibit 1002 - Page 1425
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

lower light output). Said LEDs direct its light output toward a fly's eye lens 178 which comprises a 2-D array of very small convex lenslets, such as lenslets 179 and 180. The number of said lenslets in said fly's eye lens 178 is equal to the number of pixels in the LCD 181. Hence, each lenslet focuses the light to one pixel in the LCD 181. When the pixels are in their on (clear) state (e.g. pixels 182 and 183) they transmit the light from the lenslets to a diffusing panel 184 where this light form color dots, such as 185 and 186. In this manner images can be formed on the diffusing plate 184. In order to achieve color in this display, red, blue and green constituent color images are displayed in a rapid sequence using the same pixels and the corresponding lenslets, by appropriately turning on and off sequentially sets of all LEDs of the same color, while scanning in into the LCD the corresponding constituent image.

Monochromatic LCDs can also be used in conjunction with other color light sources, such as fluorescent or gas filled plasma discharge lamps to generate color stereoscopic or enhanced resolution 2-D images. One embodiment of this scheme is illustrated in FIG. 14.

FIG. 14 depicts the top view of an autostereoscopic or an enhanced resolution 2-D display. Light sources 156 through 167 are mounted on the base 150. There are three sets each of four light sources; red 156 - 159, green 160 - 163, and blue 164 - 167. It is understood that the number of sets of light sources is not limited to four; such number will be only constrained by the physical dimensions of the display and the dimensions of the light sources. Fluorescent and gas filled plasma discharge lamps in three primary colors are readily commercially available.

The red, green and blue repeating flashing sequence, will, however, lead to the same type of image breakup phenomena seen in other field sequential color displays. It would also necessitate a much faster address speed and pixel

Microsoft Exhibit 1002 - Page 1426
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

response speeds for the LCD, as is the case with existing field sequential color systems. This is because in order to avoid flicker one would have to create a compete image every 1/60th as opposed to 1/30th second, as is the case with other field sequential color systems that illuminate the whole LCD first with red, then green, then blue light. That means that the LCD must be capable of generating 180 completely different images every second, so that, a red, a green, and a blue image component are presented every 1/60th second.

The illumination sequence used to overcome the image breakup phenomena relies on the ability of this invention's field sequential color illumination system to multiplex the illumination spatially as well as temporally. This ability should also allow one to operate the LCD and illumination system at much lower speeds - possibly as low as 30 complete images per second - without flicker becoming visible. The reason for this is that a line interlaced image can be created in which members of a set of three lines of red, green, and blue image elements is flashed sequentially.

Long ago, researchers discovered that cathode ray tubes (CRT) could be operated at 30 frames per second, instead of 60, without objectionable flicker, if an interlaced scanning system were used. In this scheme, which is used in ordinary home television sets, every other row is scanned in 1/60th second, and the remaining rows are scanned during the next 1/60th second. A complete image is built up in 1/30th second. This system allows flicker-free imaging at lower speeds because, although it takes 1/30th second for a full image to be built up, the eye still sees the screen filled with light during each 1/60th second interval. During successive intervals, the scan lines are shifting by a barely detectable amount.

This invention's system can achieve an interlace effect with field sequential color illumination. The system does this by focusing the red, green, and blue light into

Microsoft Exhibit 1002 - Page 1427
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

sequentially illuminated color spots or lines within the pixel boundaries. These lines, or rows of color spots, can be spatially and temporally interlaced in a manner similar to the scan lines of a CRT. The main difference is that to achieve the same resolution possible with other field sequential color systems, the interlace must be 3:1 instead of 2:1.

FIG. 17 shows one of several interlace configurations that can be generated with this type of optics. This particular pattern is closest to the typical CRT row interlace scheme and therefore good for illustrative purposes. The figure shows a magnified view of two representative columns of pixels on an LCD. During the first 1/90th second, the LCD is scanned and the pixels in columns 260, 263, 266, etc., are made to change their transparency to display part of the red component of an image. Pixels in columns 261, 264, 267, etc., are made to change their transparency to display part of the green component of an image, and pixels in columns 262, 265, 268, etc., are changed to display parts of the blue component of an image.

At the end of the 1/90th second period, when the pixels have had a chance to change, strobed illumination is focused into individual red, green, and blue light spots within the top third of each pixel 269.

During the second 1/90th second time period, the pixels of rows 260, 263, 266, etc., are changed to display another row of the red component of an image, the pixels of rows 261, 264, 267, etc., are changed to display the next row of the green component of the image, and rows 262, 265, 268, etc., are changed to display another row of the blue component of the image. At the end of this second 1/90th second interval, light is focused into a second row of spots 270 in the middle of each pixel.

During the last 1/90th second interval, the pixels once

Microsoft Exhibit 1002 - Page 1428
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

again change to display the remainder of the image, and strobed light would be focused into a new rows of spots 271 in the bottom third of each pixel.

Note that in this case each group of three red, green, and blue spots in each row is being used as a complete image pixel, in a manner similar to a typical color LCD with color filter stripes.

Note again the visual effect here would be similar to that seen on an interlaced CRT, except that instead of two sets of interlaced horizontal rows appearing sequentially, three rows would be used. With regard to flicker it is believed the results will not be significantly different from what is seen on a normal interlaced CRT with low persistence phosphors.

In this example, if the LCD had a pixel resolution of M (horizontal) by N (vertical), the resolution of the image would be M/3 x 3N - the total number of pixels would be the same in image and LCD, but the ratio of horizontal to vertical resolution would be different. It would be best in such a case to start out with pixels that had a high ratio (as shown) between their vertical and horizontal dimensions.

Another option, achieved by changing the way the data is placed on the LCD, is to let each pixel on the LCD to represent a pixel on the image. In such a case each pixel would represent one element of a M x N image, and would change its transmittance to reflect the intensity of red, green, and blue light at that point as the red, green, and blue light illuminated subregions of it.

It is not necessary for the red, green, and blue illuminating spots to be created in straight rows and columns. It is suspected that randomizing their placement to some degree would tend to improve performance with regard to image breakup even further. FIG. 19 shows such a randomized pattern and illuminating sequence. Rows 269,

Microsoft Exhibit 1002 - Page 1429
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

270, and 271 are illuminated sequentially as described above, but note that the red, green, and blue areas are not in the same left right sequence in the three sets of rows.

FIG. 18 shows the type of illumination array 257 and fly's eye lens 258 arrangement that could be used to generate the light patterns shown in FIG. 17. FIG. 20 shows the type of illumination array 257 and lens 258 that can be used to generate the light patterns shown in FIG. 19. A fly's eye lenslet is configured so that each lenslet is situated behind a group of pixels where the entire repeating pattern is to be focused. For example, if the pattern repeats in every group of three pixels, as in FIG. 18, lenslets of roughly the same size as a group of three pixels must be used, and placed behind every group of three.

Arrays of red, green, and blue lights on the illuminator would be arranged in the same repeating pattern, except that the pattern would be inverted, as shown, relative to the patterns focused into the pixels, because of the inversion created by the lenses. The illuminating regions on the array and the lenslets would have the proper spacing and dimensions so that the lenses created images of the illuminating regions in the correct sections of the correct pixels.

As before, the elements of each set on the illuminator could be made to turn on and off sequentially from top to bottom, following the scan of the LCD. If the illumination of FIG. 18 had 8 rows of 3 x 3 patterns, 8 sections of the LCD would be illuminated sequentially. In the figure, the lamps 280, 281, 282 would turn on during the first scan, to illuminate the top 1/3 of each pixel. Lamps 283, 284, 285 would turn on during the next scan to illuminate the middle third of each pixel, and lamps 286, 287, 288 would turn on to illuminate the bottom third of each pixel.

Note that it is not necessary to illuminate the pixels sequentially by rows. It is also theoretically possible to

Microsoft Exhibit 1002 - Page 1430
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

illuminate light spots in different rows in different pixels at the same time. For example, in FIG. 20, one could illuminate first the areas 290, 291, and 298 at the same time, then the areas 293, 294 and 292 and next the areas 296, 297, and 295. The only requirement is that during any given illumination period, red, green, and blue illumination is on, and during each three period cycle all the areas within all the pixels are illuminated.

Although three rows of illuminated sub regions of each pixel are shown in FIG.s 17 and 19, that number can be greater than three. By using greater numbers of subregions, the color image created can posses a resolution greater than the pixel resolution of the LCD. FIG. 21 is a diagram showing six lines of subregions 300 - 305 within each pixel which are illuminated sequentially, starting rows 300 and proceeding through rows 305. Given an LCD with N x N resolution, this arrangement would produce a color image with N x 2N resolution.

Of course, if more subregions are used, a faster LCD must be used to avoid flicker, since more image sub components must be illuminated sequentially during the 1/30th second period. It is suspected, also, that as the number of subregions in each pixel increases, the overall frame speed, the time in which an entire image is built up, must be shortened. At the extreme end, a very large number of sequentially illuminated sub regions within large pixels may require a frame speed of around 1/60th second, since the visual impact will start to approach that of a non-interlaced CRT, which has to be operated at 60 fps to avoid flicker.

FIG.s 19 and 21 show 3 x 3 patterns of illuminated subregions of pixels. However, larger or smaller patterns can be used. FIG. 22, for example, shows a six by six pattern that can be repeated within groups of 6 x 6/3 = 6 x 2 pixels. One such group of pixels is encircled by the dotted line in FIG. 22.

Microsoft Exhibit 1002 - Page 1431
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

In some situations, it may be desirable to use an illuminator consisting of a one dimensional array of linear light sources. The most common type of illumination used for LCDs, namely fluorescent tubes, are most often configured as long, thin tubes and cannot be made as small point like sources. Fluorescent tubes that emit red, green, and blue light can be made and easily mounted next to one another in banks. They can also be made to emit light in short bursts.

In the case of linear light sources, operating behind a typical LCD, it is best to mount them horizontally so that the members of each set can flash sequentially from top to bottom, following the scan of the LCD rows in front of it. Of course, if the LCD is scanned from side to side column by column, then the tubes should be mounted vertically.

An interlace pattern that can be produced with linear light sources and its illumination sequence are shown in FIG. 23. Red, blue and green horizontal lines are projected into each row of pixels as shown.

At the end of the first scan, after the pixels have been allowed to change to a new desired state, all the lines 310 are flashed simultaneously into the pixels. Thus, a red line is flashed into rows of pixels 320, a green line is flashed into rows of pixels 321 and a blue line is flashed into rows 322. Note that the RGB lines appear in different positions within the pixels. The pixels of rows 320 are, of course, in the appropriate states of transparency to form the red component of those rows of an image, correspondingly, the rows of pixels 321 are controlled to form the green component in those rows, and the rows of pixels 322 form rows of the blue component of the image.

After the LCD has been re-scanned and the pixels allowed to change their state again, a green line is flashed into the rows of pixels 320, a blue line into rows 321, and

Microsoft Exhibit 1002 - Page 1432
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

a red line into pixel rows 322. Again, pixels in each given row have the states appropriate to the color appearing in them. At the end of the next scan, after a new partial image has been generated on the LCD, a blue line is flashed into the pixel rows 320, a red line into the pixel rows 321, and a green line into the pixel rows 322.

The result is a full resolution, full color image in which the color lines are spatially interlaced.

FIG. 24, a side view, shows the lamp and lens arrangement that can be used to generate the line pattern and sequence of FIG. 23. A bank of linear lamps is mounted with red, green, and blue light emitting members placed vertically in the order shown. A lens sheet is mounted behind the LCD 206 as before, with its lenslets ideally of about one focal length away from the pixel layer. When using linear light sources, one has the option of using a lenticular lens 329 in place of the fly's eye lens discussed previously. A lenticular lens 329is generally easier and less costly to make than a fly's eye lens of the same size. The lenticular lens would possess an array of cylindrical lenslets spaced across its surface, parallel to the length of the linear light sources. Such a lens is shown in FIG. 24.

In either case, each lens must image light into three pixels, although in some configurations the lens may image light into more than three pixels. The lenses and the light sources must be of the correct size and spacing relative to one another so that each lens images light from each set of red, green, and blue lamps into the correct pixels.

The lamps are turned on in the following order in succession, as soon the section of the LCD in front of them has been addressed and its pixels have completed its change to their required states. Each lamp turns off a certain time period after turn on, so that it is completely off by the time the next address occurs. The lamps 330 turn at the

Microsoft Exhibit 1002 - Page 1433
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

same time to form the first set of light lines 310. Lamps 331 turn on after the next scan and pixel change to form the lines 311. Lamps 332 turn on at the same time to form lines 312.

As can be seen from the previous discussion, there are many types of spatial patterns and temporal illumination sequences that can be generated using the type of illumination systems and timing just described. The present application should be understood to encompass these other arrangements.

Various types of flashing light sources can be used to provide illumination for the displays of this invention including fluorescent lamps, gas filled arc lamps, gas filled plasma discharge devices, light emitting diodes, electroluminescent devices, electron excited phosphor displays such as cathode ray tubes, plasma displays, fluorescent displays and various steady light sources with light transmission controlling means such as arrays of liquid crystal light valves placed in front of them.

The forgoing description has been for the purpose of illustration and not limitation. Many other modifications and ramifications will naturally suggest themselves to those skilled in the art based on this disclosure. These are intended to be comprehended within the scope of this invention.

Microsoft Exhibit 1002 - Page 1434
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

It is claimed:

1. In both autostereoscopic and non-autostereoscopic high resolution displays, the improvement in illumination system comprising a plurality of linear or point like light sources, an electronic means for controlling the on and off states of said light sources in synchronization with the process of image generation on an electronically controllable light valve, a lenticular or fly's eye lens sheet spaced apart from and in front of said light emitting sources so as to focusing the light into patterns of lines, line segments, or point like areas, said light patterns illuminating selected portions of the light valve.

2. The illumination system of claim 1 in which the light valve is repeatedly addressed in row by row or column by column fashion, there being a finite time period between the address of any individual light valve (pixel) and the time that the valve has completed its change in transparency as a result of the address; and each light source is timed to turn on during the period between the time when the pixels that are in a section of the array generally in front of it have completed their change in transparency, and the time when the pixels in said section are addressed again, the light source being turned off outside of these time periods.

3. The illumination system of claim 2 in which the light sources and optical elements are positioned with respect to one another and the optical element, and the optical element is constructed in such a way as to create rapidly blinking sets of lines or points of light for the purpose of creating high resolution 3D images.

Microsoft Exhibit 1002 - Page 1435
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

4. The illumination system of claim 2 in which the light sources and optical elements are positioned with respect to one another and the light valve array so as to focus rapidly blinking sets of lines or points of light close to or within the pixel layer of the array so as to create 2D images with a resolution exceeding the pixel resolution of the light valve array.

5. The illumination system of claim 2 in which mechanical means is provided for adjusting the position of said light sources in relation to each other and in relation to the optical element.

6. The illumination system of claim 2 in which baffling means is provided between the light sources and the optical element so as to allow each light source to illuminate only the section of the light valve that is generally in front of it.

7. The illumination system of claim 2 which includes an electrically controlled light diffusing means placed between the light sources and the optical element, said diffusing means being capable of changing between a clear, transparent state and a light scattering, diffuse state under control of the user.

8. The illumination system of claim 2 which includes a passive light diffusing means upon which the optical element focuses the light and creates the light patterns.

9. The illumination system of claim 2 in which the light diffusing means consists of a layer of diffusing material on one surface of a substrate.

10. The illumination system of claim 2 in which the substrate consists of one or more sheets of transparent material, said sheets being mounted in contact with the rear most surface of the light valve on the side facing away from the observer.

Microsoft Exhibit 1002 - Page 1436
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

11. The illumination system of claim 2 which includes optical antireflection means on surfaces between transparent components of different indices of refraction, or on surfaces between transparent components and air, so as to reduce reflections at these surfaces.

12. The illumination system of claim 2 in which the light sources are comprised of steady light emanating means.

13. The illumination system of claim 12 in which a light transmission controlling means is placed between the light sources and the observer to achieve the stroboscopic effect.

14. The illumination system of claim 2 in which said light transmission controlling means is an array of light valves.

15. The illumination system of claim 2 in which said light valves are electrically controlled liquid crystal devices.

16. The illumination system of claim 2 in which said light sources are of at least three different types, each type capable of emitting light of different color.

17. In autostereoscopic display of claim 1 the improvement in the illumination system which comprising a plurality of point like or linear light sources, a fly's eye or lenticular lens sheet spaced apart from and in front of said light emitting sites so as to focus the light into arrays of lines, line segments, or point like areas, said light patterns illuminating selected portions of the light valve.

Microsoft Exhibit 1002 - Page 1437
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

18. The illumination system of claim 17 which includes a non reflective and opaque barrier immediately in front of or between said light sources, configured in such a way as to prevent light from passing through it except at the lamp locations.

19. The illumination system of claim 17 in which mechanical means is provided for adjusting the position of said light sources in relation to each other and in relation to the optical element.

20. In the display of claim 1, the further improvement comprising a stroboscopic illumination system for said display comprising (1) a plurality of light sources consisting of at least two sets of light sources, each set of light sources emitting light of a different color, and a plurality of said light sources also consisting of at least two groups, each group containing at least one member of each set, (2) electronic means for independently controlling the on and off states of said light sources in synchronization with the process of image generation on the electronically controllable light valve array, such that different groups of light sources are turned on, then off, in succession, and (3) optical means for accepting the light emanating from said light sources and to focus said light into patterns of lines, line segments, or point like areas within or near the plane of the light valve array, said light patterns illuminating selected sub regions of the elements of the light valve array;
the light sources, optics, and on/off sequence being so arranged that when any group of light sources is on, light of at least two colors emanating from members of different sets within that group is directed into subregions of different sets of light valves at the same time, so that light of different colors are being directed into different sets of light valves whereby improved images are obtained.

Microsoft Exhibit 1002 - Page 1438
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

21. The illumination system of claim 20 in which the light valve array consists of rows and columns of addressable light valves, commonly called pixels, and is repeatedly addressed in row by row or column by column fashion, there being a finite time period between the address of any individual light valve (pixel) and the time that the valve has completed its change in transparency as a result of the address: and each group of light sources is times to turn on and remain on during the period between the time when the pixel that are in a section of the array illuminated by it have completed their change in transparency, and the time when the pixels in said section are addressed again, the light source groups being turned off outside of these time periods.

22. The illumination system of claim 21 in which said light sources are grouped into three different sets, the members of each set capable of emitting light of a different color.

23. The illumination system of claim 22 in which said light sources are arranged into at least three groups, with at least one red, one green, and one blue member within each group.

24. The illumination system of claim 23 in which the light sources and optical elements are positioned with respect to one another and the light valve array, and the optical element is constructed in such a way as to create rapidly blinking sets of lines or points of light close to or within the plane of the light valve array so as to create images in color with a resolution at least equaling the pixel resolution of the light valve array, for the purpose of creating high resolution color images that do not exhibit significant visual image breakup.

Microsoft Exhibit 1002 - Page 1439
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

25. The display of claim 21 where the pixels of the light valve array are made to change their transmittance in order to display the proper brightness value of the color component of some image at that point, the color component of the image being the component with color equal to the color of the illumination which is to be directed into the pixel from a lamp after the pixels have been scanned and have had a chance to change.

26. The illumination system of claim 20 where the optical element is a planar array of lenticular lenslets or fly's eye lenslets.

27. The illumination system of claim 20 which includes a non reflective and opaque barrier immediately in front of or between said light sources, configured in such a way as to prevent light from passing through it except at the lamp locations.

28. The illumination system of claim 20 in which baffling means is provided between the light sources and the optical element so as to allow each light source to illuminate only the section of the light valve that is generally in front of it.

29. The illumination system of claim 20 which includes a passive light diffusing means upon which the optical element focuses the light and creates the light patterns.

30. The illumination system of claim 20 which includes optical anti-reflection means on surfaces between transparent components of different indices of refraction, or on surfaces between transparent components and air, so as to reduce reflections at these surfaces.

31. The illumination system of claim 20 in which the light valve array is a liquid crystal display.

Microsoft Exhibit 1002 - Page 1440
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

32. The illumination system of claim 20 in which the light sources are comprised of light emanating means and light transmission controlling means.

33. The illumination system of claim 32 in which said light transmission controlling means is an array of light valves.

34. The illumination system of claim 33 in which said light valves are electrically controlled liquid crystal devices.

35. The illumination system of claim 34 which includes a passive light diffusing means located between the light sources and the lenticular or fly's eye array.

36. In the autostereoscopic display of claim 1 having (1) a screen surface upon which is displayed, or imaged, a number of sets of thin parallel vertical light emitting lines, each set containing a multiplicity of said lines, the members of each set being located in the areas between the members of the other sets, and each set capable of being independently turned on and off, said surface remaining dark between said emitting lines, (2) a light valve array parallel to and in front of said screen, said light valve having individual picture elements, arranged in a regular pattern across its surface, said pattern possessing vertical columns of said picture elements, there being at least two vertical columns of picture elements for each of said light emitting lines in each set of said lines, said light emitting line being located behind and between said elements, so as to establish areas of space known to the art as "Viewing zones" in front of the display, within which an observer's eye sees all the light lines of a given set behind either an odd or even set of pixel columns, (3) optionally said display is in color obtained by filtering light passing through said picture elements along said columns with filters of at least three colors, and (4) electronic means to cause the left eye image or a

Microsoft Exhibit 1002 - Page 1441
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

stereoscopic image pair to be displayed on the odd or even columns of pixels, and the right eye image of a stereoscopic image pair to be displayed on the remaining columns of pixels; the improvement which comprises -

a. incorporating a device capable of monitoring the position of the head of a person who is looking at the display,

b. using information from this device to determine which set of light emitting lines is on, and which set of picture information is displayed on the odd or even columns of pixels of the display;

c. selecting which light line set is on and which set of information is displayed on which column of pixels according to which combination of line set and image display,

thereby causing the left eye viewing zone formed at the observers location to encompass the position of the observer's left eye, and the right eye zones to encompass the position of the observers right eye.

37. The device of claim 36 wherein two sets of independently controlled light lines are produced, the members of each set being substantially to the left or right of the center line halfway between the members of the other set.

38. The device of claim 37 wherein, as the observer's head moves horizontally left or right, with his or her eyes within the viewing zones created by one light line set, so that the observer's eyes approach the boundaries of the viewing zones, that light line set turns off and the other set comes on, so that the new viewing zones formed by the second set now encloses the observer's eye locations; and as the observer continues to move, and the eyes approach the zone boundaries formed by the second set, the second set turns off and the first set turns on again, and simultaneously the left and right eye image information is switched between the odd and even pixel columns, such that when the first set comes on again, left and right eye

Microsoft Exhibit 1002 - Page 1442
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

viewing zones are again positioned so as to enclose the observer's eye locations.

39. The device of claim 36 where the locus of the observer positions at which the light lines switch when the observer is moving to the right are to the right of the locus of positions where the light lines switch when the observer is moving to the left, so as to not cause the light line sets to switch rapidly when the observer is near a position where a change occurs.

40. The device of claim 36 where *n* sets of light lines are present, *n* being a whole intruder greater than 2, and as the observer who's eyes are within the viewing zones moves to the left or right, with one light lines set on, defined as set one, and the as the observer's eyes move off center and thus approach the boundaries of the viewing zones, set one turns off and set two, generally being the next set in the direction opposite the observer's movement, turns on in order to create viewing zones that are more centered on the observer's eyes.

41. The device of claim 36 wherein three sets of light lines are present, and as the observer who's eyes are near the center of the viewing zones moves to the left or right, with one light lines set on, defined as set one, and the as the observer's eyes move off center and thus approach the boundaries of the viewing zones, set one turns off and set two, being the next set in the direction the same as the observer's direction of movement, turns on, while simultaneously the left and right eye images on the screen are switched between the odd and even columns,in order to create viewing zones more centered on the observer's eyes, so as to create left and right eye viewing zones which encompass the observer's left and right eyes, respectively.

Microsoft Exhibit 1002 - Page 1443
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

42. The device of claim 36 where as the observer moves and different line sets turn on, software simultaneously and continuously redraws the scene in successive frame so as to change the perspective of the left and right eye views on the screen in a manner which is dependent on the observer's current location.

43. The device of claim 42 where the scene is redrawn so as to draw the scene with perspective seen from the observer's current eye positions, so that as the observer moves, the observer will always see the scene without appreciable distortion and can look around and over objects in the scene.

44. The device of claim 42 where the scene is redrawn in such a way that the entire scene rotates around a point at or near the display surface in such a way that an imaginary line in image space running between the point of rotation and a point between the observer's eyes always stays positioned between the observer's eyes, so that the same perspective view of the image is seen by the observer without appreciable distortion as the observer moves.

45. The device of claim 36 where all or more than one set of light emitting lines can be turned on simultaneously so the light is seen behind every pixel by each of the observer's eyes, thus allowing the observer to easily see full resolution two dimensional images displayed on the light valve.

46. The device of claim 36 where an ultrasonic emitter is worn by the observer, and two or more receivers are mounted at or near the display device, in order to obtain information on the observer's head position through triangulation.

47. The device of claim 36 where a device which can be changed from a diffuse to a transparent condition is placed in the optical path between the light line generating means

Microsoft Exhibit 1002 - Page 1444
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

and the light valve picture element layer in such a way that when the device is in a diffused condition, light from the light line generating means is diffused, so that diffuse, even illumination emanates from the variable diffusion device, so that light is seen behind every picture element by each of the observer's eyes, thus allowing the observer to easily see full resolution two dimensional images displayed on the light valve.

48. The device of claim 47 where more than one set of light lines is turned on when the variable diffusion device is in the diffuse state to improve the evenness of the illumination behind the light valve when it is used for two dimensional viewing.

49. The device of claim 36 where the illumination system used to create the light lines comprises more than one set of linear light sources or point like light sources arranged in columns, each set being capable of being turned on and off independently of the others, a fly's eye or lenticular lens sheet spaced apart from and in front of said light emitting sites so as to focus the light into arrays of lines, line segments, or columns of point like areas, a non-reflective and opaque barrier immediately in front of or between said light sources, configured in such a way as to prevent light from passing through it except at the light source locations, means to adjust the position of said light sources in relation to each other and in relation to the optical element, a passive thin layer of light diffusing means upon which the optical element focuses the light and creates the patterns of light lines or columns of segment or points, and optical anti-reflection means on surfaces between transparent components of different indices of refraction, or on surfaces between transparent components and air, so as to reduce reflections at these surfaces, said illumination system causing different sets of light lines to appear behind the light valve by means of turning different sets of the linear or point like light sources on and off according to information provided by the head position

Microsoft Exhibit 1002 - Page 1445
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

sensing device.

50. The device of claim 36 where the light lines are formed by more than one set of small linear light sources or columns of line segment or point like light sources spaced across the light line plane, and no lenticular lens or fly's eye lens is present.

51. The device of claim 36 where the head position sensing device consists of an ultrasonic range finding device consisting of at least one emitter and at least two receivers mounted at or near the display and allowing position determination of the observers head through triangulation, using measurements of the time required for ultrasonic impulses to travel from the emitter to the receivers.

52. The device of claim 36 where the position of the observer`s head is determined by means of an electromagnetic sensor mounted on the display, which measures the direction and orientation of a electromagnetic field emitted by an electromagnetic emitter mounted on the observers head or headgear.

53. The device of claim 36 where the position of the observer's head is measured by means of an infrared emitter which illuminates the region in front of the display, and two infrared sensors which image the infrared light reflected from an observer's head or a reflective device positioned on the observers head or headgear.

54. The display of claim 36 where the observers head position is determined by the use of infrared, ultrasound, or electromagnetic sensors working in combination.

55. In an autostereoscopic display device having (1) a screen surface upon which is displayed, or imaged, a multiplicity of thin parallel vertical light emitting lines, said surface remaining dark between said emitting lines, (2)

Microsoft Exhibit 1002 - Page 1446
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

a light valve array parallel to and in front of said surface, said light valve having individual picture elements arranged in a regular pattern across its surface, said pattern possessing vertical columns of said picture elements, there being at least two vertical columns of picture elements for each of the light emitting lines, said light emitting line being located behind and between said elements, so as to establish areas of space known to the art as "Viewing zones" in front of the display, within which an observer's eye sees all the light lines behind either an odd or even set of pixel columns, (3) said display optionally being in color obtained by filtering light passing through said picture elements along said columns with filters of at least three colors, and (4) electronic means to cause the left eye image of a stereoscopic image pair to be displayed on the odd or even columns of elements, and the right eye view of the stereoscopic image pair to be displayed on the remaining columns of elements; the improvement which comprises -

a. incorporating a device capable of monitoring the position of the head of a person who is looking at the display, and

b. using information from this device to physically move the device which creates or images the light lines horizontally in a direction opposite the direction of the observer's movement by such a distance that the left eye viewing zone moves to follow the observer in such a way that it continues to encompass the position of the observer's left eye, and the right eye zone also follows the observer in such a way that it continues to encompass the position of the observers right eye.

56. The device of claim 55 wherein the illumination system used to create the light lines and cause the light lines to move comprises (1) light emitting sites which are multiple linear light sources or point like light sources arranged in columns, (2) a fly's eye or lenticular lens sheet spaced apart from and in front of said light emitting sites so as to focus the light into arrays of lines, line

Microsoft Exhibit 1002 - Page 1447
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

segments, or columns of point like areas, (3) a non-reflective and opaque barrier immediately in front of or between said light sources, configured in such a way as to prevent light from passing through it except at the light source locations, (4) means to adjust the position of said light sources in relation to each other and in relation to the optical element, (5) a passive thin layer of light diffusing means upon which the optical element focuses the light and creates the patterns of light lines or columns of segment or points, (6) an optical anti-reflection means on surfaces between transparent components of different indices of refraction, or on surfaces between transparent components and air, so as to reduce reflections at these surfaces, and (7) mechanical means to move the lenticular lens sheet or fly's eye lens horizontally in a direction opposite the direction of the observer's head movement, according to information supplied by the head position sensing device.

Microsoft Exhibit 1002 - Page 1448
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

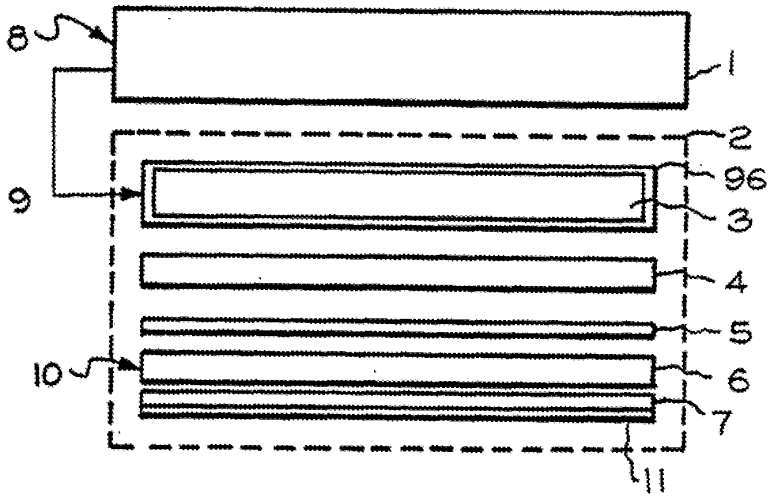


FIG. 1

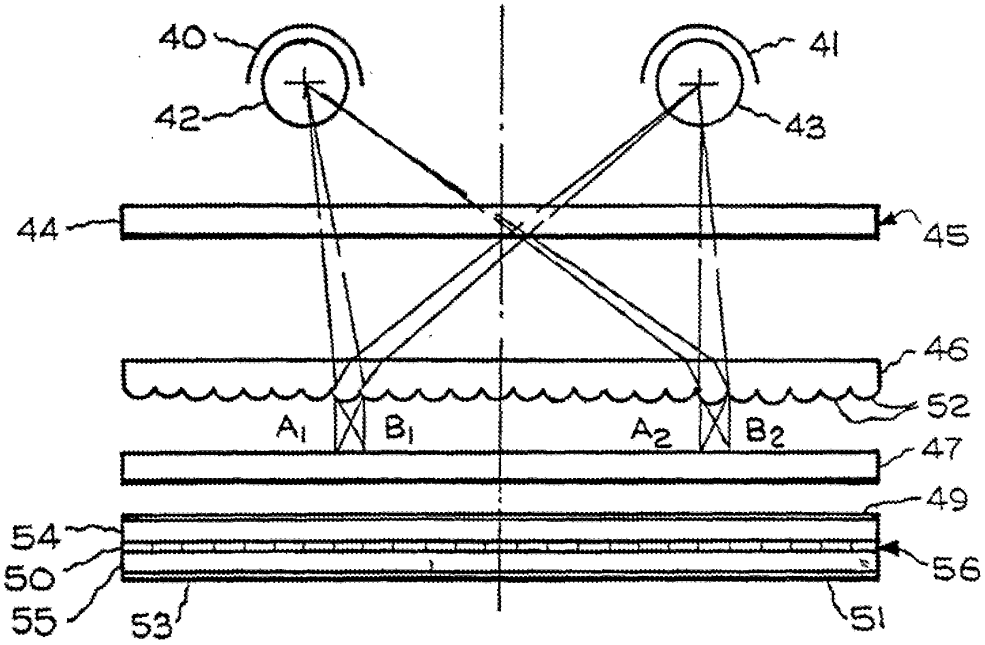


FIG. 2

Microsoft Exhibit 1002 - Page 1449
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

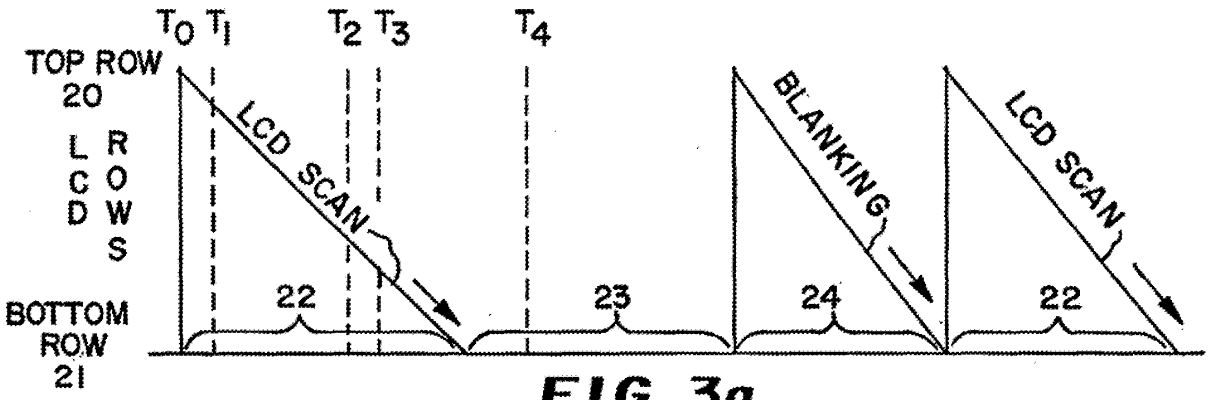


FIG. 3a

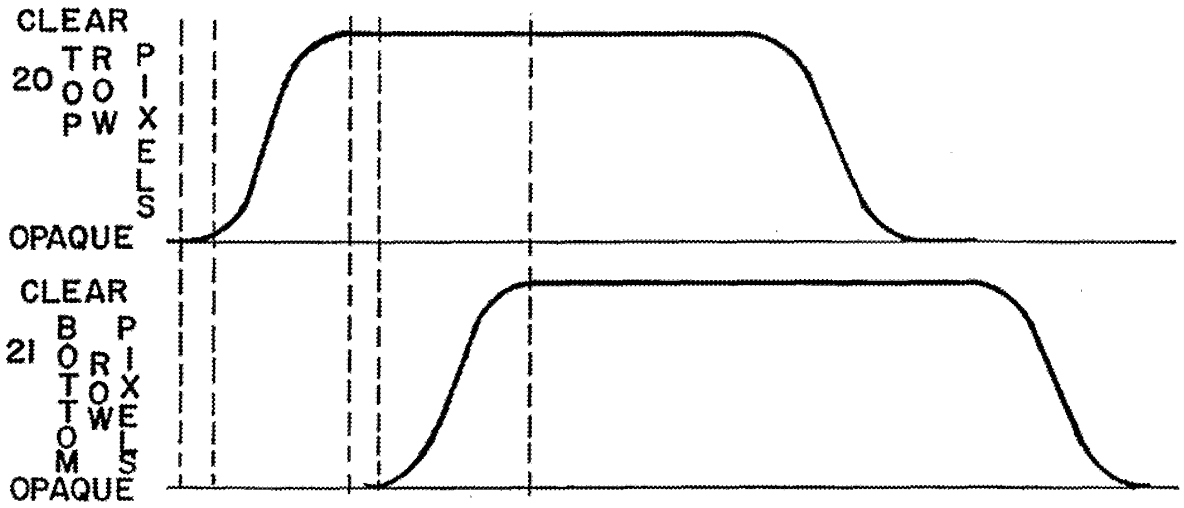


FIG. 3b

Microsoft Exhibit 1002 - Page 1450
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

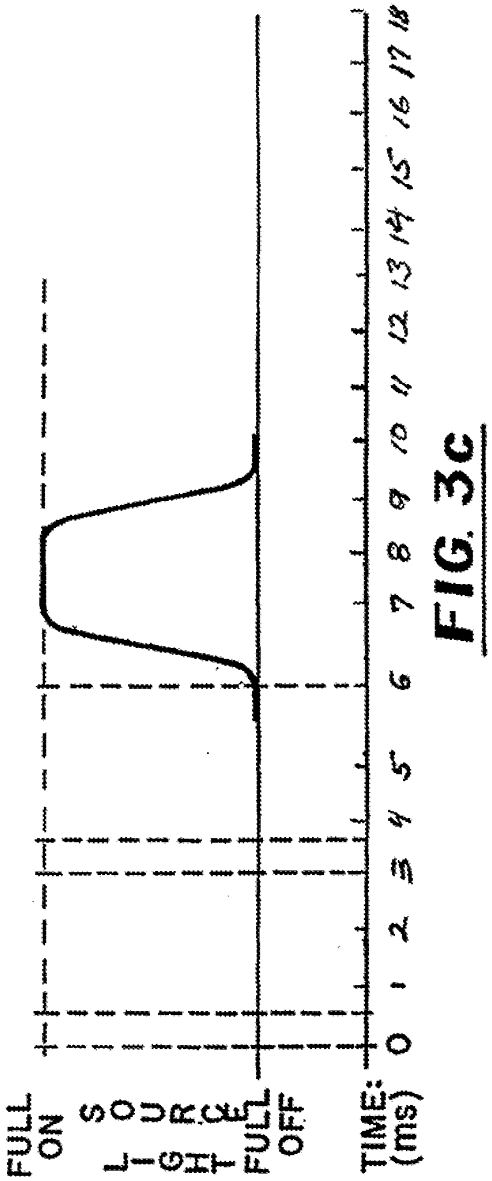


FIG. 3c

Microsoft Exhibit 1002 - Page 1451
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

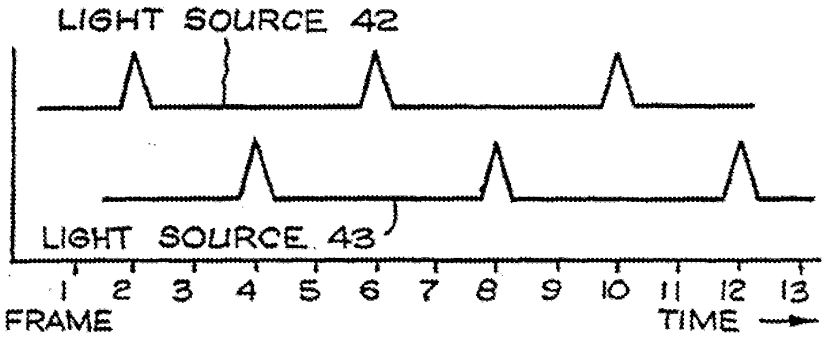


FIG. 4

Microsoft Exhibit 1002 - Page 1452
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

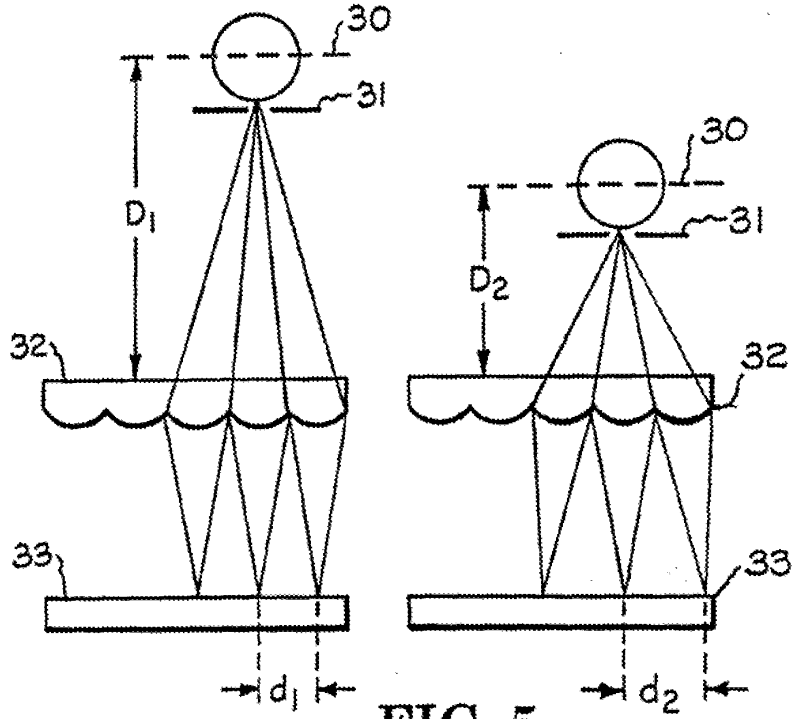


FIG. 5

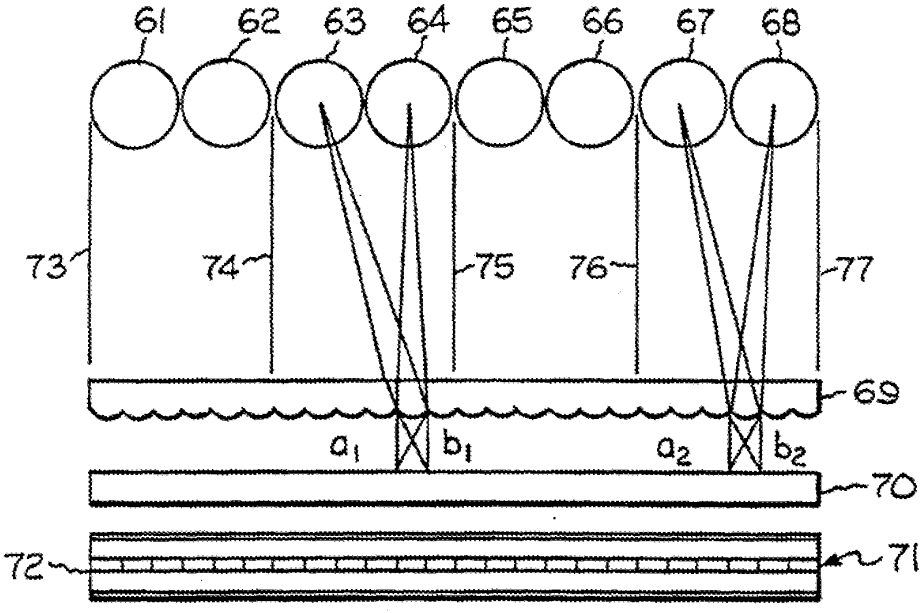


FIG. 6

Microsoft Exhibit 1002 - Page 1453
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

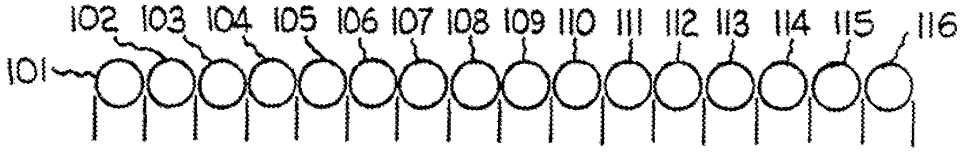


FIG. 6A

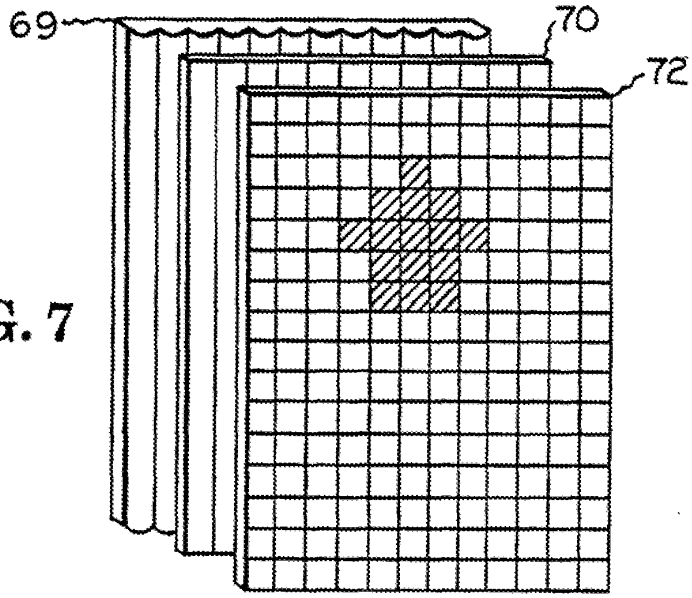


FIG. 7

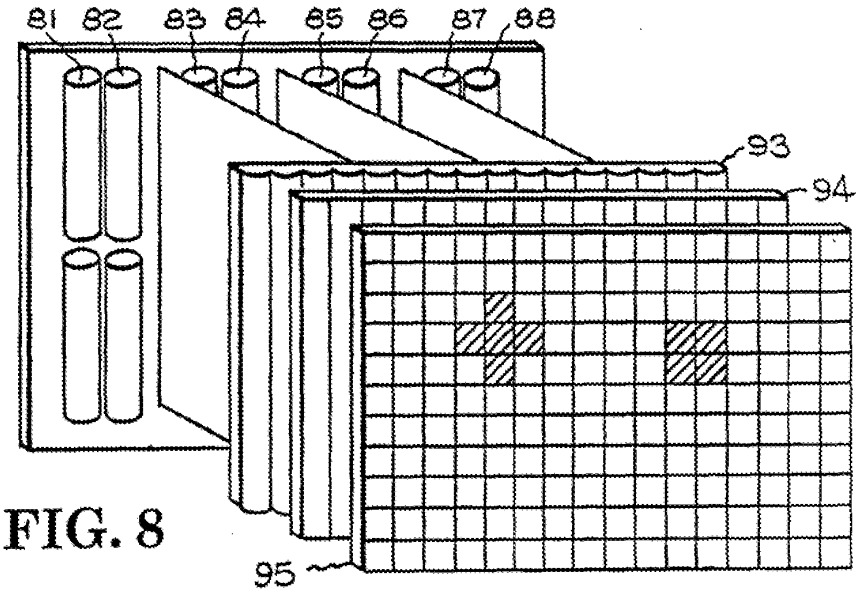


FIG. 8

Microsoft Exhibit 1002 - Page 1454
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

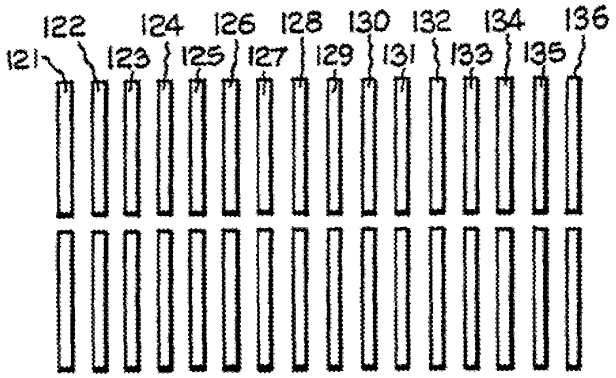


FIG. 8A

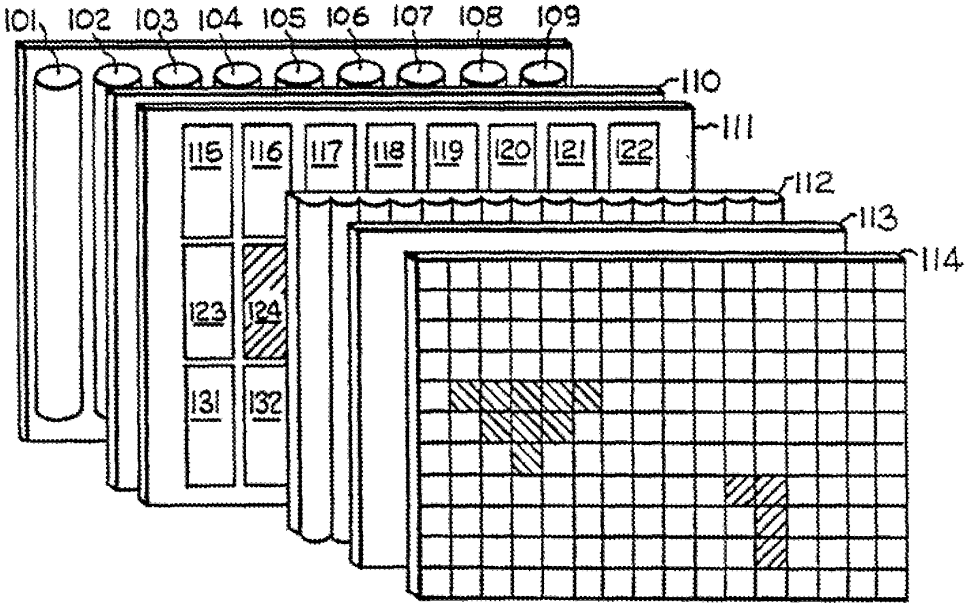


FIG. 9

Microsoft Exhibit 1002 - Page 1455
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

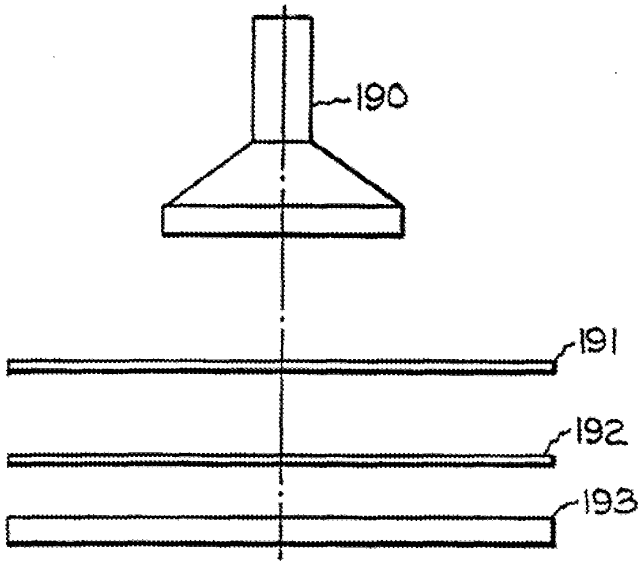


FIG. 10

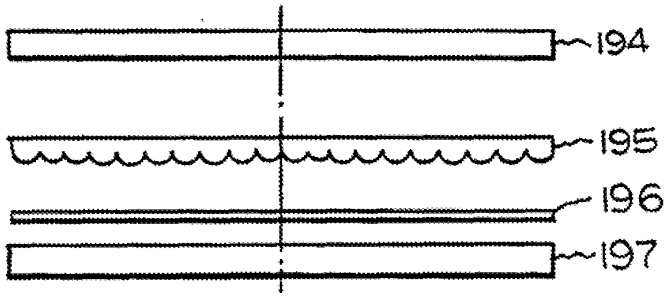


FIG. 11

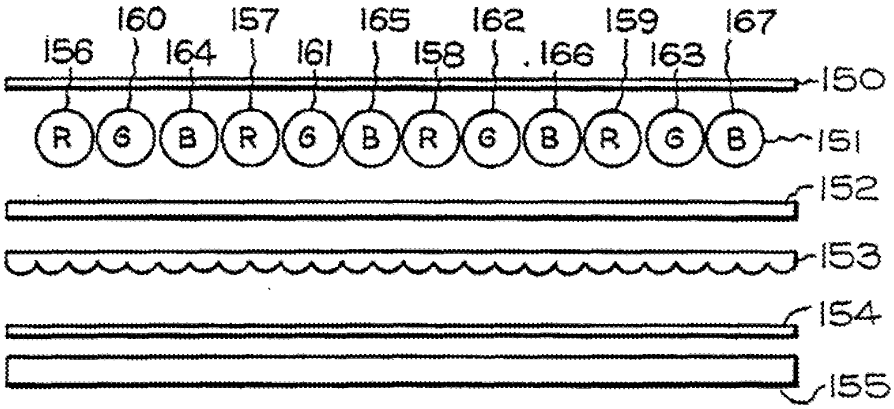


FIG. 14

Microsoft Exhibit 1002 - Page 1456
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

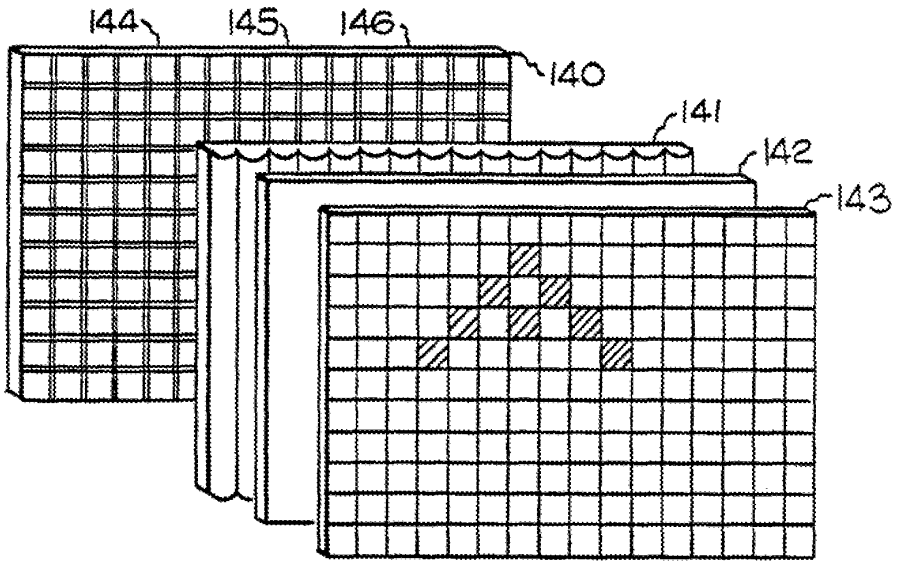


FIG. 12

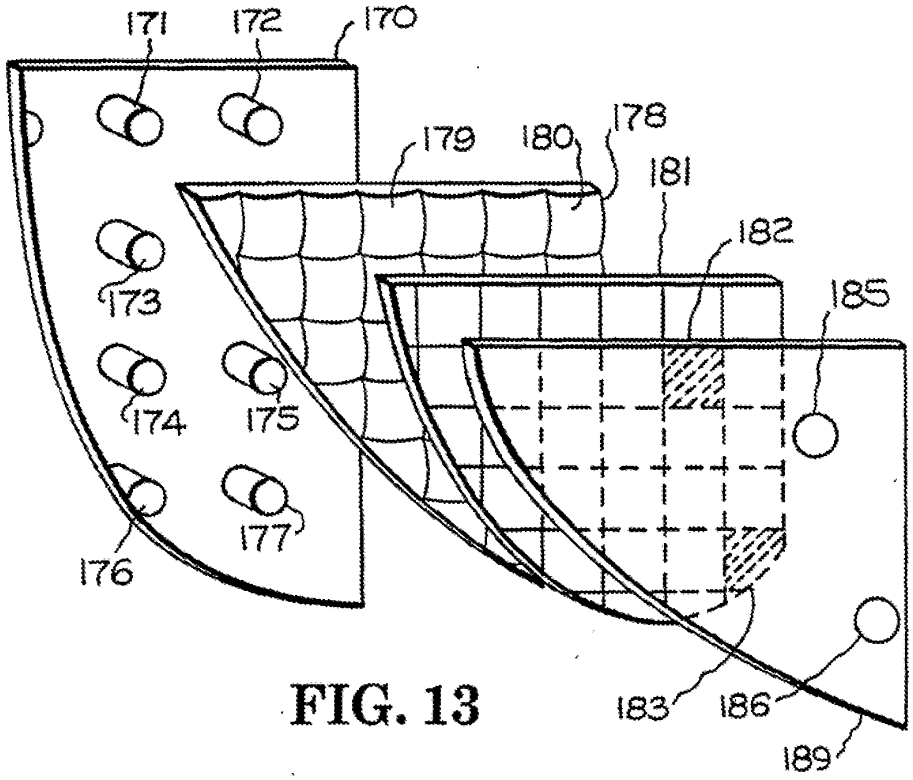


FIG. 13

Microsoft Exhibit 1002 - Page 1457
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

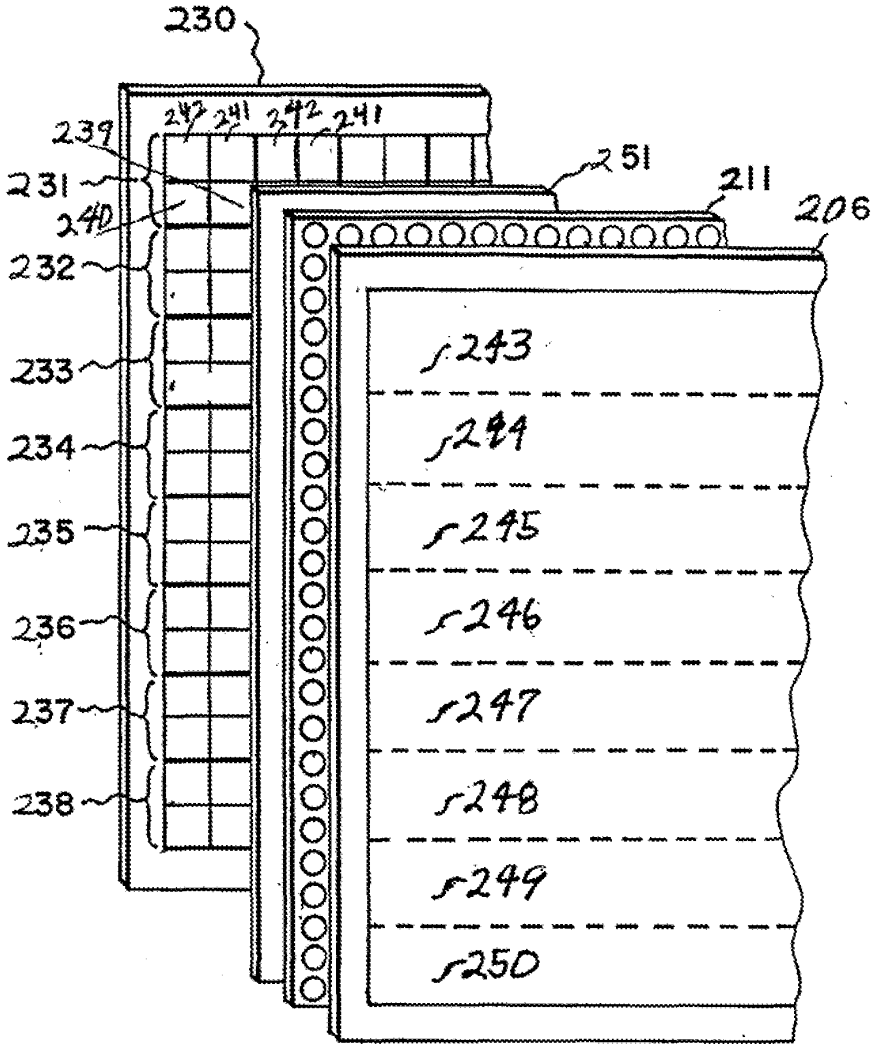


FIG. 15

Microsoft Exhibit 1002 - Page 1458
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

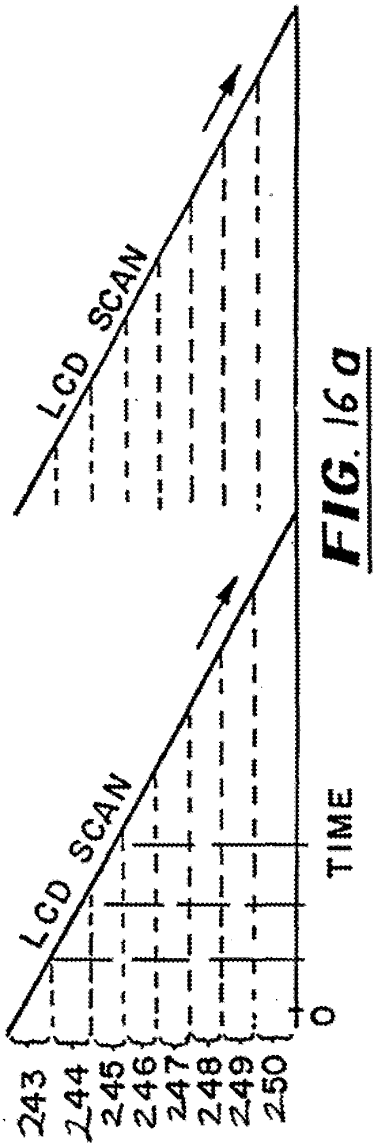


FIG. 16a

Microsoft Exhibit 1002 - Page 1459
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

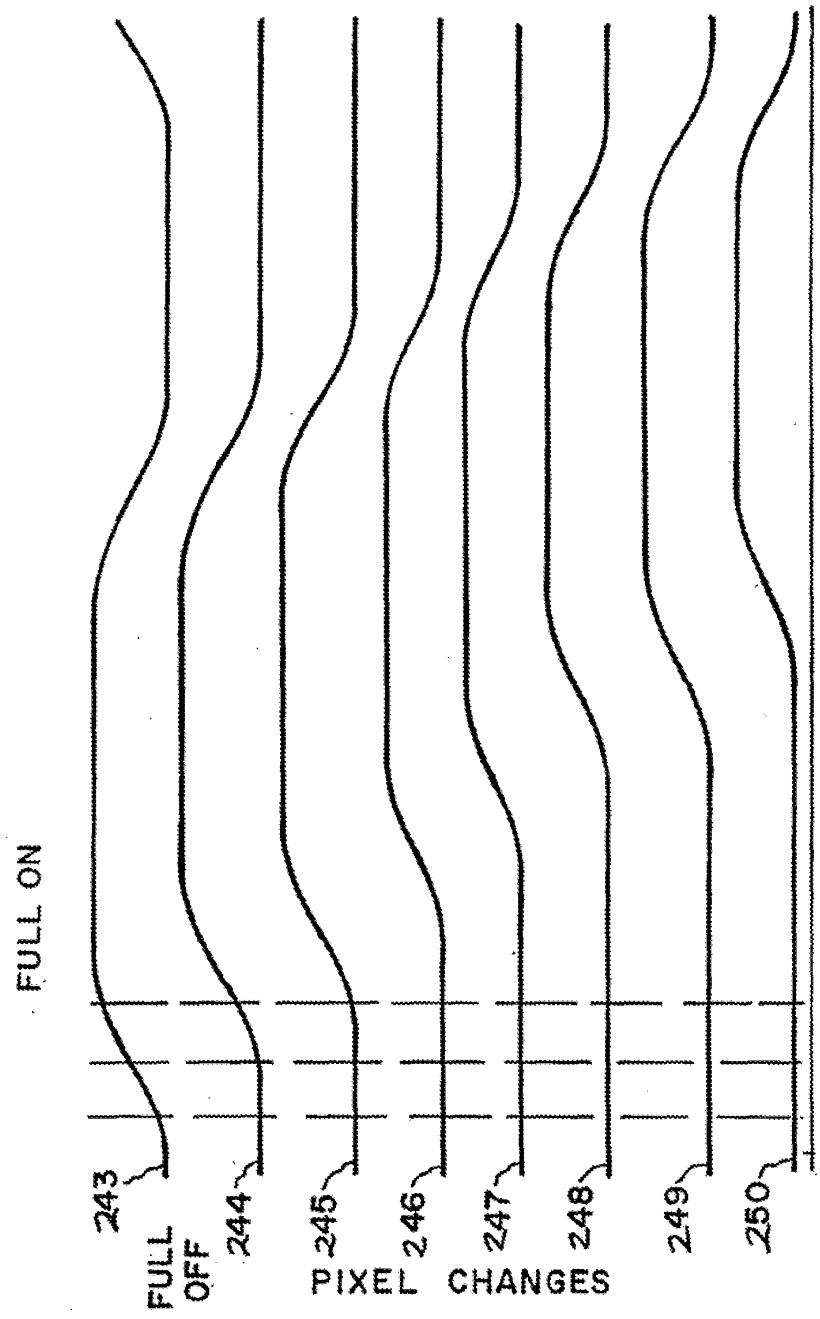


FIG. 16b

Microsoft Exhibit 1002 - Page 1460
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

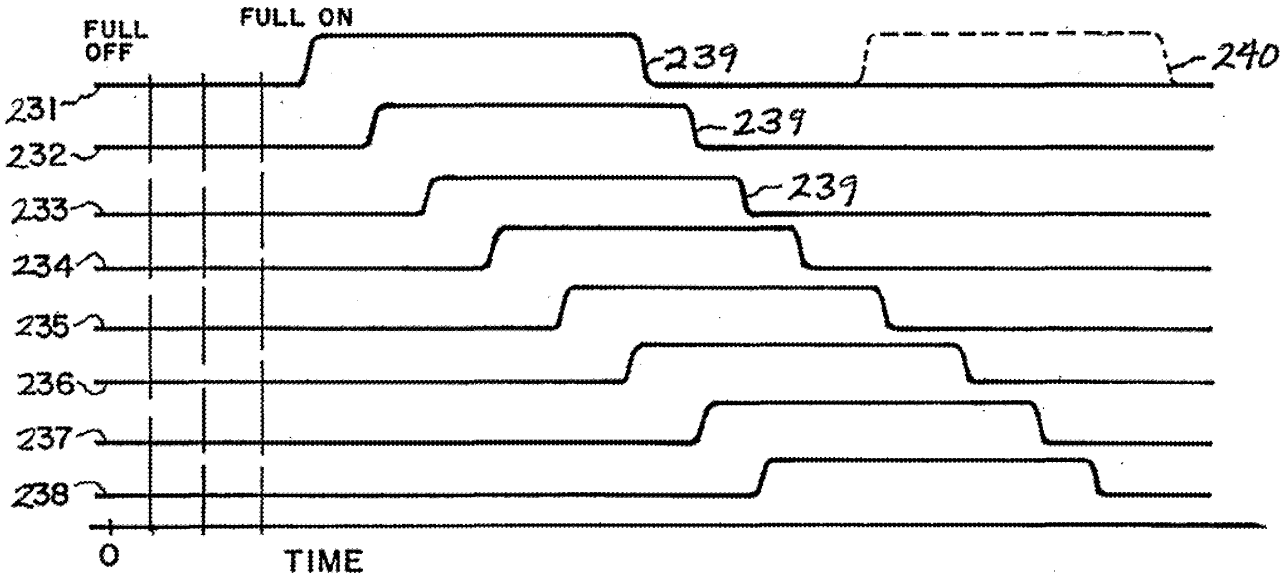


FIG. 16c

Microsoft Exhibit 1002 - Page 1461
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

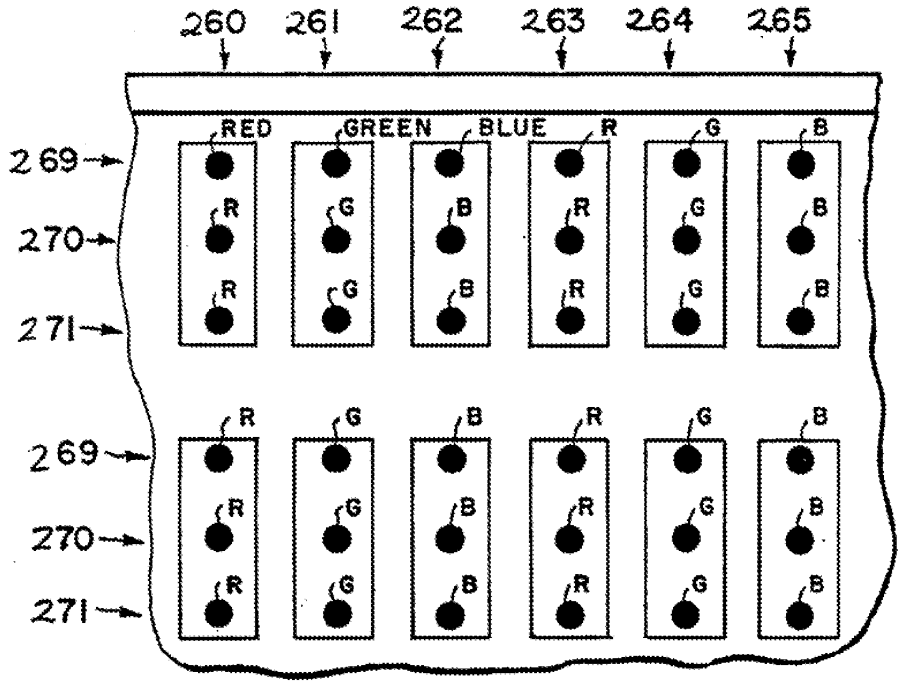


FIG. 17

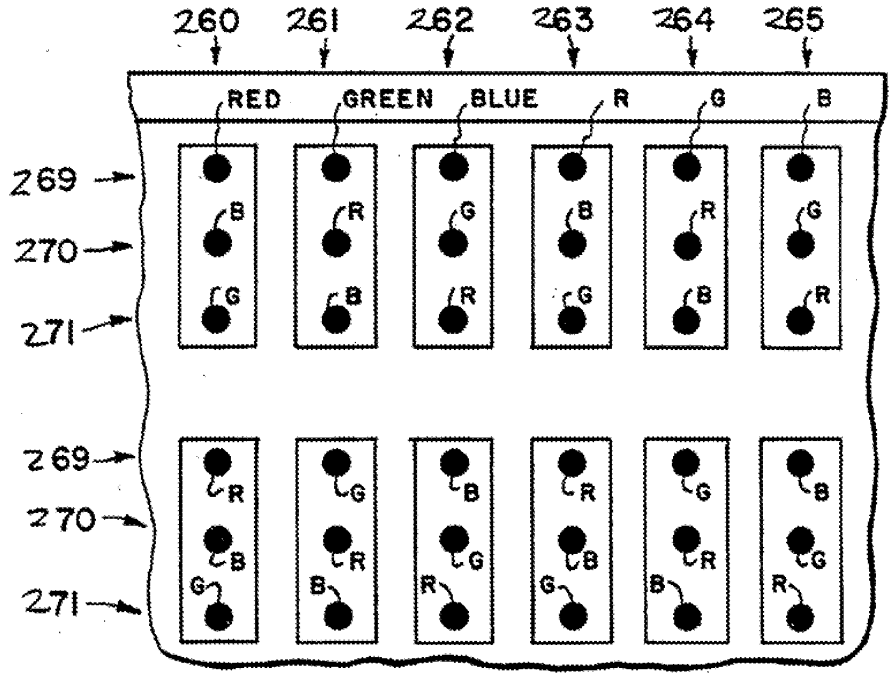


FIG. 19

Microsoft Exhibit 1002 - Page 1462
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

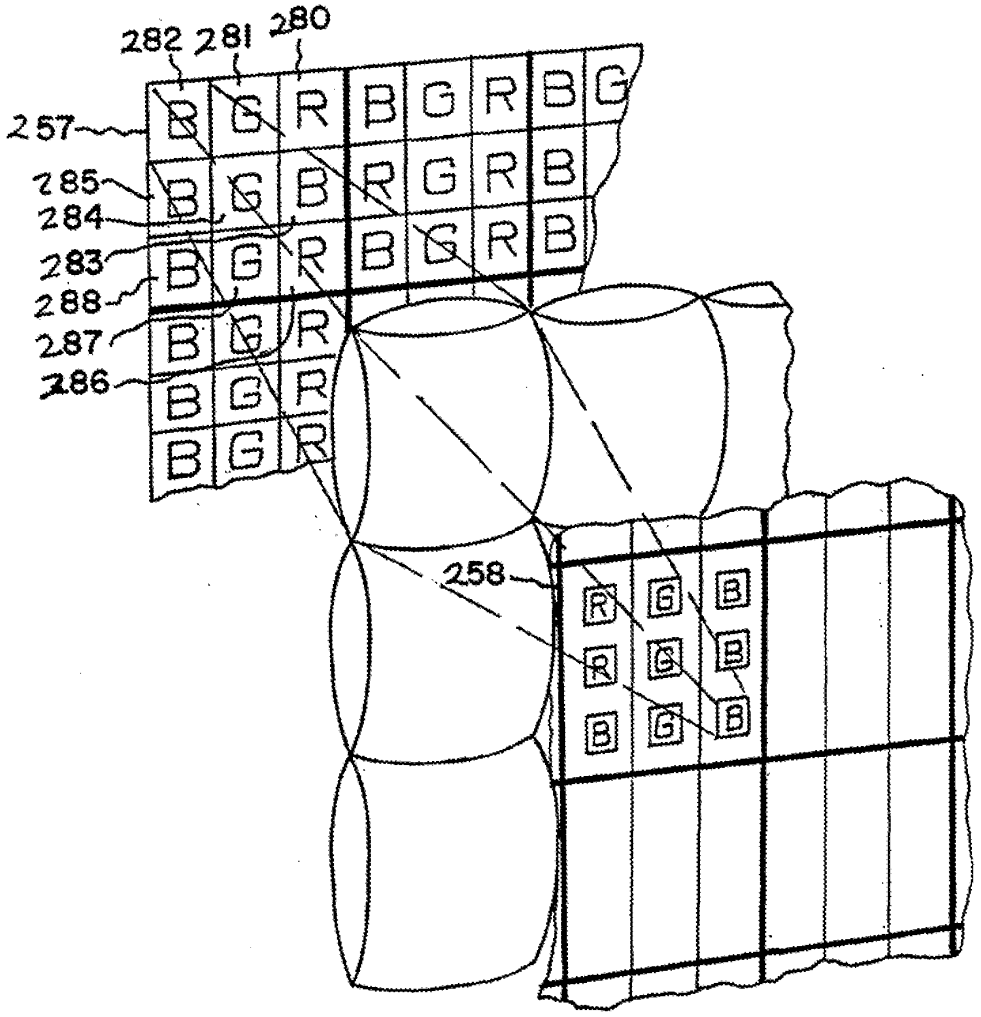


FIG. 18

Microsoft Exhibit 1002 - Page 1463
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

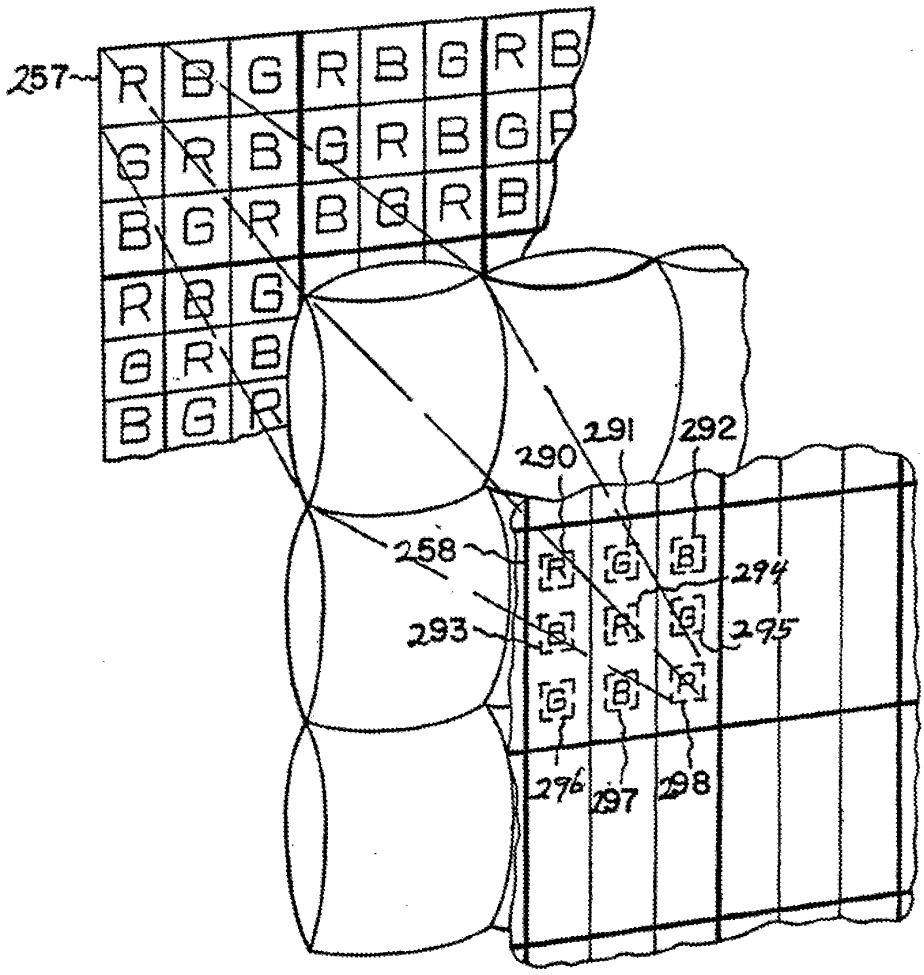


FIG. 20

Microsoft Exhibit 1002 - Page 1464
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

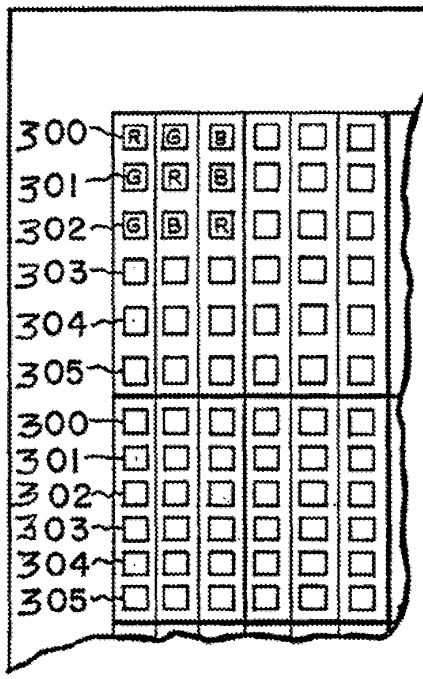


FIG. 21

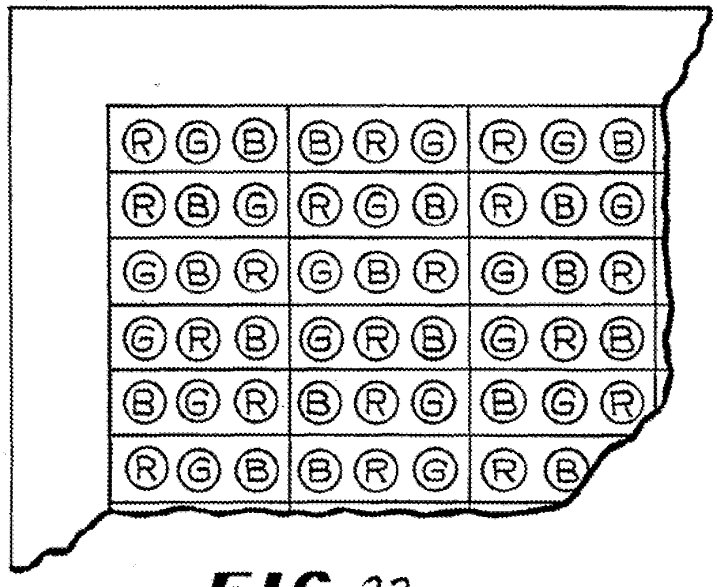


FIG. 22

Microsoft Exhibit 1002 - Page 1465
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

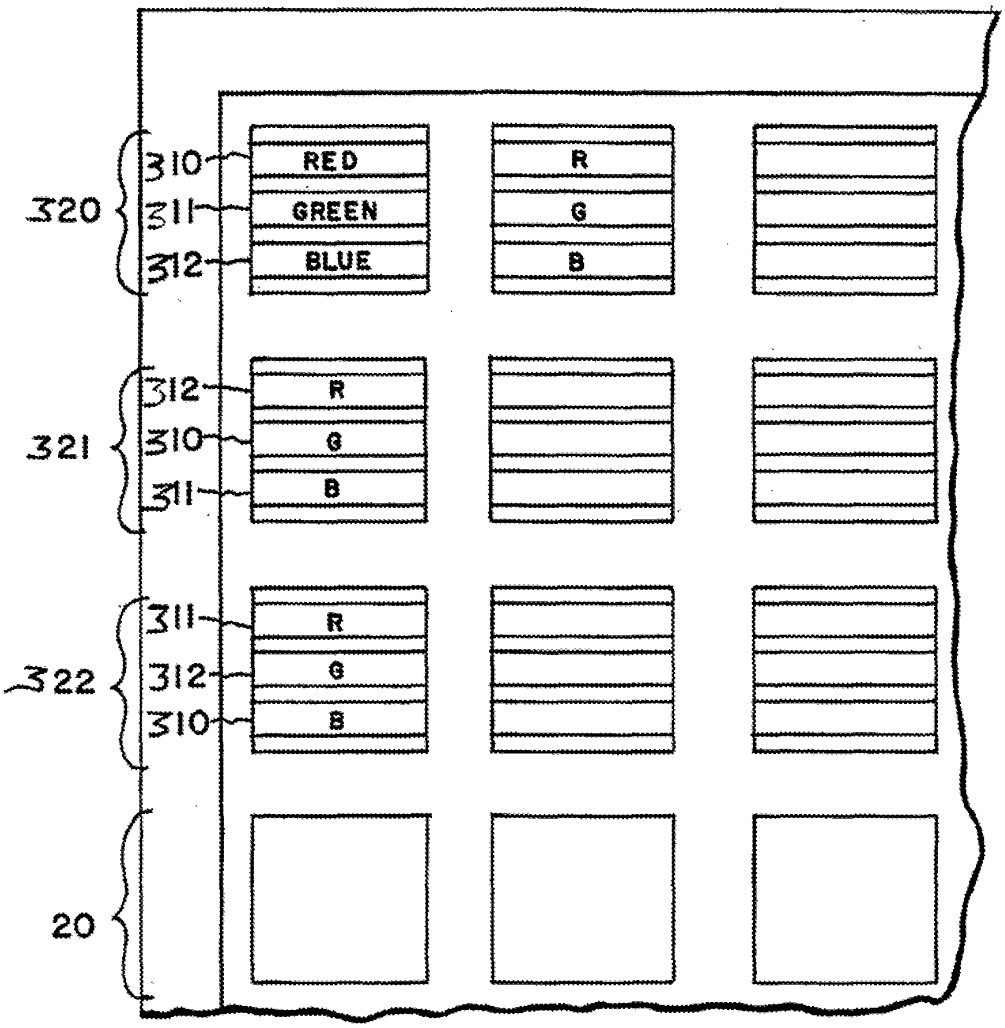


FIG. 23

Microsoft Exhibit 1002 - Page 1466
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

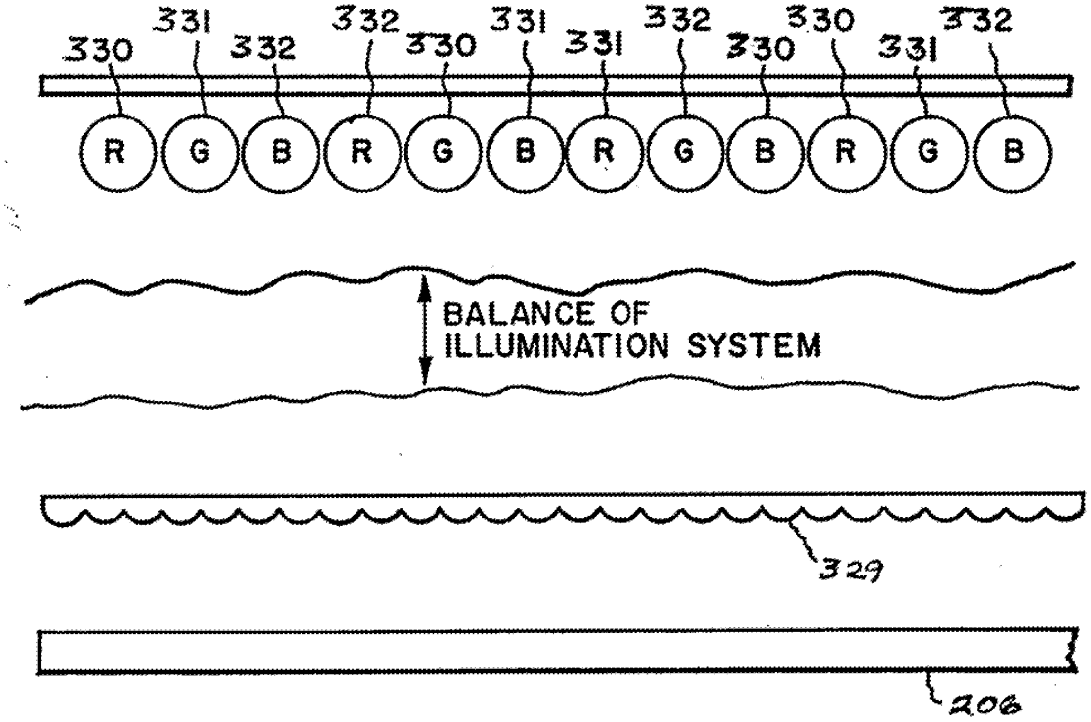


FIG. 24

Microsoft Exhibit 1002 - Page 1467
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

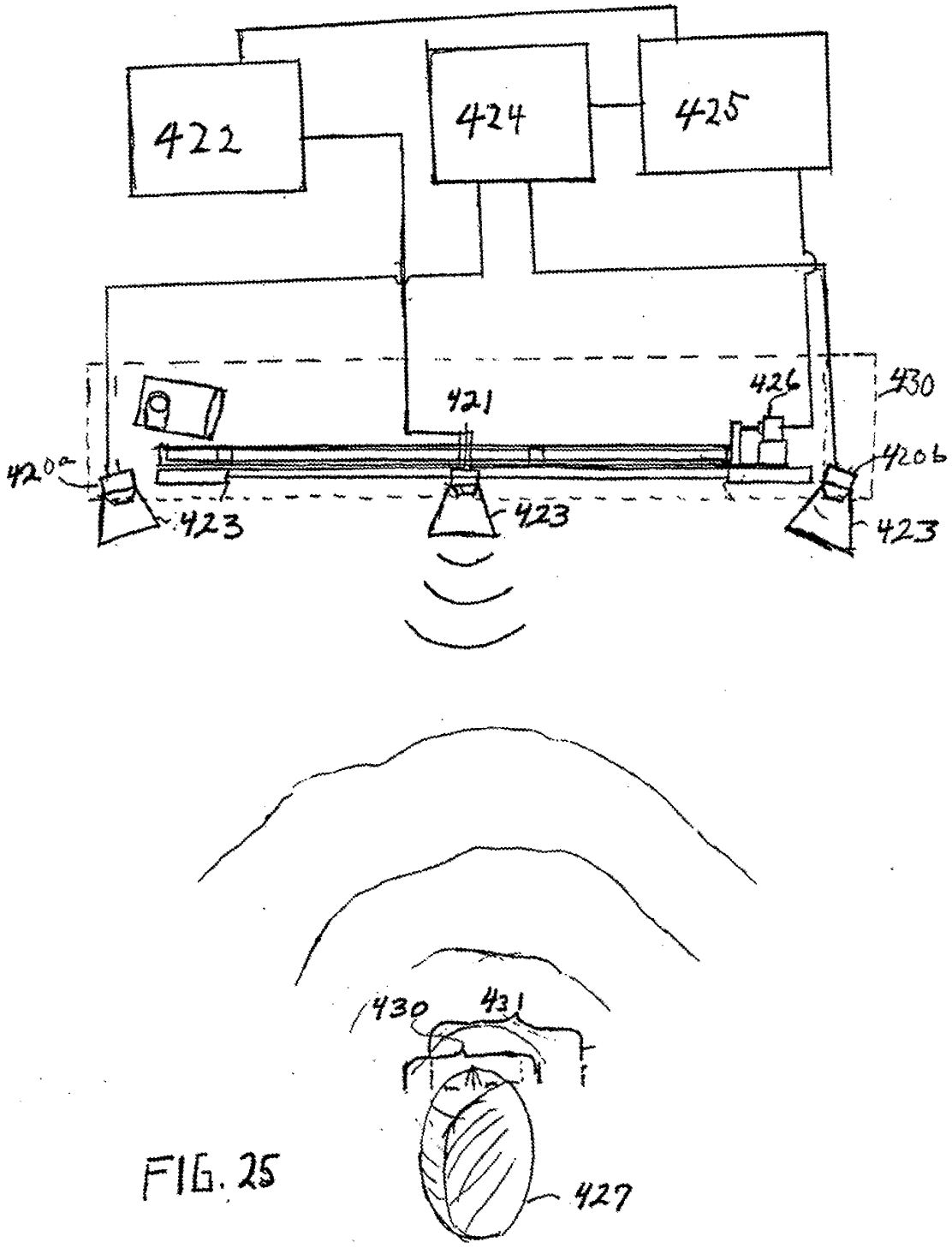


FIG. 25

Microsoft Exhibit 1002 - Page 1468
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

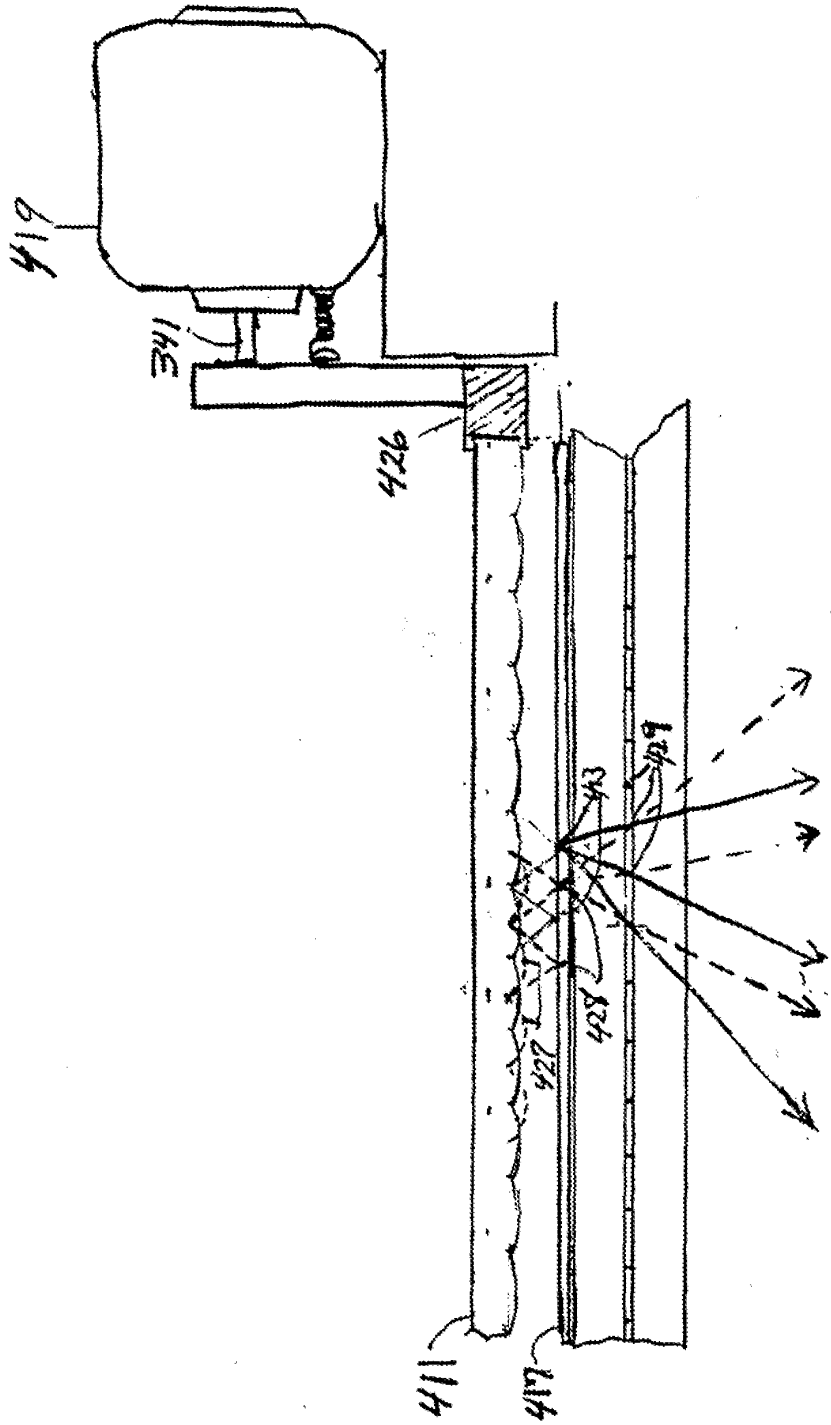


FIG. 26

Microsoft Exhibit 1002 - Page 1469
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

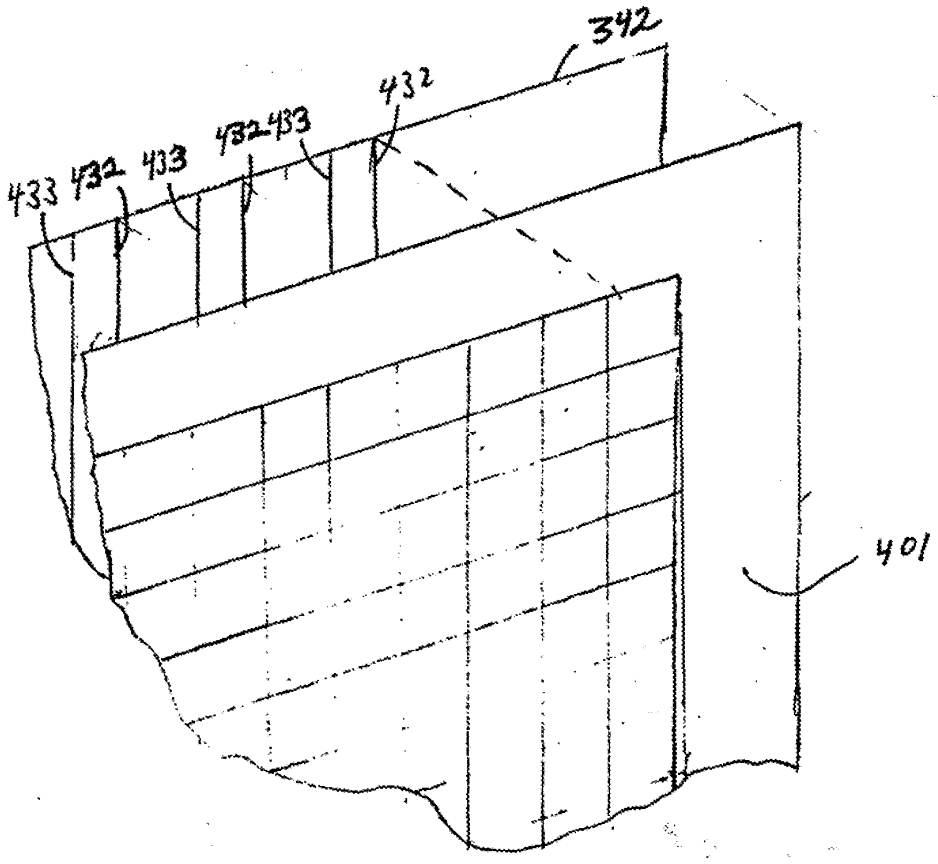


FIG. 27

Microsoft Exhibit 1002 - Page 1470
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

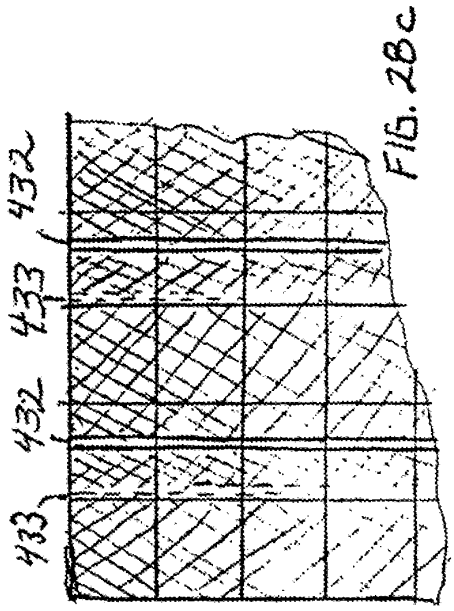


FIG. 28c

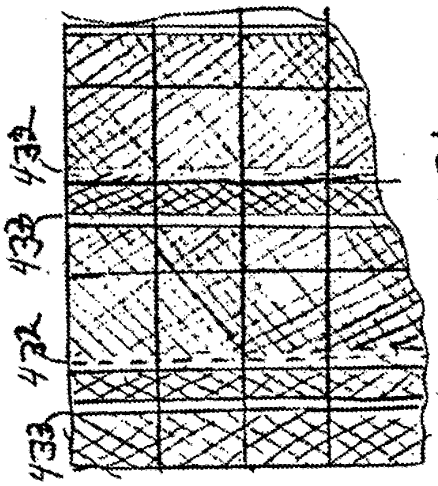


FIG. 28b

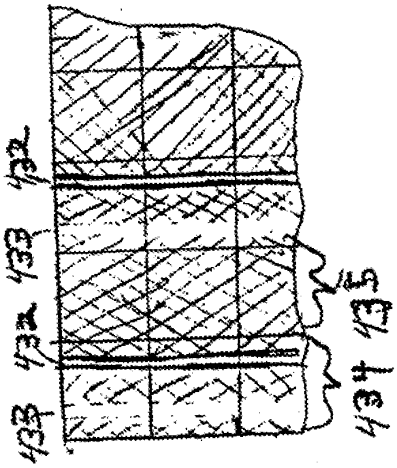


FIG. 28a

Microsoft Exhibit 1002 - Page 1471
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

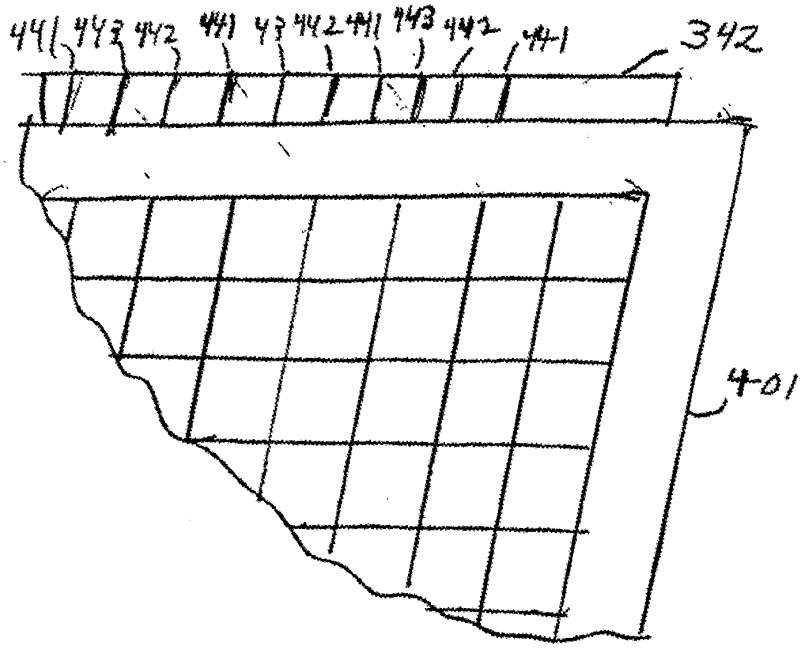


FIG. 29

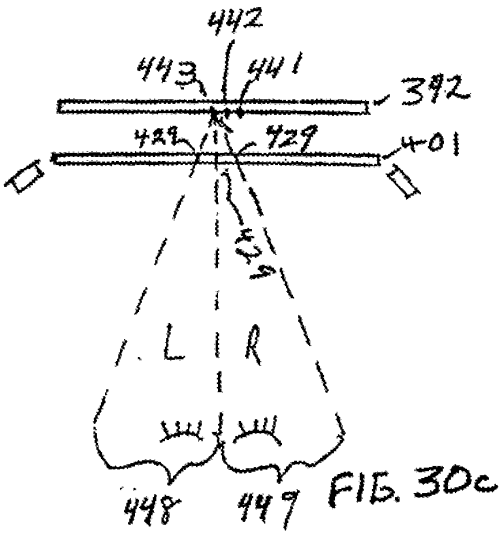


FIG. 30c

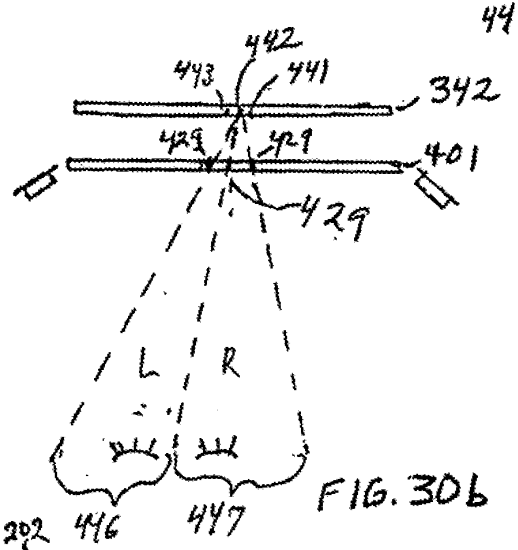


FIG. 30b

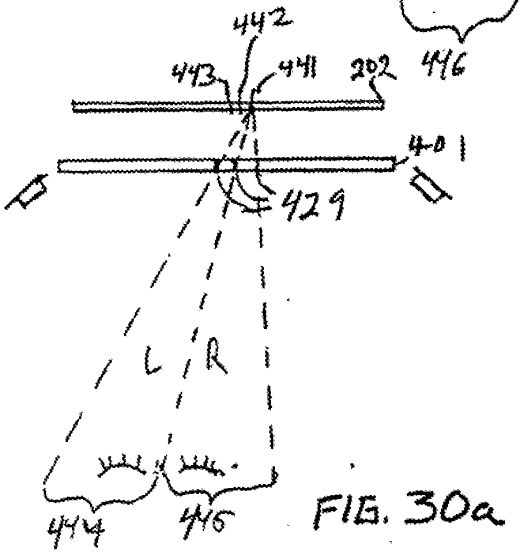


FIG. 30a

Microsoft Exhibit 1002 - Page 1473
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

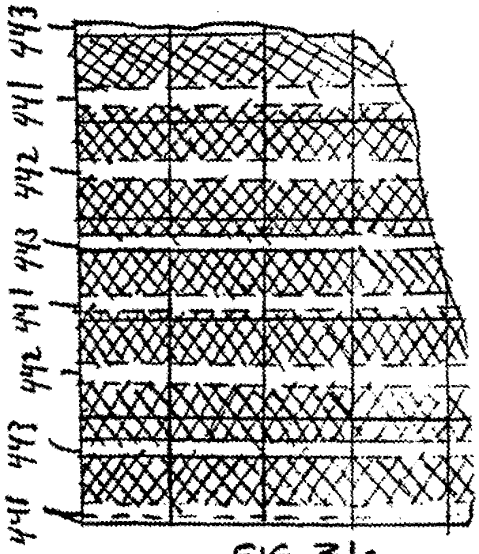


FIG. 31c

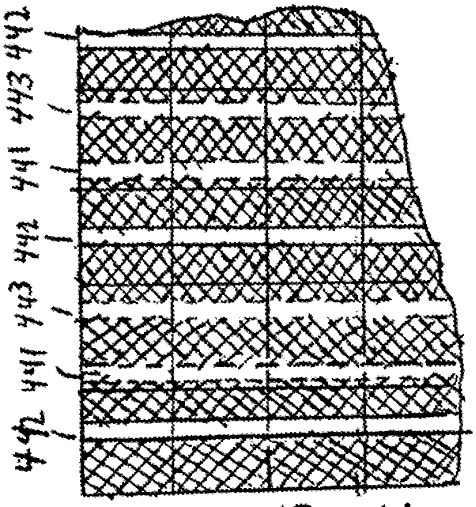


FIG. 31b

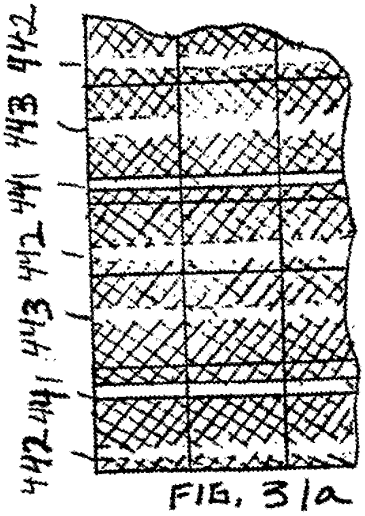
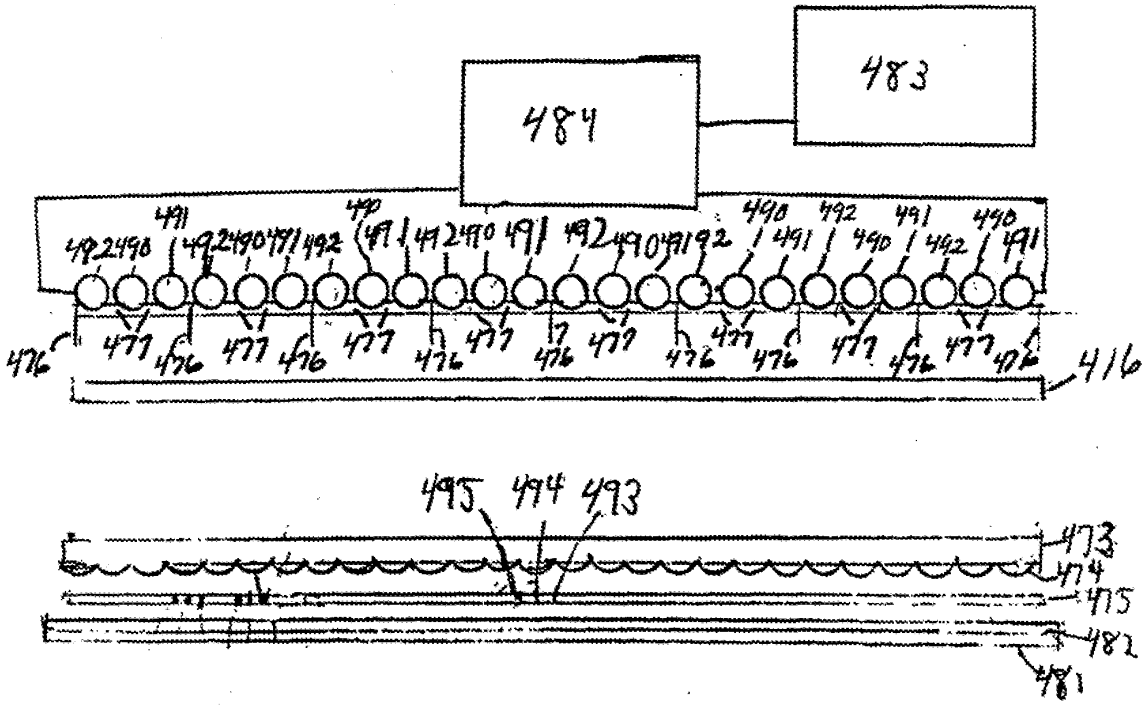


FIG. 31a

Microsoft Exhibit 1002 - Page 1474
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985



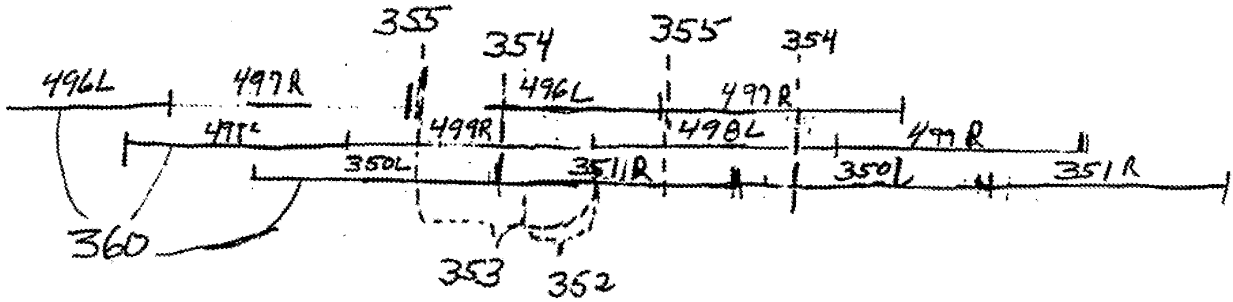


FIG. 32

Microsoft Exhibit 1002 - Page 1475
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

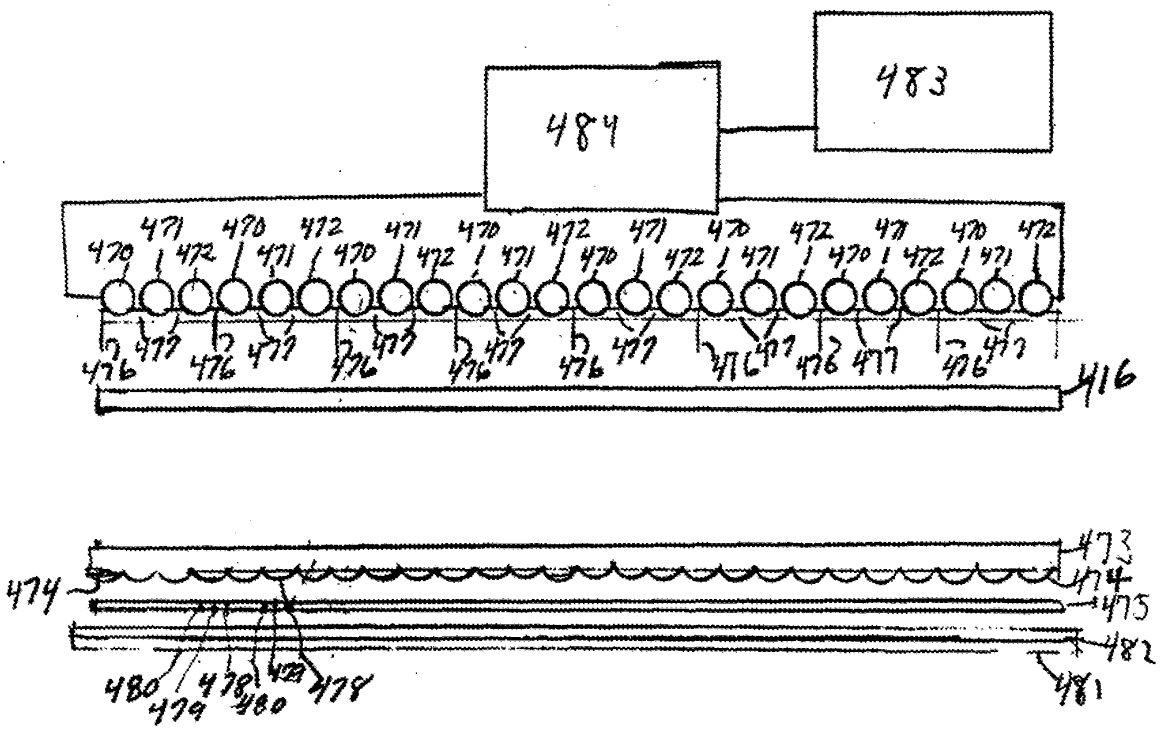


FIG. 33

Microsoft Exhibit 1002 - Page 1476
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985



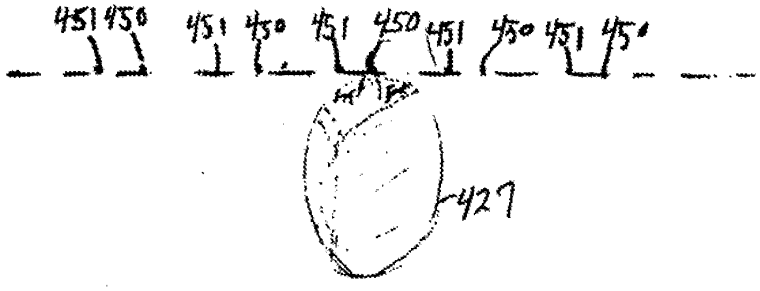


FIG. 34

Microsoft Exhibit 1002 - Page 1477
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/08412

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H04N 13/04
US CL :358/3, 88,; 359 462-464, 475-477; H04N 15/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 358/3, 88,; 359 462-464, 475-477; H04N 15/00, H04N 13/04

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

none

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Microsoft Exhibit 1002 - Page 1478
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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(22) International Filing Date: 12 January 1995 (12.01.95)

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189,418 31 January 1994 (31.01.94) US

(71) Applicant: SDL, INC. [US/US]; 80 Rose Orchard Way, San Jose, CA 95134 (US).

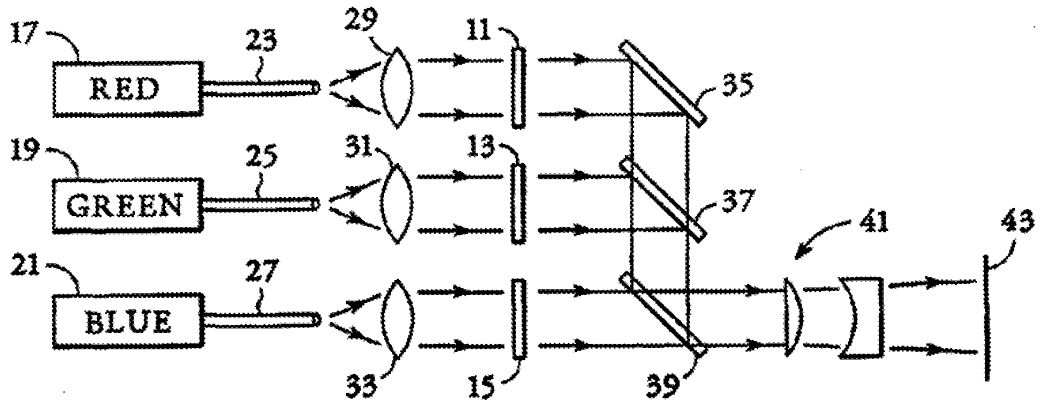
(72) Inventors: WAARTS, Robert, G.; 958 Van Auken Circle, Palo Alto, CA 94303 (US). SCIFRES, Donald, R.; 80 Rose Orchard Way, San Jose, CA 95134 (US). WELCH, David, F.; 1894 Oak Knoll Lane, Menlo Park, CA 94025 (US). LANG, Robert, J.; 7580 Olive Drive, Pleasanton, CA 94588 (US).

(74) Agent: SCHNECK, Thomas; Schneck & McHugh, P.O. Box 2-E, San Jose, CA 95109-0005 (US).

(81) Designated States: JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: LASER ILLUMINATED DISPLAY SYSTEM



(57) Abstract

A display system in which lasers scanlessly illuminate the pixels of a spatially modulating display panel (11, 13, 15), such as a liquid crystal display or micromirror array. At least three sources at least one of which is a laser with each different wavelengths are used, such as laser diode-based sources (81, 83, 85) producing red, green and blue light. The laser may be pulsed rapidly in sequence to provide time multiplexed illumination of all of the display pixels or may be operated in continuous (cw) mode, using color filters on the display, phase plates (147) or microlens arrays to image light spots (148) of each color only on designated pixels. Two sets of laser sources (123), either orthogonally linearly polarized or at slight different wavelengths, can be used to create 3-D images. Each set may illuminate a different display panel, one for each eye, or the two sets may be time multiplexed using the same display panel (125). A viewer has polarizing or bandpass filters in front of each eye to separate the binocular images. Fiberoptic coupling (99) of the laser sources (81, 83, 85, 87) can be used to physically separate these sources and their power supply from the display panel (115).

Microsoft Exhibit 1002 - Page 1479
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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Microsoft Exhibit 1002 - Page 1480
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Description

Laser Illuminated Display System

Technical Field

The present invention relates to optical systems involving optical spatial modulators, such as liquid crystal or micromirror array display panels, and in particular relates to efficient illumination of such panels.

Background Art

Optical spatial modulators using liquid crystal material or deformable micromirrors have found application as flat panel displays in portable or notebook computers, and are being seriously explored for use in head-mounted display virtual-reality systems, in high-definition projection television systems and in digital motion picture theatre projection systems. Monochrome and color liquid crystal display panels are commercially available and improvements based on active matrix and other technologies are presently being developed. A survey of the present display technology and the development efforts is presented by Kenneth Warner in IEEE Spectrum, November 1993, on pages 18-26 in an article entitled "The flat panel's future". The basic illumination for such systems is from a fluorescent lamp passing light through a diffuser and linear polarizer onto the liquid crystal display panel. For color displays, the panel includes red, green and blue filters corresponding to display pixels. While the electrical-to-optical efficiency of a fluorescent lamp is generally high (over 50%), significant optical losses between the lamp and the display panel, including unused back or side directed light, polarization losses of at least 50% and the unused wavelengths of the broad spectrum fluorescent lamp lost at the color filters, the overall efficiency is very low. Further losses occur from illumination of the interpixel areas of the

Microsoft Exhibit 1002 - Page 1481
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

display panel which contain control and pixel driver electronics.

Catoptric collection systems to redirect the backwards propagating light forward make the illumination optics much more complicated and make the already cumbersome head-mounted systems under development even heavier.

Another display technology which is currently available from Texas Instruments Inc. is digital micromirror devices. The devices use a matrix of deformable silicon micromirrors which can be oriented by control electronics in either of two directions. Light that illuminates the micromirrors is either reflected through a projection lens onto a view screen or misses the projection lens aperture and is trapped, depending on the tilt of the individual mirrors. Color systems use a rotating color wheel inserted into the light path and synchronized to the system electronics. A survey of this micromirror technology is presented by Jack Younse in IEEE Spectrum, November 1993, on pages 27-31 in an article entitled "Mirrors on a chip". Again the illumination system includes a broad spectrum light source, color wheel, and projection lens leading to optical losses between the source and display. However, since this display is polarization insensitive, polarization losses are eliminated.

Other display systems are illuminated by red and green LEDs behind every pixel and a blue color emitting fluorescent lamp illuminating all of the blue pixels, as described in U.S. Pat. No. 5,164,715 to Kashiwahara et al. Sequential illumination of display pixels by scanning laser beams is described in U.S. Pat. No. 4,978,202 to Yang, and in U.S. Pat. No. 5,018,007 to Lang et al. In the latter patent, a sheet of fiber optic cables that have been treated to emit light transversely overlie the display screen and a scanning laser sequentially transmits light to the optical fibers to illuminate one row of pixels after another. The liquid crystal

Microsoft Exhibit 1002 - Page 1482
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

shutters are activated row by row synchronized with the sequential illumination.

An object of the invention is to provide a display system with efficient illumination of the spatial modulator panel.

Disclosure of the Invention

The object is met by a display system which uses lasers to scanlessly illuminate the pixel elements in a spatially modulating display panel, such as a liquid crystal or micromirror array panel. At least three lasers are used, preferably laser-diode-based red, green and blue sources. For the green and blue sources, or any other sources with a wavelength less than about 600 nm, the sources may be frequency doubled laser diodes using optically nonlinear harmonic generators. Alternatively, upconversion fiber lasers could be used. More than three colors may be used for better color control.

Alternatively, at least one laser source used in conjunction with other illumination means can have at least some of the advantages listed from the use of three laser sources.

In some embodiments, the laser sources all illuminate the same pixel elements of the display panel but are sequentially pulsed to provide rapid time multiplexing of the display illumination. This allows a reduction in the number of display pixels by a factor of three in a color display. In other embodiments, the different color laser sources illuminate different sets of pixel elements, either by means of color filters on the display panel itself or by means of phase plates or microlens arrays that form light spots of each color only on designated pixels. Such phase plate or microlens optics can also be used to reduce optical losses by ensuring that interpixel areas of a display panel are not illuminated. In order to create three dimensional images, two sets of laser sources illuminate one or two display panels, the sources being either linearly polarized in orthogonal

Microsoft Exhibit 1002 - Page 1483
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

directions or at slightly different wavelengths in the two sets, and the viewer has polarizing or bandpass filters in front of each eye to separate the two separately recorded binocular images. Other embodiments are described in the detailed description that follows.

An advantage of laser illumination over the prior lamp-based illumination is that laser-diode-based sources are small and lightweight and produce a beam that can be collected and distributed with simpler and lighter optics. Also, despite the lamp's possibly greater intrinsic efficiency, the laser-diode-based system has a greater overall efficiency because it produces a brighter output and has less overall light loss between the light source and the display. This allows a smaller, lighter weight battery-powered display owing to the reduced heat generation and lower power requirement. Further, use of fiberoptic coupling can physically separate the laser sources and power supply from the display panel for a lighter, less cumbersome, head-mounted display. Further, the ability to modulate each laser source rapidly can reduce the number of display pixels required by a factor of three substantially decreasing the display cost. Still further, the laser source may be polarized leading to a factor of two improvement in efficiency relative to unpolarized sources which illuminate polarization sensitive displays such as liquid crystal displays.

Brief Description of the Drawings

Fig. 1 is a schematic view of a first laser illuminated display system of the present invention.

Figs. 2 and 3 are respective top and side sectional views of a frequency doubled laser light source for use in the present invention with the section taken along the line 3-3 in Fig. 2.

Fig. 4 is a perspective view of a laser diode light source for use in the present invention.

Fig. 5 is a schematic view of a second laser illuminated display system of the present invention.

Microsoft Exhibit 1002 - Page 1484
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Fig. 6 is a transparent perspective view of a light dispersing block for use in the laser illuminated display systems of the present invention.

Fig. 7 is a graph of intensity and filter transmissivity versus wavelength for two sets of laser illumination sources and viewer eyepiece filters for a three-dimensional display system of the present invention.

Fig. 8 is a schematic view of a third laser illuminated display system of the present invention.

Figs. 9a and 9b are respective schematic views of a fiber coupled multilaser light source and a time multiplex multilaser illuminated display system of the present invention.

Figs. 10a-c are schematic views of speckle reducing laser light sources for display systems of the present invention.

Fig. 11 is a schematic view of a fifth laser illuminated display system of the present invention.

Figs. 12a and 12b are graphs of light intensity versus time illustrating pulse modulation of three light sources for color balance.

Fig. 13 is a side view of a laser illuminated micromirror display panel in a system of the present invention.

Figs. 14a and 14b are schematic views of two laser illuminated display systems of the present invention for projecting multiple color sources onto different sets of display pixels.

Fig. 15a is a graph of laser source intensity versus wavelength for a set of high brightness illumination sources for the display systems of the present invention.

Fig. 15b is a schematic view of an optical system for combining two source beams into one higher brightness beam.

Microsoft Exhibit 1002 - Page 1485
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Fig. 16 is a schematic view of a dual phase plate optical system for use with the display systems of the present invention to source change intensity profiles.

Best Mode of Carrying Out the Invention

With reference to Fig. 1, a display system of the present invention includes one or more spatial light modulators, in this particular embodiment three in number, 11, 13 and 15, such as liquid crystal or micromirror matrix display panels, and at least three laser sources 17, 19 and 21 of different wavelengths or colors, here labeled as red, green and blue. The red laser source 17 typically emits light with a wavelength between 630 and 650 nm. The green laser source 19 typically emits light with a wavelength between 520 and 540 nm. The blue laser source 21 typically emits light with a wavelength between 460 nm and 480 nm. The actual wavelengths selected for each source will depend on the wavelength standard adopted for a particular application, such as for high definition television, digital motion picture theatre projection systems, or virtual reality head-mounted displays.

In the embodiment shown in Fig. 1, the laser sources 17, 19 and 21 are optically coupled to light transmissive fibers, or to bundles of such optical fibers, 23, 25 and 27. Lasers without fibers may also be used. This may be preferred if maintaining polarization is of importance for efficient operation of the display. The fibers may also be chosen to maintain the laser polarization. The output ends of these fibers or fiber bundles 23, 25 and 27 are, in turn, optically coupled to collimating lenses 29, 31 and 33 placed in front of the display panels 11, 13 and 15. In this manner, the laser sources 17, 19 and 21 are capable of scanless illumination of the spatial light modulators 11, 13 and 15. Light transmitted through the spatial light modulators 11, 13 and 15 can be combined into a single color image by a series of dichroic reflectors 35, 37 and 39. In

Microsoft Exhibit 1002 - Page 1486
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

this example, the reflector 35 reflects the red light image that has been transmitted through display panel 11. The reflector 37 reflects the green light image that has been transmitted through display panel 13 and also transmits the red light image that was reflected by reflector 35. The reflector 39 reflects both the red and green light images received from reflectors 35 and 37 and transmits the blue light image that has been transmitted through display panel 15. Other arrangements for combining the separate images are also possible. The combined color image is then projected through well known lens projection optics 41 to a view screen 43. Other display system embodiments using three or more laser sources to illuminate a single spatial light modulator, rather than three or more distinct modulators 11, 13, and 15, are described below.

With reference to Figs. 2 and 3, the laser sources are typically diode lasers or laser diode arrays. In the case of wavelengths shorter than about 600 nm, the diode lasers that are presently available which can directly emit light of such wavelengths, namely II-VI compound semiconductor lasers, such as MgZnSSe diode lasers, are currently capable of producing less than about 100 mW of optical output. This is acceptable for some applications, such as head-mounted displays, but is insufficient for others, including flat-screen televisions or digital theater projection systems. It is expected that the power output for these and the, as yet experimental, III-V nitride compound semiconductor lasers will increase as the technology develops. However, at present, frequency doubled diode lasers are the laser source of choice for the green and blue wavelengths. Other blue and green sources may include frequency converted lasers that are based on difference frequency mixing (DFM) of diode laser outputs, and upconversion fiber lasers. Frequency doubling waveguides 47, difference frequency mixing (DFM) media, and other nonlinear optical devices capable of producing frequency converted lasers, are collectively

Microsoft Exhibit 1002 - Page 1487
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

known in the art as optically nonlinear frequency converters. Such devices are known to be useful for shifting the wavelength of the light emitted from a laser, as in the frequency doubled laser 21 in Figs. 2 and 3. Such a frequency doubled laser 21 (or 19) may include a monolithic MOPA array 45 followed by a planar, optically nonlinear waveguide 47, both mounted on heat sink submount 49. MOPA array 45 can have multiple light emitting elements, typically 10 to 20 in number, each of which includes a single spatial mode DBR laser oscillator section 51 followed by a flared amplifier section 53. A collimating lens element 55 may be integrated into the wide output end of each amplifier section 53. The nonlinear waveguide 47 is preferably butted against the output end of the MOPA array 45. The nonlinear optical material 47, e.g. $LiNbO_3$ may be periodically poled, that is, have periodically alternating ferroelectric polarization domains, for phase matching or quasi-phase-matching the fundamental and second harmonic wavelengths of light in order to obtain efficient frequency doubling. Also, the laser oscillators 51 in the MOPA array are preferably constructed so as to oscillate in the TM polarization mode for best frequency doubling efficiency. A MOPA array of 10 elements emitting 920 nm to 960 nm light with a power of one watt per element can produce a frequency doubled output from the nonlinear waveguide 47 of 460 nm to 480 nm blue light with a power of about 100 mW per element, for a total blue light output power of one watt. Likewise, a 10 element MOPA array emitting 1040 nm to 1080 nm light with a power of one watt per element will result in 520 nm to 540 nm green light after frequency doubling with a total power of about one watt.

The blue or green laser output is coupled into an array of optical fibers 57 corresponding in number to the number of lasing elements in the MOPA array 45. Preferably, the optical fibers 57 are butted or lens coupled to the output end of the frequency doubling waveguide 47. The fiber array 57 may be arranged for ease of

Microsoft Exhibit 1002 - Page 1488
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

alignment on a grooved fiber tray 59 and mounted with the laser source's submount 49 on a heatsink 61. The optical fibers 57 are rearranged at the fiber outputs as a round fiber bundle, typically with a 400 μm diameter and less than 0.4 NA for a 7-fiber array. The overall electrical-to-optical efficiency from the electrical power input to the MOPA array 45 to the optical power output 63 from the end of the fiber bundle is about 15 percent or 30 lumens per watt, with the brightness of the fiber output 63 being on the order of 10^6 lumens/sr·cm^2.

Many alternatives to the MOPA frequency doubled array exist. The first is to resonantly frequency double a single MOPA. The concept of resonant cavity doubling is well described in Kozlovsky et al., Appl. Phys. Lett. 56, 2291 (1990). The 1 W MOPAs with collimating optics are now a standard commercial product. This light is injected into the resonant doubler. A feedback loop and a frequency tunable MOPA are used to lock the laser to the resonator frequency for maximum visible wavelength conversion efficiency. A second alternative is to couple a single mode index guided laser, such as the commercially available SDL 5420 laser, to a quasi-phase matched nonlinear optical waveguide. This type of waveguide frequency doubler is described in a paper by Van der Poel, 57, 2074, (1990) and Risk, Appl. Phys. Lett. 58, 19 (1991). An array of such devices could also be coupled to an array of quasi-phase matched nonlinear optical waveguides. The visible light output could then be at least partially collimated by a lens array or other optics to achieve uniform illumination of a light modulator array such as a liquid crystal display. The output from such a device would be linearly polarized. Each laser element in the array could be modulated at high speed greater than 1 MHz or all elements could be driven in parallel in either a pulsed or CW mode.

With reference to Fig. 4, the red laser source can be a ten-element phase-locked laser array with an optical power output of about 100 mW per element for a

Microsoft Exhibit 1002 - Page 1489
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

total output of one watt. Alternatively, a single lasing element with a flared gain region could be used. As seen in Fig. 4, this single lasing element may have an InGaP active quantum well 65 and InGaAsP cladding layers 67 on a GaAs substrate 69. The structure may have a 1 to 5 μm wide single mode waveguide 71 adjacent to one cavity reflector 73 followed by a flared gain section 75 of about 1 mm to 2 mm length terminating in a 100 to 300 μm wide aperture at a second cavity reflector 77. Such a laser produces approximately one watt of optical output at 640 nm in nearly a single transverse mode. Other high power, high brightness, red laser diode sources are known and could be used. These include a multimode broad area laser or arrays of single mode or multimode lasers.

It should be noted that many of the laser sources that have wavelength selective losses within the laser cavity, such as laser-diode-based sources with one or more grating reflectors, can be actively tuned. For example, a MOPA or DBR laser diode can be actively tuned to emit any wavelength within a certain range (typically about 10 nm, but often as much as 30 nm) by adjusting the refractive index in a grating region of such devices via current injection or charge depletion in the grating region. Such active tuning of the wavelength emission of diode-laser-based sources can be used to adjust the color balance of a laser illuminated display system for the best color image. It may also be used to create 3-D images as explained below with reference to Fig. 7.

With reference to Fig. 5, light from red, green, blue and optional infrared laser sources 81, 83, 85 and 87 is coupled into optical fibers or fiber bundles 91, 93, 95 and 97, respectively, which are then combined into a single fiber or a mixed fiber bundle 99. For a head-mounted display system, optical power of 0.1 mW to 10 mW per color is sufficient. The laser sources can thus be laser diodes directly emitting red, green and blue light, or frequency doubled or difference frequency mixed laser diode, for the green and blue light, or up-

Microsoft Exhibit 1002 - Page 1490
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

conversion lasers, such as thullium (red, green and blue), erbium (green), praseodymium (red or blue) and holmium (green) doped ZBLAN fiber lasers. The light 101 emitted from the output end 100 of the fiber or fiber bundle 99 is incident upon a dichroic beamsplitter 103 that reflects the infrared light from laser source 87 and transmits the visible light from laser sources 81, 83 and 85. The reflected infrared light 105 is imaged by a lens 107 onto an infrared detector 109. The electrical output 110 of the detector 109 can be used to power the electronics of the display panel 115 if the infrared source 87 is operated to supply power to charge a battery, which then powers the display electronics circuit. The infrared source can also be modulated with the digitally encoded display data signal to trigger the electronics to turn pixels on and off. This would eliminate any electrical wires going into the display region. Since the laser sources 81, 83, 85 and 87 are fiber coupled to the display panel 115, they can be located remote from a head-mounted display. The visible light 111 transmitted through the dichroic beamsplitter 103 passes through an optional binary diffusing screen 113 and illuminates a display panel 115. Display panel 115 is a spatial light modulator, such as a liquid crystal or micromirror display, and the spatially modulated light 117 appears after either being transmitted through or being reflected off of the display panel 115. The laser sources 81, 83 and 85 may be pulsed in sequence at a rate of about 200 Hz or greater, with each source illuminating the entire panel 115. The panel electronics change the pixels of the display panel 115 after each laser pulse to create a rapid sequence of monocolor images that are perceived by humans as a full color image. Such sequential pulsing of each lasing color allows a display with three times fewer pixels to be used relative to lamp illuminated displays. Active matrix liquid crystal display panels, especially those using ferroelectric liquid crystal materials, have a sufficiently fast response time for such rapid config-

Microsoft Exhibit 1002 - Page 1491
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

uring of the display pixels. Alternatively, the visible laser sources 81, 83 and 85 can all operate in a continuous mode and illuminate a color display panel employing color filters behind each pixel.

Two sets of laser sources can illuminate a pair of display panels to create a binocular image. Alternatively, the single fiber or mixed fiber bundle 99 in Fig. 5 can split into two fibers or fiber bundles for illumination of two display panels, like panel 115, one for the left eye and the other for the right eye.

With reference to Fig. 6, one technique of obtaining uniform illumination of a display panel, such as a liquid crystal display 125, by the laser sources 123, uses a transparent material, light guiding, parallelepiped-shaped block 121. The fiber ends of the red, green and blue laser sources 123 are butted to a back surface of the block 121. This back surface is preferably near 100% reflecting, except for light entrance areas coinciding with the fiber ends. The light from the sources 123 is thus admitted into the light dispersing block 121, and travels down the length of the block 121 to its front surface. If the block 121 is long enough, the light will uniformly illuminate the front surface. This light can then directly impinge on the display 115 and the exit surface 124 might be antireflection coated. Preferably, the front surface 124 has about 90% reflectivity. This allows the light to bounce back and forth inside the block 121 to effectively create a longer path parallelepiped thereby increasing the light uniformity impinging on display 115 without requiring a long dispensing block 121. Additionally, the three light sources may each be made up of multiple lasing elements which can be coupled separately via multiple fibers to the back surface of the light dispersing block 121, or a single fiber from each source may be split into multiple fibers by fiber splitters, so that light can enter the block 121 in multiple regions, producing uniform illumination in a shorter distance. The parallel side walls

Microsoft Exhibit 1002 - Page 1492
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

and sharp corners of a rectangular-shaped block 121 preserve the desired linear polarization of the laser sources 123 for more efficient use of the light by the illuminated liquid crystal display panel 125. That is, in a liquid crystal display 50% of unpolarized light will be lost. Therefore the linearly polarized laser beam aligned with the proper LC display polarization allows nearly 100% of the illumination light to be visible on the display screen.

Another use of the linearly polarized laser illumination is the creation of 3-D displays. Such displays can be made using two sets of linearly polarized laser sources, one set being laterally polarized red, green and blue sources and the other set being vertically polarized red, green and blue sources, so that each color has both laterally polarized and vertically polarized laser sources. These sources are used in conjunction with a polarization insensitive spatial light modulator, such as a micromirror matrix display panel, for example, the deformable silicon-based reflector arrays made by Texas Instruments. The image is viewed through a set of orthogonally linearly polarized glasses. The laser sources are pulsed sequentially at a rate of at least 360 Hz so that each color and polarization is refreshed at a cycle rate of at least 60 Hz, giving each pulse a one-sixth duty factor and at most 2.8 msec pulse length. A typical illumination sequence might be laterally polarized red, laterally polarized green, laterally polarized blue, vertically polarized red, vertically polarized green, vertically polarized blue, etc. or possibly laterally polarized red, vertically polarized red, laterally polarized green, vertically polarized green, laterally polarized blue, vertically polarized blue, etc. Other sequences are also possible. The spatial modulator is reconfigured for each pulse. Because, one eyepiece of the view glasses is laterally polarized and the other is vertically polarized, each eye receives only the light from a particular polarization, and because of the high

Microsoft Exhibit 1002 - Page 1493
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

pulse repetition rate, the rapid sequence of monocolor images is perceived by the viewer as a color image, so that a slightly different color scene can be sent to each eye. By having separate digital color cameras record an image from separate locations and angles, as if separated by the separation of the human eyes, and by sending this data to the spatial modulator for illumination by each set of linearly polarized laser sources, a true three dimensional image of the scene can be viewed.

With reference to Fig. 7, another method of achieving three-dimensional pictures is similar to the first, but the sets of linearly polarized laser sources are replaced by two sets of lasers operating at slightly different wavelengths. The polarizing glasses are replaced with filters with passbands at different wavelengths. Figs. 7a and 7c show the laser outputs in intensity I versus wavelength λ for the two sets of laser sources. One set of sources (Fig. 7a) produces light, represented by the intensity spikes 131, 133 and 135, at 440 nm (blue), 520 nm (green) and 630 nm (red). The other set of sources (Fig. 7c) produces light, represented by the intensity spikes 137, 139 and 141, at the slightly longer wavelengths 470 nm (blue), 540 nm (green) and 650 nm (red). Alternatively, a single set of wavelength tunable laser sources may be actively tuned in time multiplexed manner to produce the two sets of emission wavelengths. Figs. 7b and 7d show the filter bandpasses in transmissivity $\mathcal{T}$ versus wavelength λ for the two eyepieces of the viewing glasses. One eyepiece (Fig. 7b) has bandpass wavelengths, represented by the transmissivity envelopes 132, 134 and 136, coinciding with the 440 nm, 520 nm and 630 nm intensity spikes of the first set of laser sources and generally blocking transmission of the wavelengths from the other set of sources. The other eyepiece (Fig. 7d) has bandpass wavelengths, represented by the transmissivity envelopes 138, 140 and 142, coinciding with the 470 nm, 540 nm and 650 nm intensity spikes of the second set of laser sources and generally

Microsoft Exhibit 1002 - Page 1494
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

blocking transmission of the wavelengths of the first set of sources. The cameras recording the image data for use in controlling the spatial modulator configurations for each color also need to be equipped with light wavelength filters with transmissivity bandpasses coinciding with Figs. 7b and 7d in order to render the viewed image as true to color as possible. Filters with the necessary characteristics can be made with colored glass or using interference techniques.

A third method of 3-D imaging is to use both wavelength filtering and linear polarization filtering. This may be required in cases where a particular laser source is not readily linearly polarized or if a particular wavelength laser or filter cannot be fabricated in a cost effective manner.

With reference to Fig. 8, in another embodiment, a single spatial mode laser 143 emits light 144 which is collected and collimated by a lens 145. The light 144 then illuminates a first phase plate 147. The phase plate 147 is constructed so that light transmitted therethrough interferes so as to form, after propagating a certain distance, a periodic two-dimensional array of light spots 148. A spatial modulator 149 having a periodicity matching the spacing of the light spots 148 is positioned at the location of the array of light spots 148. Typically, spatial light modulators, such as liquid crystal arrays have large areas between the pixels 150 occupied by drive electronics where light is not transmitted. If a liquid crystal display panel is directly illuminated with a collimated beam, that portion of the light that falls on interpixel areas is wasted. In this embodiment, all or most of the light is constructed by the phase plate 147 to fall as spots 148 on the pixel areas and thus the light spots 148 are fully transmitted through the display elements 150. As an option, a second phase plate 151 is positioned to reshape the light that is transmitted through the liquid crystal array 149 into

Microsoft Exhibit 1002 - Page 1495
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

a single collimated beam. Projection optics 152 image the light onto a view screen.

With reference to Figs. 9a and 9b, multiple laser light sources may be used. In Fig. 9a, N laser sources 155-157 are coupled to a number of optical fibers 158-160. At the output end 161 of these fibers, the fibers are arranged in a matrix or other bundle configuration to produce a single high power output beam. An advantage of this scheme is that similar laser sources can be used for both relatively low power applications, such as head-mounted displays or home television projection systems, as well as for relatively high power applications, such as theatre projection systems, simply by scaling the number of laser sources to obtain the required optical power. Note that multiple laser sources without fibers can also be used. These may be lensed to achieve uniform display illumination while maintaining linear polarization.

In Fig. 9b, multiple laser sources are time multiplexed to reduce power requirements and simplify control of the spatially modulating display panels. In this example, four laser sources (including fiber coupling) 163-166 are arranged to illuminate different portions 169-172 of a display panel 168. A lens 167 images the laser light onto the display 168. By pulsing each of the lasers 163-168 sequentially at different time intervals, only a quarter of the display panel 168 is illuminated at each time. Therefore only a quarter of the display panel 168 need be addressed at each time.

Use of multiple, spatially incoherent, laser emitters and other techniques can reduce speckle. Speckle is an effect, related to the coherence of the laser light, which causes unwanted graininess in the image. In the multiple laser embodiment in Fig. 9a, the light from the optical fiber outputs 161 are all incoherent with respect to each other. Since each of the laser sources 155-157 produces its own speckle pattern,

Microsoft Exhibit 1002 - Page 1496
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

the speckle in the overall image will be reduced as the multiple speckle patterns average out with each other.

In Fig. 10a, light 175 from a laser source is injected into a multimode optical fiber 176, which is tightly looped around a vibrating mechanical transducer 177, such as a piezoelectric crystal or a small loudspeaker-type magnetic transducer. The vibrating transducer 177 stresses the multimode fiber 176 so as to scramble the optical modes of the light 175 propagating in the fiber 176. This results in a smearing of the speckle pattern observed at the output 178 of the fiber. The vibration rate is preferably much faster than display frame rate. The speckle pattern changes faster than the human eye and visual cortex can respond, so the speckle is averaged out.

In Fig. 10b, light 181 from a single spatial mode laser 180 is coupled into an array of fibers 182, which forms a fiber bundle at the output 183. Each of the fibers 182 in the bundle will illuminate a display panel at a different position and will cause different speckle patterns in the image formed on a view screen. Averaging of the different speckle patterns will reduce the total speckle in the viewed image.

Also in Fig. 10b, if the fibers 182 in the bundle have different lengths, and the difference in the lengths of the fibers 182 is longer than the coherence length of the light 181 from the laser source 180, then even if the single light source 180 illuminates the inputs of the fibers 182 with a spatially coherent beam 181, the light at the output 183 of the fiber bundle will no longer be spatially coherent. Each fiber 182 in the bundle will emit light with a different speckle pattern and the overall speckle in the display image will be reduced through the averaging of the different speckle patterns.

With reference to Fig. 10c, a plurality of laser sources 185, each with a slightly different wavelength are coupled into a plurality of optical fibers 187 which

Microsoft Exhibit 1002 - Page 1497
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

are gathered together into a fiber bundle 189. This results in an output beam 190 with an overall spectrum for each primary color which is broadened relative to the spectrum from any one laser source 185. The width of the spectrum results in reduced coherence length for the light 190, and thus speckle, which depends on the coherence of the source, is reduced in the final display image. The wider the spectrum of the light 190, the less speckle will be generated, because the light no longer interferes coherently. Another way to produce a wider spectrum, although generally not as broad as the multiple source approach shown in Fig. 10c, is to pulse the laser diode. Laser pulsing causes multiple wavelength emission from the laser diode which reduces speckle. The effect can be enhanced by coupling the pulsed light into a glass waveguide with relatively high dispersion. This causes light of slightly different wavelengths to have slightly different optical path lengths. The longer the waveguide is and greater the dispersion, the greater the variation in path lengths and the less speckle that will result. Waveguides, such as the parallelepiped shown in Fig. 6, wherein the light makes multiple passes between the walls and mirrors will also greatly reduce the speckle.

With reference to Fig. 11, a laser source 191 emits light 192, which can be either single or multi-spatial mode light, that is semicollimated by a lens 193. The collimated light 194 illuminates a liquid crystal array 196 through a microlens array 195. The purpose of the lens array 195 is to improve the transmission of light 194 through the liquid crystal array 196 by reducing the amount of light which is incident upon and absorbed by area between the liquid crystal pixel elements in the array 196. For this purpose, the microlens array 195 has a periodic spacing of microlens elements which matches the periodicity of the liquid crystal array's pixels. Each lens element is positioned in front of one liquid crystal pixel element at about a focal length distant. Use of light 194 which has been at least partially

Microsoft Exhibit 1002 - Page 1498
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

collimated in the most highly divergent transverse dimension by the lens 193, greatly reduces the numerical aperture requirements of the microlens array 195 and improves the collection efficiency of the microlenses. A second lens array 197, substantially matching the first lens array 195, is placed on the output side of the liquid crystal array 196 to recollimate the transmitted light. Multiple laser sources at different wavelengths can be combined readily in the collimated beam region 194 by use of dichroic mirrors so that only one display 196 is required if sequenced laser pulsing is used.

With reference to Figs. 12a and 12b, time multiplexing of each laser source makes it possible to adjust color balance in a color display image in either of two ways. In Fig. 12a, the peak power or intensity of each pulse of the red, green and blue sources can be changed to compensate for differences in brightness of the various sources and the sensitivity of the human eye to different wavelengths. Here, the pulse 201 of the red source is given the most power, the pulse 22 of the green source is given less power and the pulse 203 of the blue source is given the least power. These power levels can be adjusted as needed to create the desired color balance. Alternatively, in Fig. 12b, the pulse length t_1, t_2 or t_3, for each wavelength or color of light is adjusted to create color balance. Here, for example, the green pulse 205 is given a greater pulse length t_2 than the red or blue pulse 204 and 206. The overall combined repetition rate for all three colors remains at 60 Hz or greater to avoid flicker, but the duty factor is increased or decreased to give one or another color more or less relative duration for its pulses. Color balancing can also be achieved by active tuning of one or more laser wavelengths. This wavelength tuning can also be combined with the peak power or pulse width adjustment described in Fig. 12.

With reference to Fig. 13, an incoming collimated beam 210 of light from a plurality of laser sources

Microsoft Exhibit 1002 - Page 1499
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

illuminates a deflecting micro-mirror-type spatial light modulator 209. This spatial light modulator 209, available commercially from Texas Instruments, has a matrix of deformable silicon micromirrors 211-215, etc. formed on a substrate. Each micromirror represents one pixel and may be deflected or not deflected (or alternatively, deflected in one direction or another). A typical deflection angle is about 10°. The light 210 from the laser sources is reflected from the mirror array 209 and the angle of deflection depends on the orientation of each mirror 211-215, etc. In one deflection position, represented by mirrors 211, 213 and 215, the light 216 reflected by the mirrors is transmitted through a projection lens 217. In the other deflection position, represented by mirrors 212 and 214, the light 218 reflected from the mirrors misses the projection lens 217 and is lost. By using laser sources to produce the collimated beam 210, rather than incoherent light sources, the angle of the incident light 210 is much better defined and the required change in angle of the mirrors 211-215, etc. for projection or loss of the reflected light 216 and 218 is reduced. In addition, contrast of the system is improved. Further, a narrow spatial filter may be used before the projection lens 217 to further take advantage of the high directionality of the laser beam 216.

With reference to Figs. 14a and 14b, phase plates may be used to locate red, green and blue light spots on designated pixels of a display panel to produce a color image without an array of individual color filters on the display panel itself. In Fig. 14a, shown with just two of the colors for simplicity, red and blue laser sources 221 and 222, such as the output ends of laser diode coupled fibers or fiber bundles, provide light to a collimating lens 223. The sources 221 and 222 are differently positioned relative to the optical axis of the lens 223, and so the lens 223 creates collimated beams 224 and 225 with different beam directions for each color. The collimated beams 224 and 225 are directed

Microsoft Exhibit 1002 - Page 1500
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

onto a phase plate 226. An array of light spots 227 is created by the phase plate 226, where the red and blue spots have the same periodicity but are spatially separated from each other. Each light spot 227 is modulated by a single element of the liquid crystal array 228. A second phase plate 229 on the output side of the liquid crystal array 228 recollimates the light transmitted through the array 228 to form a color image.

In Fig. 14b, phase plates 226 and 229 are replaced by lens arrays 235 and 236. Light coming from sources 231 and 232 is directed as collimated beams in different directions. Light incident on the lens array 235 at different angles are focused by the lens elements onto different pixels of the display panel 234. The light transmitted by the display panel elements is recollimated as a color image by the lens array 236.

With reference to Figs. 15a and 15b, the output power from a laser-based light source can be increased by combining the light from many individual lasers. Typically, the many light sources will increase the total numerical aperture of the combined light source. Therefore, the brightness of the combined light source remains constant when more laser beams are added. However, by combining the light from laser sources of slightly different wavelengths, the intensity of the combined beam can be increased above the level of individual beams. In Fig. 15b, light of a first wavelength λ_1, is combined with light of a second wavelength, λ_2 by means of a dichroic filter 246. The spectrum resulting from combining four sources for each of the blue 241, green 243 and red 245 color sets is shown in Fig. 15a.

With reference to Fig. 16, the intensity profile 253 of a typical laser beam 251 is not optimally matched to the size of a typical display screen. A laser beam 251 typically has a Gaussian type intensity distribution 253 with a certain aspect ratio. The display, on the other hand, is rectangular and a uniform illumination is required. By overfilling the display with light from

Microsoft Exhibit 1002 - Page 1501
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

the laser, the central, more uniform part of the laser beam may be used. However, this leads to large losses from discarding the non-uniform edge portions of the beam. In Fig. 16, two phase plates 252 and 254 are used to create a uniform light intensity distribution 256 which is matched to the size of the display. Light 251 from the laser is dispersed and collimated by the two phase plates 252 and 254 to change the intensity distribution from the Gaussian profile 253 of the input beam 251 to a uniform distribution 256 for the output beam 255. This approach can also be used in combination with the phase plate of Fig. 8 that was used to create many light spots in front of the liquid crystal display. In this case, all of the light spots will have uniform intensity.

Microsoft Exhibit 1002 - Page 1502
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Claims

1. A display system comprising

a spatial light modulator having a plurality of pixels,

at least three laser sources of different wavelengths, each source positioned for scanless illumination at a given time of pixels of said spatial light modulator that correspond at that time to the wavelength of that source, and

means disposed between said laser sources and said spatial light modulator for dispersing light from said sources uniformly onto said illuminated pixels.

2. The display system of claim 1 wherein each pixel of said spatial light modulator corresponds sequentially to each of said wavelengths and said laser sources are pulsed in sequence for time multiplexed scanless illumination by each successive source of all of said pixels of said spatial light modulator.

3. The display system of claim 1 wherein each pixel of said spatial light modulator is dedicated to a particular wavelength and said laser sources are operated in a continuous mode, each laser source illuminating only a designated subset of pixels of said spatial light modulator consisting of all pixels dedicated to the particular wavelength emitted from that laser source.

Microsoft Exhibit 1002 - Page 1503
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

4. The display system of claim 3 wherein a phase plate is disposed between said laser sources and said spatial light modulator, said phase plate forming light spots on each said designated subset of pixels of corresponding wavelength.

5. The display system of claim 3 wherein a microlens array is disposed in front of groups of pixels of said spatial light modulator, light from said sources being imaged by said microlens array onto said designated subset of pixels of corresponding wavelength.

6. The display system of claim 1 wherein a phase plate is disposed between said laser sources and said spatial light modulator, said phase plate forming light spots on each pixel of said spatial light modulator.

7. The display system of claim 1 wherein a microlens array is disposed in front of said spatial light modulator, said microlens array and spatial light modulator having matching spatial periodicity.

8. The display system of claim 1 wherein said means for dispersing comprises a transparent, light guiding, parallelepiped-shaped block with reflective front and back surfaces, light from said sources being coupled into said block through said back surface and coupled out of said block to uniformly illuminate said spatial light modulator through said front surface.

Microsoft Exhibit 1002 - Page 1504
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

9. The display system of claim 1 wherein said laser sources comprise laser diodes.

10. The display system of claim 1 wherein at least two of said laser sources are wavelength tunable.

11. The display system of claim 1 wherein each laser source has an adjustable pulse duty factor.

12. The display system of claim 1 wherein there are two sets of at least three laser sources each, said two sets of sources having different sets of light emission wavelengths.

13. The display system of claim 1 wherein said spatial light modulator is a liquid crystal display panel.

14. The display system of claim 1 wherein said spatial light modulator is an array of deflectable micromirrors on a monolithic substrate.

15. The display system of claim 1 wherein each laser source comprises a plurality of laser emitters, said laser emitters emitting light which are incoherent with respect to each other, and means for combining light emitted from said laser emitters into a single beam illuminating said spatial light modulator.

Microsoft Exhibit 1002 - Page 1505
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

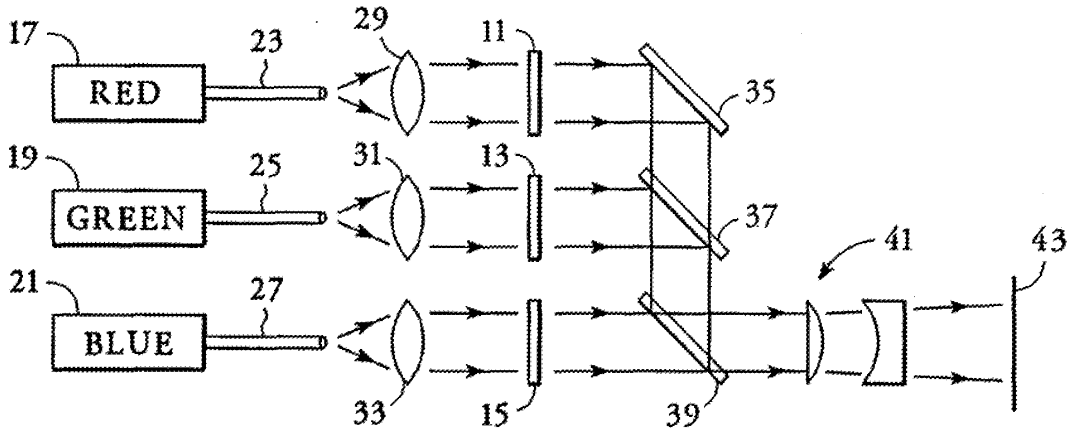


FIG. 1

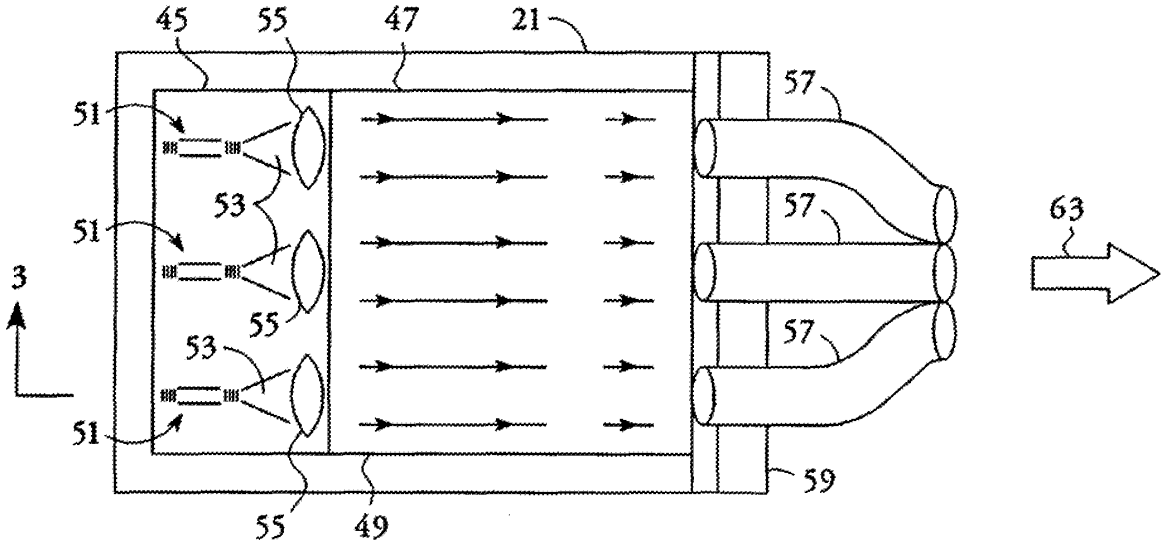


FIG. 2

Microsoft Exhibit 1002 - Page 1506
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

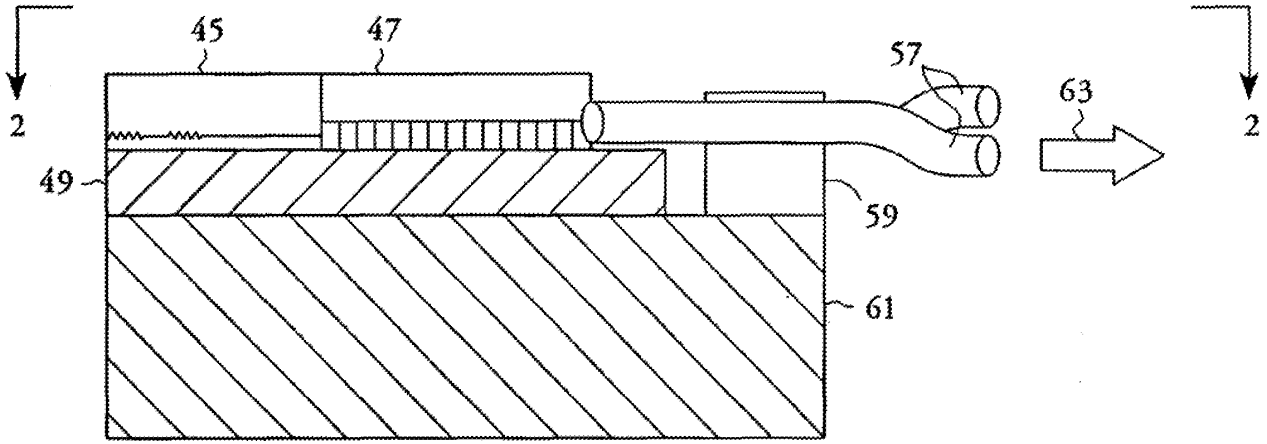


FIG. 3

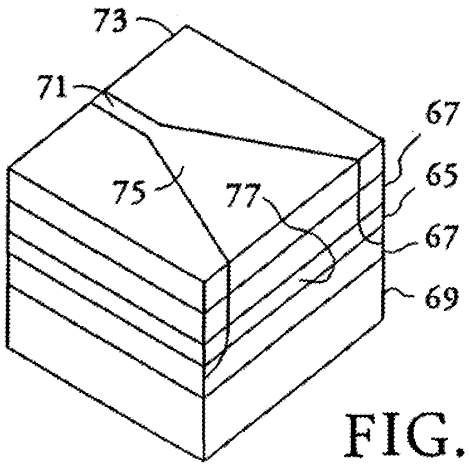


FIG. 4

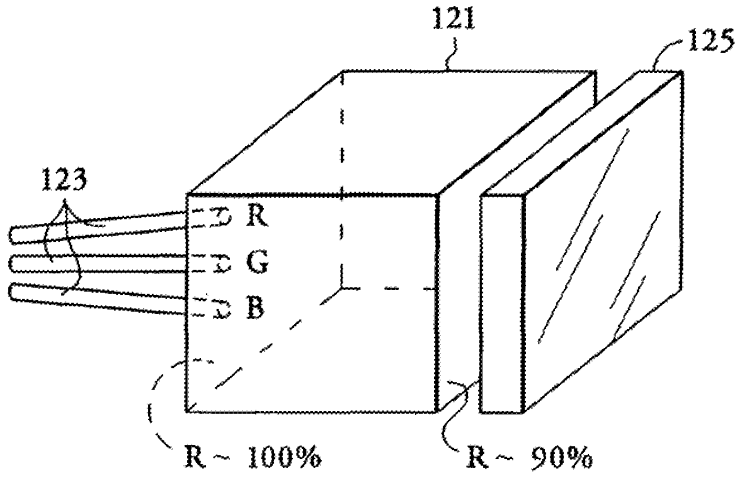


FIG. 6

Microsoft Exhibit 1002 - Page 1507
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

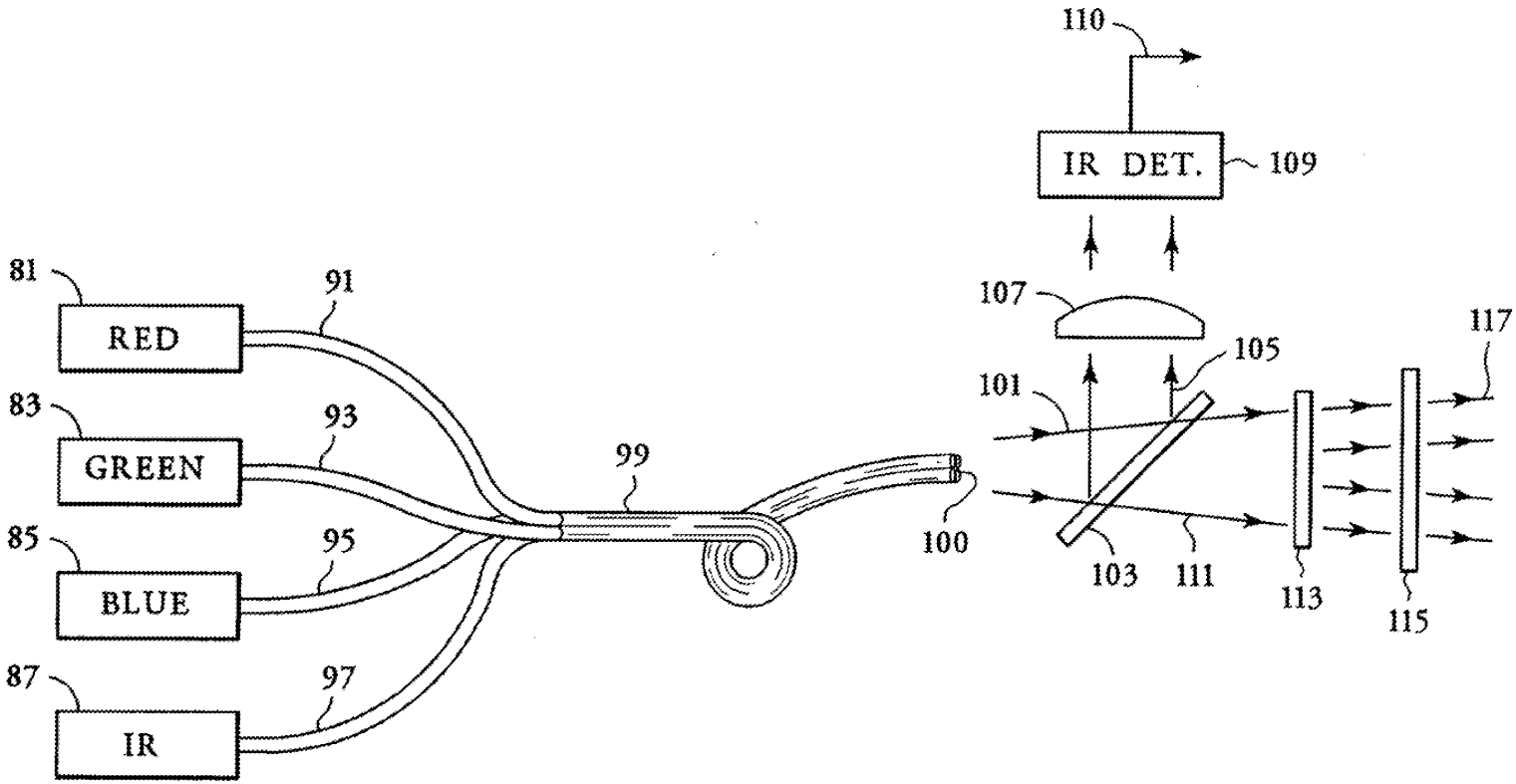


FIG. 5

Microsoft Exhibit 1002 - Page 1508
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

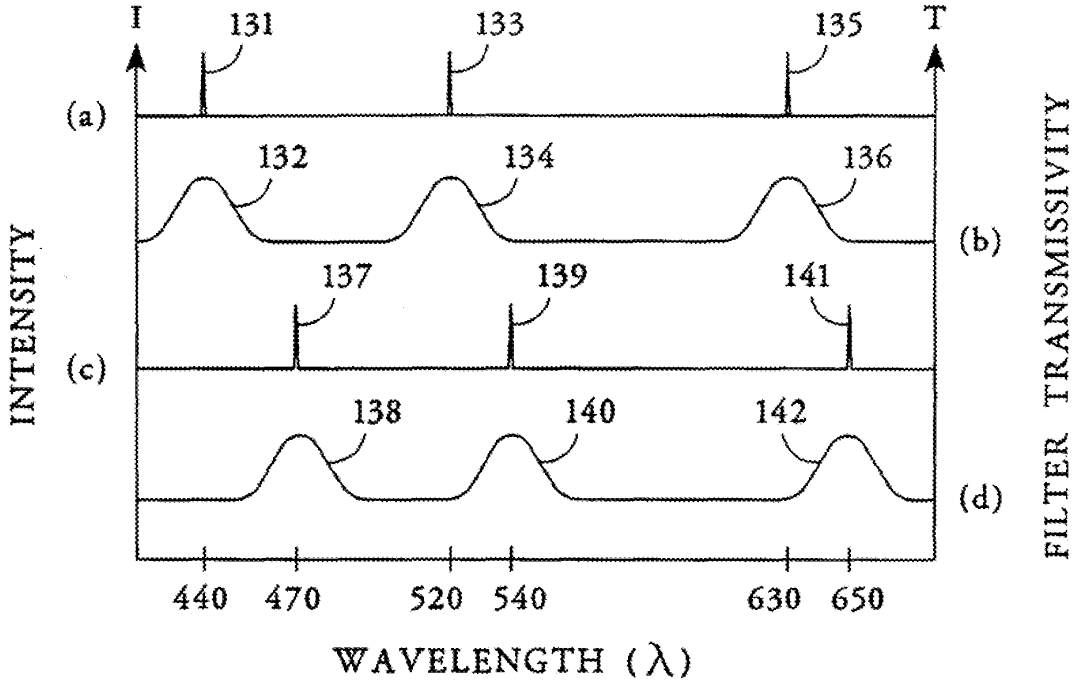


FIG. 7

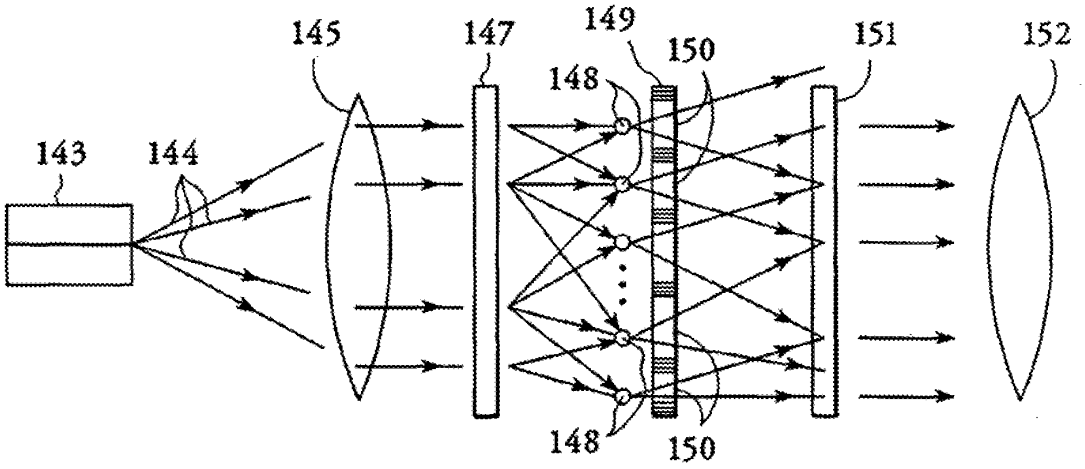


FIG. 8

Microsoft Exhibit 1002 - Page 1509
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

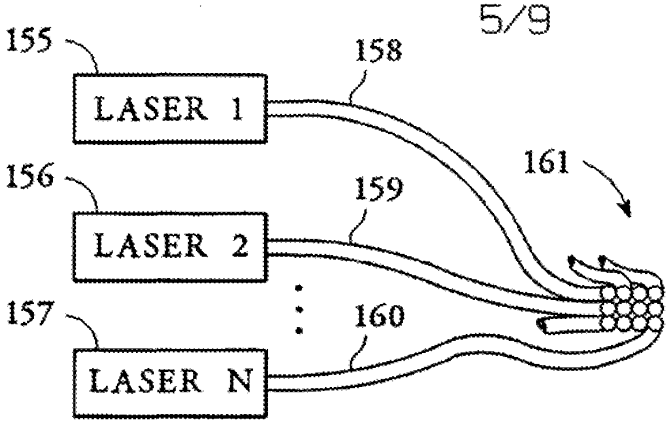


FIG. 9A

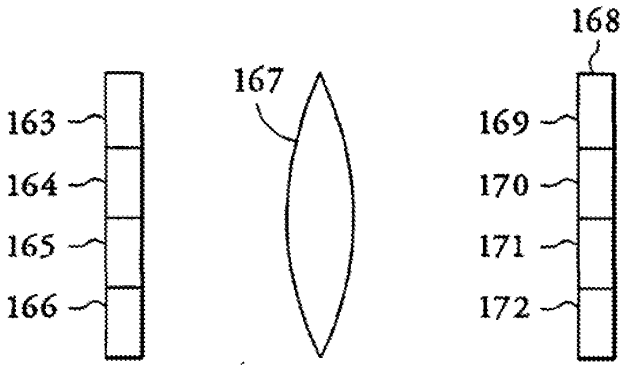


FIG. 9B

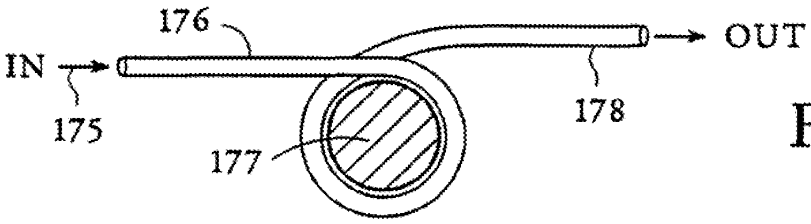


FIG. 10A

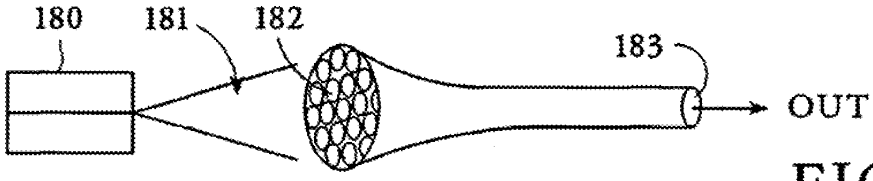


FIG. 10B

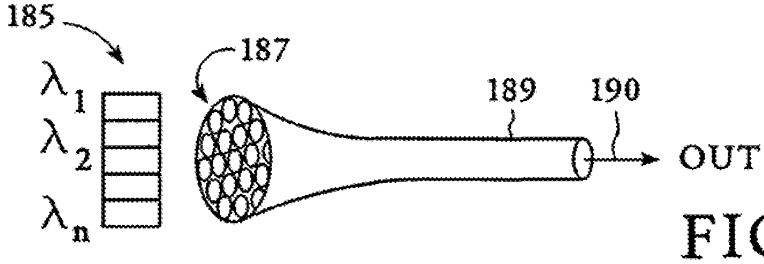


FIG. 10C

Microsoft Exhibit 1002 - Page 1510
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

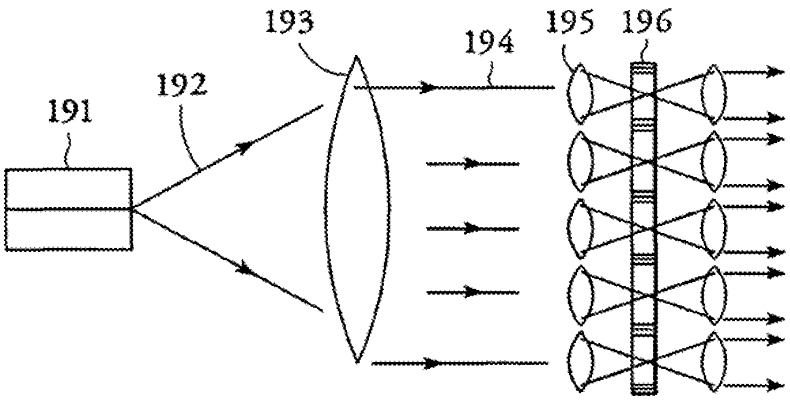


FIG. 11

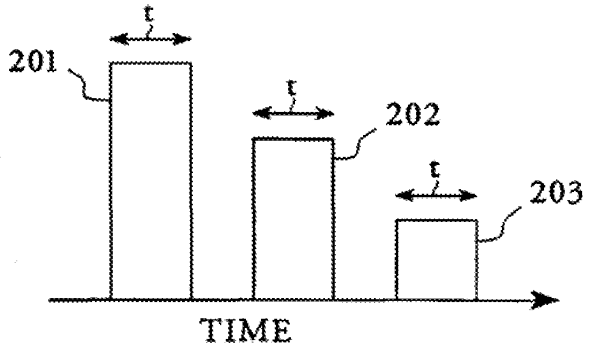


FIG. 12A

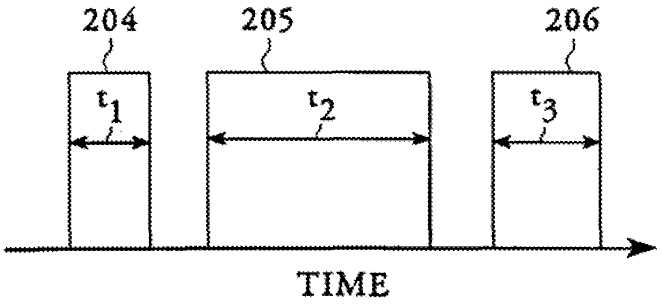


FIG. 12B

Microsoft Exhibit 1002 - Page 1511
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

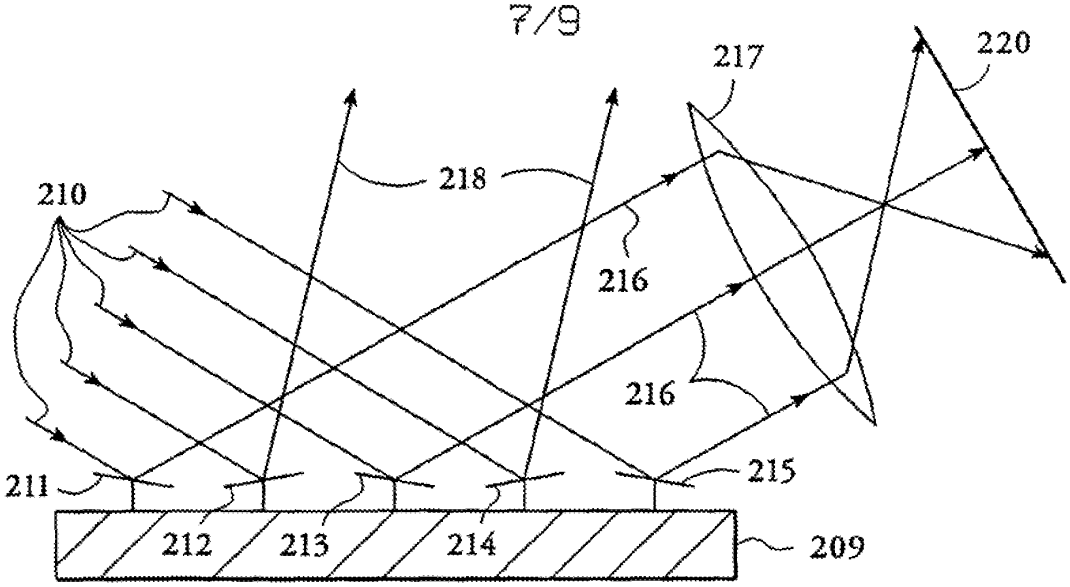


FIG. 13

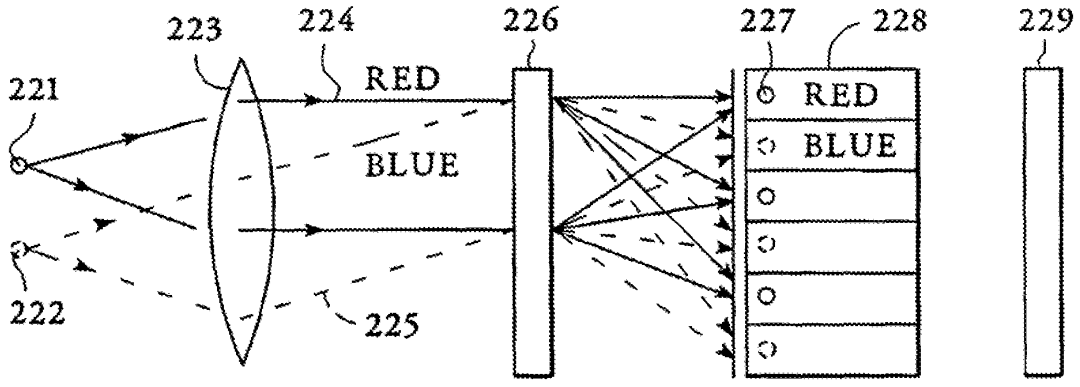


FIG. 14A

Microsoft Exhibit 1002 - Page 1512
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

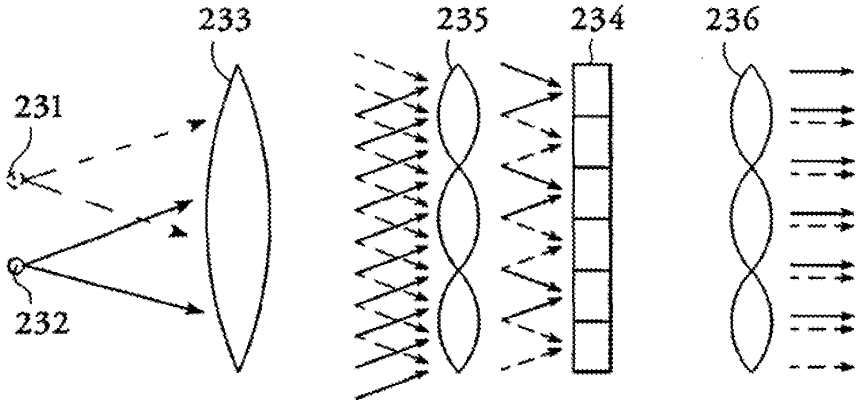


FIG. 14B

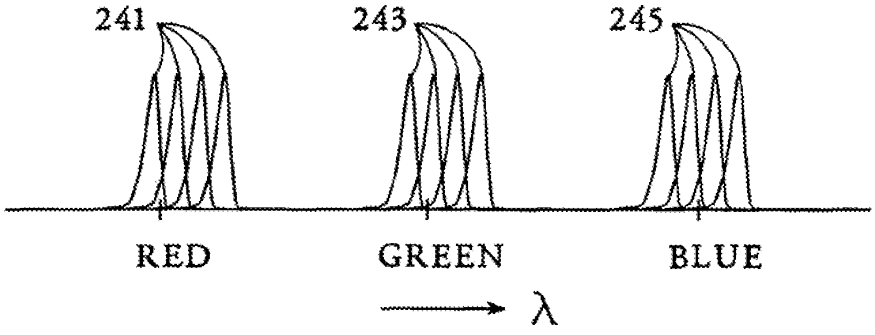


FIG. 15A

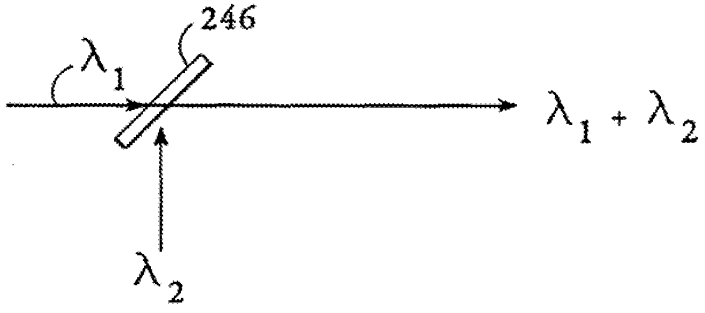


FIG. 15B

Microsoft Exhibit 1002 - Page 1513
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

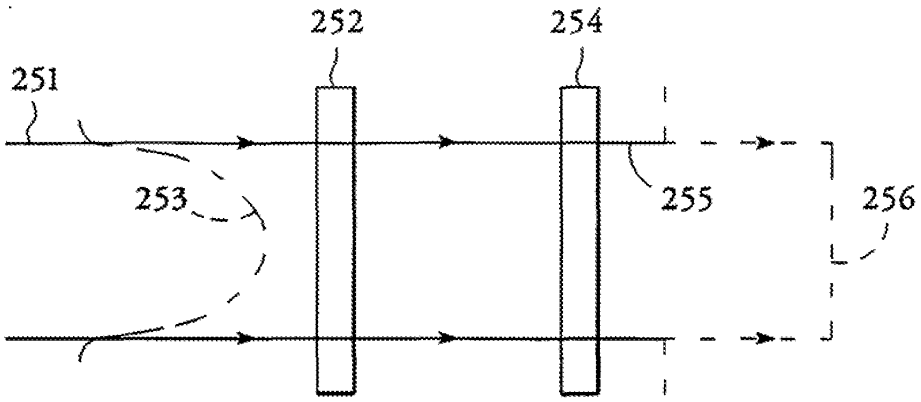


FIG. 16

Microsoft Exhibit 1002 - Page 1514
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/00581

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) : G09G 3/22, 3/28
US CL : 345/32, 87
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 345/32, 87; 349/758, 761

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 practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,978,202 (YANG) 18 December Col. 2, lines 23-54, Col. 4, lines 3-6, and Fig. 1.	1-15
Y	US, A, 4,978,952 (IRWIN) 18 December 1990 Col. 4, lines 20-49, Col. 5, lines 9-14, Col. 8, lines 6-10, Col. 12, lines 41-46, and Fig. 2.	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Microsoft Exhibit 1002 - Page 1515
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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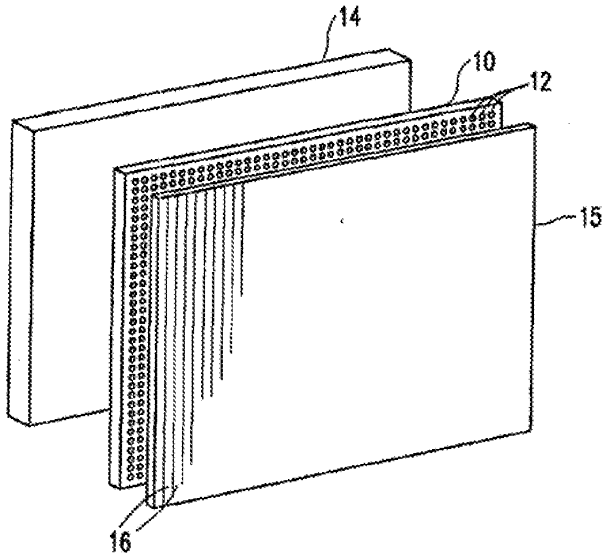
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Published
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(54) Title: AUTOSTEREOSCOPIC DISPLAY APPARATUS



(57) Abstract

An autostereoscopic display apparatus comprises a display device (10), for example a matrix LC display panel, for producing a display output consisting of rows and columns of pixels (12) and lenticular means (15) at the output side of the display device comprising an array of lenticular elements (16) through which different groups of pixels, forming one or more stereoscopic pairs, are seen by respective eyes of a viewer. The lenticular means includes electrooptic material (38) having an electrically-alterable refractive index and which can be selectively switched to remove the action of the lenticular elements thereby allowing high resolution 2-D images to be viewed.

Microsoft Exhibit 1002 - Page 1516
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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Microsoft Exhibit 1002 - Page 1517
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

DESCRIPTION

AUTOSTEREOSCOPIC DISPLAY APPARATUS

The present invention relates to an autostereoscopic display apparatus comprising an image display device for providing a display output composed of rows and columns of pixels and a lenticular means comprising an array of lenticular elements for directing the outputs from respective groups of pixels in mutually different directions so as to enable a stereoscopic image to be perceived.

Examples of such autostereoscopic display apparatus are described in the paper by C. van Berkel et al entitled "Multiview 3D - LCD" published in SPIE Proceedings Vol. 2653, 1996, pages 32 to 39 and in GB-A-2196166. In these examples the display device comprises a matrix LC (liquid crystal) display panel which has rows and columns of pixels (display elements) and which acts as a spatial light modulator to modulate light directed therethrough from a light source. The display panel can be of the kind used in other display applications, for example computer display screens for presenting display information in two dimensional form. A lenticular sheet, for example in the form of a molded or machined sheet of polymer material, overlies the output side of the display panel with its lenticular elements, comprising (semi) cylindrical lens elements, extending in the column direction with each lenticular element being associated with a respective group of two, or more, adjacent columns of display elements and extending parallel with the display element columns. In an arrangement in which each lenticule is associated with two columns of display elements, the display panel is driven to display a composite image comprising two 2D sub-images vertically interleaved, with alternate columns of display elements displaying the two images, and the display elements in each column providing a vertical slice of the respective 2D (sub) image. The lenticular sheet directs these two slices, and corresponding slices from the display element

Microsoft Exhibit 1002 - Page 1518
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

columns associated with the other lenticules, to the left and right eyes respectively of a viewer in front of the sheet so that, with the sub-images having appropriate binocular disparity, the viewer perceives a single stereoscopic image. In other, multi-view, arrangements, in which each lenticule is associated with a group of more than two adjacent display elements in the row direction and corresponding columns of display elements in each group are arranged appropriately to provide a vertical slice from a respective 2-D (sub-) image, then as a viewer's head moves a series of successive, different, stereoscopic views are perceived for creating, for example, a look-around impression. In view of the need for the lenticular elements to be accurately aligned with the display pixels, it is customary for the lenticular screen to be mounted over the display panel in a permanent manner so that the position of the lenticular elements is fixed in relation to the array of pixels.

Autostereoscopic display apparatus of this kind can be used for various applications, for example in medical imaging, virtual reality, games and CAD fields.

It is an object of the present invention to provide an improved autostereoscopic display apparatus which is capable of performing further display functions.

According to the present invention, there is provided an autostereoscopic display apparatus of the kind described in the opening paragraph which is characterised in that the lenticular means comprises electro-optic material whose refractive index is switchable by selective application of an electrical potential thereto between a first value whereby the light output directing action of the lenticular means is provided and a second value whereby the light output directing action is removed. By switching the electro-optic material, therefore, the lens action of the lenticular means can be cancelled. In effect, the lenticular means can be switched "on" and "off". In one setting, the "on" mode, the lenticular means is operable to perform a lens action in the usual manner to direct the light outputs from groups of pixels appropriately and enable a

Microsoft Exhibit 1002 - Page 1519
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

stereoscopic image to be perceived when suitable stereoscopic sub-images are displayed on the image display device. In the other setting, the "off" mode, this lens action is removed and the lenticular means behaves like a simple sheet of transparent material thereby allowing the same display information to be received by both eyes of a viewer as in the case of a conventional two-dimensional display. This enables high resolution two dimensional display information to be viewed utilising for the display the full available horizontal resolution of the display device, as determined by the pixel columns. Thus, the apparatus can be used for 3-D stereoscopic displays and conventional 2-D displays of higher resolution e.g twice that of the 3-D displays, merely by switching the lenticular means between these two modes. In the known autostereoscopic display apparatus it is not possible to present a full resolution 2-D display in view of the lens action of the lenticular sheet. Also, because the display device and the lenticular sheet are normally fixedly mounted together in view of the requirement for accurate alignment it is not convenient simply to remove the lenticular screen in order to display 2-D images. The invention thus offers the significant advantage of enabling the same display apparatus to be used for both high resolution 2-D and 3-D display purposes. When used as, for example, as computer display screen, a user can simply switch between the 3-D display mode for stereoscopic images and the increased resolution 2-D display mode for text processing or the like as and when required.

In a preferred embodiment of the invention, the lenticular means comprises a lenticular sheet, similar to those used in the known apparatus, whose one side has a profiled surface defined by lenticular elements therein over which the electro-optic material is arranged with the side of the electro-optic material remote from that surface being generally flat, the refractive index of the electro-optic material being switchable between a value which is substantially similar to that of the material of the lenticular sheet and a different value. Transparent electrodes, across which an electrical potential is applied to control the refractive index of the electro-optic material, are provided adjacent respectively the flat side and the profiled surface of the lenticular

Microsoft Exhibit 1002 - Page 1520
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

sheet. With the potential across these electrodes set such that the refractive index of the electro-optic material differs from that of the lenticular sheet, the required lens action is obtained from the lenticular elements. With the applied potential being such that the refractive index of the electro-optic material substantially matches that of the lenticular sheet the combination of the lenticular sheet and the adjacent electro-optic material behave optically as a single, transparent, body and the lensing action of the lenticular elements is then removed.

It is envisaged that alternative forms of lenticular means could be employed. For example, the lenticular means may comprise a sheet of transparent polymeric material within whose thickness cavities are provided defining the lenticular elements and which are filled with electro-optic material with the control electrodes extending over the opposing sides of the sheet.

The electro-optic material preferably comprises a liquid crystal, typically a nematic liquid crystal although any suitable electro-optic material capable of being switched to provide the different refractive indices required may be used. In the above preferred embodiment, the liquid crystal is contained by a substrate of transparent material, e.g glass or plastics, spaced from the profiled surface of the lenticular sheet with the liquid crystal filling the gap between profiled surface and the substrate.

The lenticular means may be arranged to be switched between the two modes as a whole. Alternatively, it may be arranged to be switched in part only, such that a higher resolution 2-D display is obtained for example from one half of the overall display area, or in discrete portions of its area which constitute individually switchable windows enabling 3-D and 2-D displays to be provided simultaneously. This can be achieved simply by providing separate electrodes whose areas define, for example, the windows to which the electrical potentials for switching can be applied individually and selectively.

Embodiments of autostereoscopic display apparatus in accordance with the invention will now be described, by way of example, with reference to the

Microsoft Exhibit 1002 - Page 1521
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

accompanying drawings, in which:-

Figure 1 is a schematic perspective view of the apparatus;

Figure 2 is a plan schematic view of part of the apparatus operating, for example, to provide four views;

Figure 3 is a schematic perspective view of a part of one embodiment of a lenticular means used in the apparatus;

Figure 4A and 4B illustrate the operation of the lenticular means in two different modes;

Figure 5 illustrates a modified form of the lenticular means; and

Figure 6 shows schematically in section a part of another embodiment of a lenticular means used in the apparatus.

It should be understood that the Figures are merely schematic and are not drawn to scale. In particular, certain dimensions may have been exaggerated whilst other have been reduced. The same reference numerals are used throughout the drawings to indicate the same or similar parts.

Referring to Figure 1, the apparatus comprises a matrix display device acting as a spatial light modulator and comprising an active matrix LC display panel 10 having a planar array of individually addressable,regularly-spaced and similarly-sized pixels (display elements) 12 arranged in aligned rows and columns perpendicularly to one another. The pixels are shown schematically with only a comparatively few in each row and column for simplicity. The display panel 10 is illuminated by a light source 14 which can be of any suitable kind and in this example comprises a planar back-light co-extensive with the area of the pixel array. Light incident on the panel is modulated by the individual pixels by the application of appropriate drive voltages thereto so as to produce the desired image display output.

Overlying the output side of the display panel 10, there is disposed a lenticular means 15 providing an array of elongate, parallel, lenticular elements 16. The lenticular elements 16 comprise optically cylindrically converging lenticules, for example formed as convex cylindrical lenses which extend

Microsoft Exhibit 1002 - Page 1522
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

parallel to the pixel columns and serve in known manner to provide separate images, which are generated in the pixel array of the panel 10 in a vertically interleaved fashion, to the two eyes of a viewer facing the side of the sheet 15 remote from the panel 10 so as to produce a stereoscopic display. Autostereoscopic display apparatus using lenticular sheets in conjunction with matrix display panels are well known and it is not thought necessary to describe here in detail their operation. Examples of such apparatus and their operation are described in the aforementioned papers by C. van Berkel et al and in GB-A-21296166 to which reference is invited. Each lenticular element 16 may overlie a respective group of two, three, or more, adjacent columns of pixels, to provide a corresponding number of views. Each lenticular element provides a spatially discrete output beam from each of the associated pixel columns in mutually different, angular directions. The display panel is driven so that a narrow vertical slice of a 2-D (sub) image is produced by each column of pixels with the display produced comprising a plurality of interleaved 2-D (sub) images which are to be seen by the left and right eye respectively of a viewer. Each lenticular element 16 thus provides a plurality of output beams, one from each of its associated columns of pixels, whose optical axes are in mutually different directions and angularly spread around the longitudinal axis of the lenticular element. With appropriate 2-D image information applied to respective columns of display elements then to a viewer whose eyes receive different ones of the beams a 3-D image is perceived. With each lenticular element being associated with several pixel columns then different stereoscopic images can be viewed as the viewer's head moves in the row direction.

Figure 2 illustrates, in plan view, the operation of the apparatus in producing, in this example, a four view display output, in which each lenticular element 16 overlies a respective group of four adjacent pixel columns such that four vertical strips, each representing a vertical slice of a respective 2-D view, are presented to the viewer. With appropriate 2-D image information applied to the pixels, and with the viewer's eyes being at a suitable distance to receive different ones of the output beams, a 3-D image is perceived. As the viewer's

Microsoft Exhibit 1002 - Page 1523
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

head moves in the row direction, three stereoscopic images can be viewed in succession. The numbers 1 to 4 denote the vertical slices of the corresponding views. The other lenticular elements provide similar slices. Thus, with the viewer's eyes situated as shown a stereoscopic image comprised of views 2 and 3 will be seen. By moving sideways the viewer will see two other stereoscopic images composed of views 1 and 2 and views 3 and 4. Of course, the number of views provided can be varied from just two views giving a single stereoscopic image to more than four views, for example seven views providing six stereoscopic images.

If, for example, a standard SVGA type LC display panel is used, having an array of 800 (row) by 600 (column) pixels (each comprising three different colour sub-pixels in the case of a colour display) then for a four view system providing three stereo pairs, at a fixed viewing distance, the resulting display would have a resolution of 200 in the horizontal, row, direction and 600 in the vertical, column, direction.

The lenticular means 15 of the apparatus is controllable such that the lens action of the lenticular elements 16 can in effect be switched on and off. In the "on" setting the lenticular means behaves as described above. In the "off" setting the lenticular means 15 behaves as if it were merely a simple sheet of transparent material. Thus, with the lenticular means in the off setting and with the pixels of the display panel being driven to present a 2-D image, this 2-D image is seen by both eyes of the viewer and by utilising all the available columns of pixels in the panel the viewer will see a 2-D image whose horizontal resolution (800) is considerably increased compared with that obtained for each stereo view. The ability to switch the lenticular means in this manner enables the display apparatus to be used not only to provide stereoscopic images but to provide also higher resolution 2-D images, as required for text display for example, when desired.

Figure 3 is a schematic perspective view of the lenticular means 15 used in this embodiment. The lenticular means comprises a lenticular sheet 30 of generally conventional kind and having an array of juxtaposed parallel lenticular

Microsoft Exhibit 1002 - Page 1524
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

elements 16 in the form of convex cylindrical lenses and molded (or machined) from optically transparent polymeric material. Alternatively, the lenticular elements may be formed using a photolithographic process in known manner. One side 31 of this sheet is flat while its other side 32 comprises a profiled (convex-ribbed) surface as determined by the contours of the lenticular elements. The profiled surface is covered by a thin layer 34 of transparent, electrically conductive material such as ITO which serves as an electrode. A transparent, flat-surfaced, plate 36 of glass or plastics material is arranged overlying and spaced from the lenticular sheet 30 and carries on its surface facing the sheet a thin, electrically conductive, and transparent layer 37, again for example of ITO, serving an opposing electrode. An electro-optic material 38 whose refractive index can be altered by the selective application of electrical potential thereacross is disposed between the sheet 30 and the plate 36. The space between the sheet 30 and the plate 36 is completely filled by this material so that the material 38 is contiguous with the profiled surface of the sheet 30. In this example, the electro-optic material 38 comprises a suitable liquid crystal material, generally a nematic liquid crystal, which is sandwiched between the sheet 30 and the plate 36, or more precisely the covering electrodes 34 and 37, in a manner analogous to that conventionally used in the manufacture of liquid crystal display devices with seals being provided around the periphery of the lenticular means to retain the material. As will be appreciated by persons skilled in the art of liquid crystal displays, appropriate orientation layers, are provided on one or both of the electrodes 34 and 37.

The lenticular means 15 thus consists of a lenticular sheet 30 and a contiguous LC cell, constituted by the parts 34,38,37,36 whose adjoining surfaces conform with one another.

The selective application of an electrical potential to the electrodes 34 and 37 is illustrated in simple manner in Figure 3 by a potential source 40 and switch 41.

Assuming, for example, that with no potential applied between the

Microsoft Exhibit 1002 - Page 1525
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

electrodes 34 and 37 the liquid crystal material 38 is oriented such that its refractive index, in the direction of view, differs from, and more particularly is lower than, that of the material used for the sheet 30 and that when a predetermined potential is applied to the electrodes the liquid crystal is oriented such that its refractive index in the direction of view is changed and substantially matches that of the sheet 30 then it will be appreciated that the lens action of the lenticular elements 16 will effectively be turned on and off. In the absence of an applied electrical potential the lenticular means 15 behaves much the same as would the lenticular sheet 30 by itself so that with the output side of the display panel 10 positioned closely adjacent the flat, outer, side 31 of the lenticular sheet 30, the lenticular means 15 operates in the manner of a conventional lenticular sheet to direct sub-image displays on the panel to different eyes of the viewer thereby enabling a stereoscopic image to be seen. With an electrical potential applied across the material 38 so that its refractive index in the viewing direction becomes substantially the same as that of the sheet 30, the lens action of the lenticular elements 16 is removed and the lenticular means 15 behaves like a light transmissive plate overlying the display panel with the path of the light output from the display panel 10 being substantially unaffected. In this case a 2-D image displayed in the display panel will be seen by a viewer as a 2-D image with a resolution as determined by the display panel (e.g 800 by 600) and as if the lenticular means 15 were not present.

The two operational modes are illustrated schematically in Figures 4A and 4B respectively which show in plan view a part of the combination display panel 10 and lenticular means 15 and example light paths for a typical lenticular element 16 and its associated four columns of pixels 12, A to D. Figure 4A illustrates the "on" mode in which light from each of the four columns of pixels (A to D) associated with the lenticular element, whose paths are indicated by the solid lines, dotted lines, dashed lines and dot-dashed lines respectively, is directed in mutually different directions towards a viewer's eyes by virtue of the lens action of the lenticular element so that a viewer sees a

Microsoft Exhibit 1002 - Page 1526
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

different pixel column in each eye. The lens action of the lenticular element 16 forms an image of the pixel columns A to D close to the eye positions. Figure 4B illustrates the "off" mode in which the separating lens action is removed and the viewer sees all four pixel columns A to D with each eye.

The electrodes 34 and 37 may extend completely over the areas of the sheet 30 and the plate 36 respectively so that the lenticular means 15 switches between its two operations modes as a whole. If desired, the electrodes 34 and 37 may extend, in registration, over a part only of the total area of the lenticular array so that a portion only of the lenticular means, corresponding to the area of the overlapping electrodes, is switchable so as to enable, for example, a 2-D text image to be displayed in a dedicated part of the display area alongside a 3-D image simultaneously. Alternatively, each electrode may comprise a plurality of discrete area electrodes, respective pairs of such discrete electrodes on the sheet 30 and the plate 36 being in registration with one another, with each respective pair being individually addressable to apply selectively thereto an electrical potential to change the refractive index of the LC material over the area defined by the electrode pair independently of the areas defined by the other electrode pairs. Thus, discrete areas of the lenticular means may be switched either alone or in combination to provide in effect one or more windows in a 3-D display in which 2-D text images for example are displayed, or vice versa one or more windows in a 2-D image in which a 3-D display is produced.

By way of example, and with reference to Figure 5 which shows schematically a frontal view of the lenticular means 15, the electrodes 34 and 37 may be divided to define four equal quadrants 50A-50D, together covering the area of the lenticular array, which are each switchable independently. The individual regions can be switched either above or in combination. By switching all four quadrants together, an effect analogous to that using electrodes which cover completely the sheet 30 and the plate 36 is achieved.

With regard to the embodiment of Figure 3, it will be appreciated that the lenticular means 15 could be arranged inverted such that the LC layer 38 rather

Microsoft Exhibit 1002 - Page 1527
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

than the sheet 30 is adjacent the LC display panel and so that the flat outer surface of the sheet 30 becomes the output side of the lenticular means rather than the plate 36. In this case, the plate 36 may comprise a transparent substrate of the LC display panel.

It will also be appreciated the profile of the adjoining surfaces of the sheet 30 and the LC layer 38 could be opposite to that shown. The surface of the lenticular sheet may instead be formed with a concave ribbed profile, as illustrated in Figure 6 which shows schematically a cross-section through another embodiment of the lenticular means 15. The sheet 30 thus provides an array of elongate, parallel, optically cylindrically diverging lenticular elements formed as concave cylindrical lenses. In this case the LC material is such that its refractive index is switchable between a value which is higher than that of the material of the sheet 30, so that the necessary lens action required for stereoscopic display is achieved, and a value which substantially matches that of the sheet 30 so that the lens action is cancelled enabling 2-D images displayed on the display panel to be viewed in full resolution.

Of course, the number of pixel columns associated with each lenticular element can be varied so as to provide more, or less, stereoscopic pairs.

While in the above described embodiments a lenticular sheet having an array of elongate, cylindrical, lenticular elements has been used, it will be understood that the lenticular sheet could instead comprise an array of spherical microlens elements instead, such spherical lens elements lenticular sheets already being known in the field of autostereoscopic display apparatus.

Also, the lenticular elements need not extent parallel to the pixel columns but could instead be slightly slanted with respect to the pixel columns, as described in EP-A-0 791847.

In summary, therefore, an autostereoscopic display apparatus has been disclosed which comprises a display device for example a matrix LC display panel, for producing a display output consisting of rows and columns of pixels and lenticular means at the output side of the display device comprising an array of lenticular elements through which different groups of pixels, forming

Microsoft Exhibit 1002 - Page 1528
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

one or more stereoscopic pairs, are seen by respective eyes of a viewer, and in which the lenticular means includes electro-optic material having an electrically - alterable refractive index and which can be selectively switched to remove the action of the lenticular elements thereby allowing high resolution 2-D images to be viewed.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the field of autostereoscopic display apparatus and component parts thereof and which may be used instead of or in addition to features already described herein.

Microsoft Exhibit 1002 - Page 1529
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

CLAIMS

1. An autostereoscopic display apparatus comprising an image display device for providing a display output composed of pixels in a row and column array and lenticular means comprising an array of lenticular elements for directing the outputs from respective groups of pixels in mutually different directions so as to enable a stereoscopic image to be perceived, characterised in that the lenticular means comprises electro-optic material whose refractive index is switchable by selective application of an electrical potential thereto between a first value whereby the light output directing action of the lenticular means is provided and a second value whereby the light output directing action is removed.

2. An autostereoscopic display apparatus according to Claim 1, characterised in that the lenticular means comprises a lenticular sheet having a profiled surface defined by the array of lenticular elements and the electro-optic material overlies said surface, the side of the electro-optic material remote from that surface being generally flat and the refractive index of the electro-optic material being switchable between a value which is substantially similar to that of the material of the lenticular sheet and a different value.

3. An autostereoscopic display apparatus according to Claim 2, characterised in that the electro-optic material comprises a liquid crystal material.

4. An autostereoscopic display apparatus according to Claim 3, characterised in that a transparent plate is arranged spaced from the profiled surface of the lenticular sheet with the liquid crystal material disposed therebetween.

5. An autostereoscopic display apparatus according to Claim 4,

Microsoft Exhibit 1002 - Page 1530
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

characterised in that the transparent plate comprises a substrate of the image display device.

6. An autostereoscopic display apparatus according to any one of the preceding claims, characterised in that the lenticular means is divided into a plurality of separate regions each of which is individually switchable.

7. An autostereoscopic display apparatus according to any one of the preceding claims, characterised in that the image display device comprises a liquid crystal display device.

Microsoft Exhibit 1002 - Page 1531
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

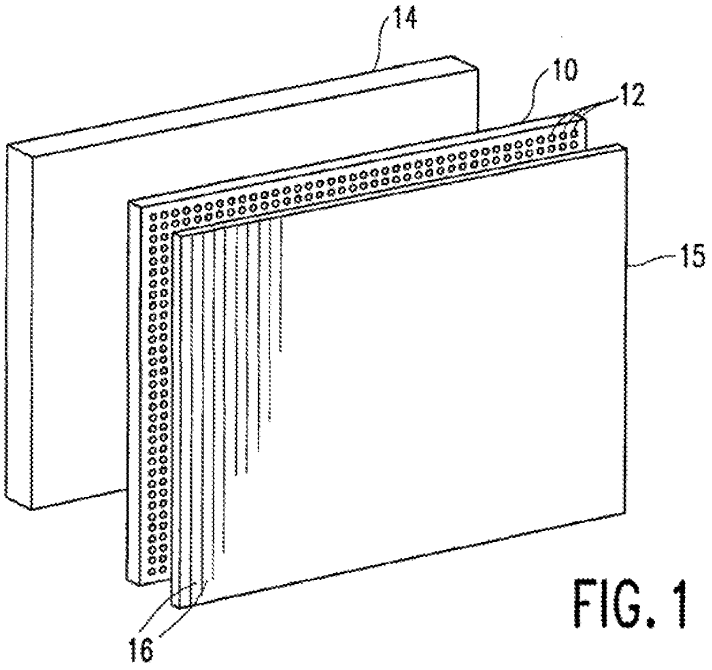


FIG. 1

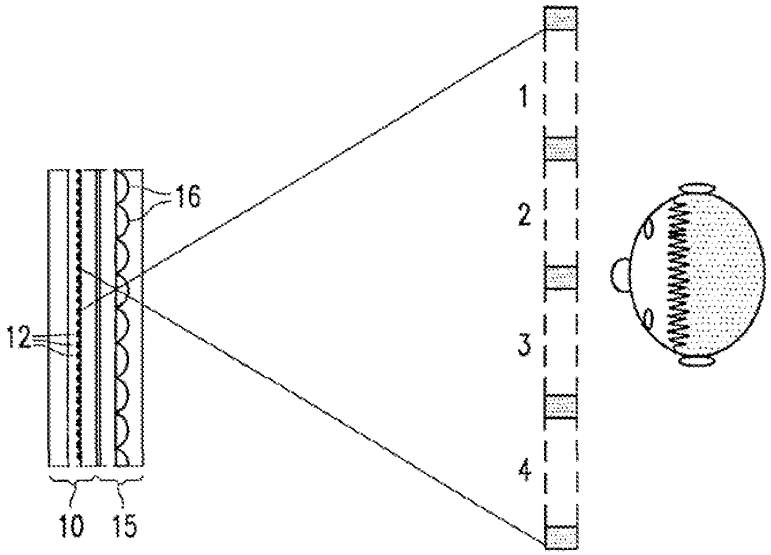


FIG. 2

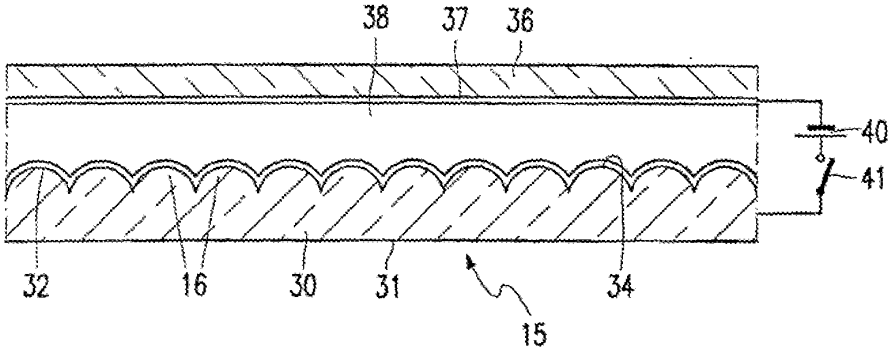


FIG. 3

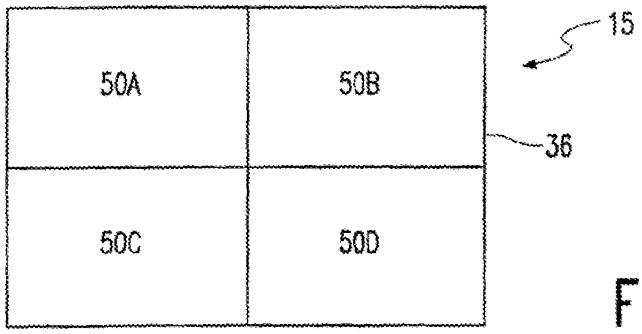


FIG. 5

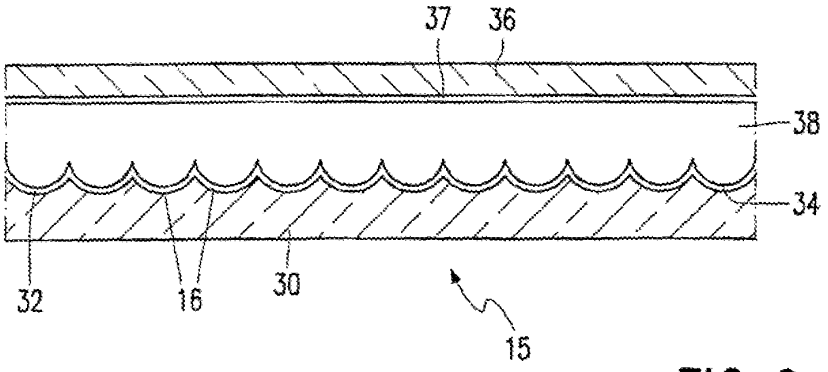


FIG. 6

Microsoft Exhibit 1002 - Page 1533
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

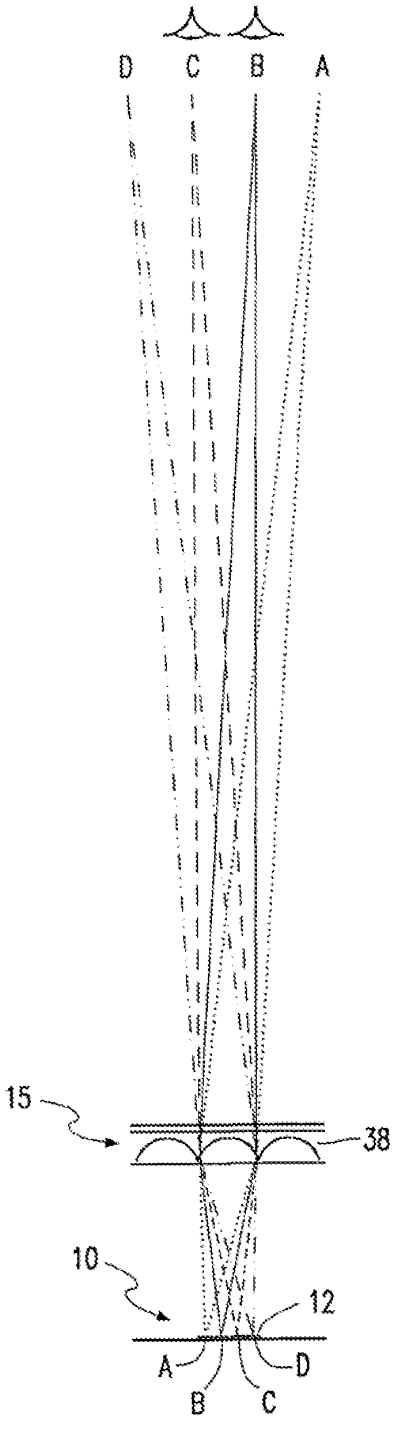


FIG. 4A

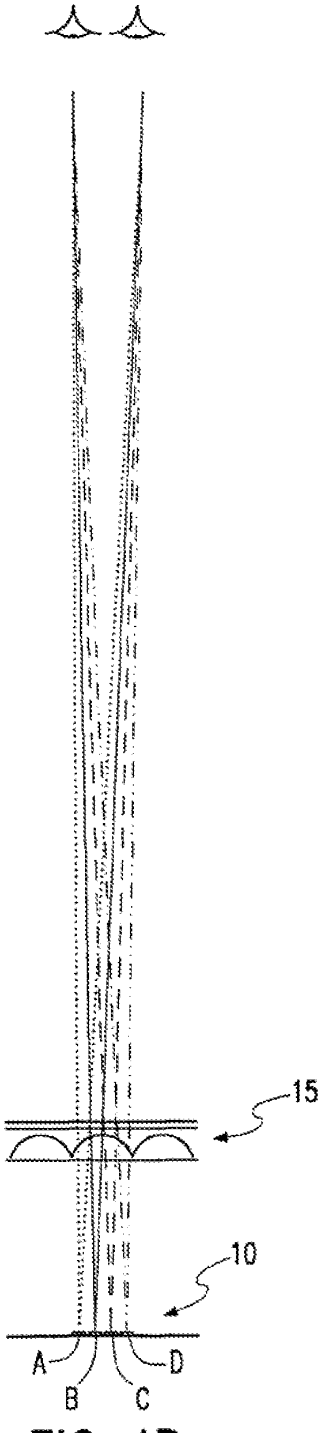


FIG. 4B

Microsoft Exhibit 1002 - Page 1534
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/01269

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G02B 27/22
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)

IPC6: G02B

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPOQUE: EPODOC, WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0721130 A2 (SHARP KABUSHIKI KAISHA), 10 July 1996 (10.07.96), figures 6A, 6B,10,11 --	1-7
A	US 5500765 A (JESSE B. EICHENLAUB), 19 March 1996 (19.03.96) --	1-7
A	US 5036385 A (JESSE B. EICHENLAUB), 30 June 1991 (30.06.91) --	1-7
A	GB 2196166 A (MARTIN LAWRENCE BASS), 20 April 1988 (20.04.88) --	1-7

☐ Further documents are listed in the continuation of Box C. ☒ 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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"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
2 March 1998	02 -03- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Bertil Dahl Telephone No. + 46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

Microsoft Exhibit 1002 - Page 1535
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/02/98

International application No.
PCT/IB 97/01269

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Microsoft Exhibit 1002 - Page 1536
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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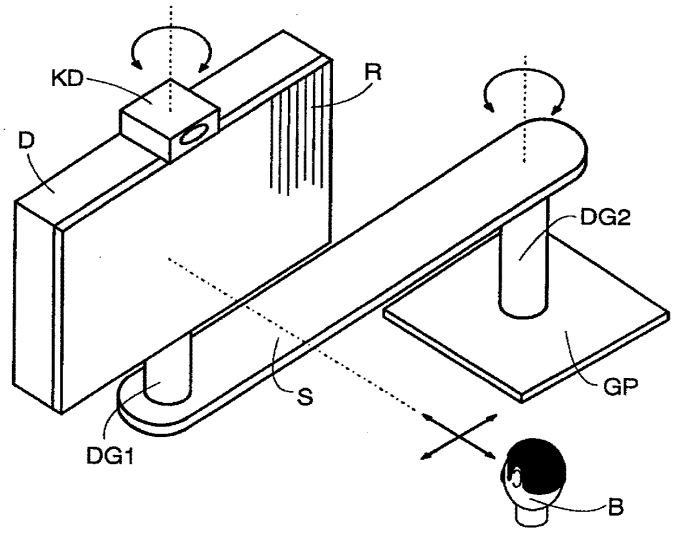
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(54) Title: DEVICE FOR AUTOMATICALLY ADJUSTING AN AUTOSTEREOSCOPIC FLAT SCREEN

(54) Bezeichnung: VORRICHTUNG ZUM NACHFÜHREN EINES AUTOSTEREOSKOPISCHEN FLACHBILDSCHIRMS

(57) Abstract

The invention concerns a device comprising a detection system, defining the position of the observer's head relative to the flat screen plane, and a regulator, processing the measured data and transmitting these control/drive data to a least a drive device adjusting automatically the flat screen according to the movements of the head. In said device, the flat screen (FB) is in the form of a unit consisting of a matrix of lenses (R) with extremely small inter–lens spacing of a lens structure with optimal correction and a flat display (D), and the drive device for automatically adjusting which executes translation and/or rotation movements and automatically adjusts the flat screen (FB) when the observer (B) moves his head, such that the observation distance and the observation angle remain constant. Said device enables automatic adjustment, lateral as well as frontal, of an autostereoscopic flat screen, according to the observer's movements.



(57) Zusammenfassung

In einer Vorrichtung mit einem Detektionssystem, das die Kopfposition des Betrachters in Bezug auf die Flachbildschirmebene bestimmt, und einem Regler, der die gemessenen Daten verarbeitet und diese Steuer–/Antriebsdaten auf mindestens einen Antrieb überträgt, der den Flachbildschirm den Kopfbewegungen des Betrachters nachführt, ist der Flachbildschirm (FB) als Einheit aus einem Linsenraster (R) mit extrem kleinen Linsenpitches von optimal korrigierter Linsenstruktur und einem Flachdisplay (D) gebildet und besteht der Antrieb zum Nachführen des Flachbildschirms aus einem mehrstufigen Gelenkgetriebe, das translatorische und/oder rotatorische Bewegungen ausführt und den Flachbildschirm (FB) bei einer Kopfbewegung des Betrachters (B) in konstanter Betrachtungsentfernung und konstantem Betrachtungswinkel nachführt. Die Vorrichtung ermöglicht sowohl ein laterales als auch ein frontales Nachführen eines autostereoskopischen Flachbildschirms bezüglich der Bewegung des Betrachters.

Microsoft Exhibit 1002 - Page 1537
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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Microsoft Exhibit 1002 - Page 1538
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Bezeichnung

Vorrichtung zum Nachführen eines autostereoskopischen Flachbildschirms

Beschreibung

Die Erfindung betrifft eine Vorrichtung zum Nachführen eines autostereoskopischen Flachbildschirms, bestehend aus einem Detektionssystem, das die Kopfposition des Betrachters in Bezug auf die Flachbildschirmebene bestimmt, einem Regler, der die gemessenen Daten verarbeitet und diese Steuer-/Antriebsdaten auf mindestens einen Antrieb überträgt, der den Flachbildschirm den Kopfbewegungen des Betrachters nachführt.

Bei der autostereoskopischen Bildwiedergabe ist die Betrachtung von typischerweise gerasterten und zusammengefügten oder von den Bildschirmen selbst zerrasterten Stereobildern mit Linsen- oder Streifenraster-Bildschirm nur in kleinen Betrachtungszonen möglich. Diese Zonen sind trapezoid in horizontaler Ausrichtung. Befindet sich der Betrachter außerhalb dieser Zonen, treten Bildstörungen auf, da die notwendige Bildtrennung der Stereoteilbilder für das rechte und das linke Auge verlorengeht.

Um die Bereiche für den Betrachter zu erweitern, in denen eine Bildtrennung der linken und der rechten Stereoteilbilder gewährleistet ist, sind Trackingverfahren vorgeschlagen worden, bei denen beispielsweise Projektorpaare oder die dem Zuschauer zugewandte Rasterscheibe der Bewegung des Betrachters nachgeführt werden. Wird hierbei als Flachbildschirm ein LCD verwendet, wird der laterale Trackbereich beim Linsenraster-Tracking dadurch eingegrenzt, daß sich die optischen Abbildungen der Linsen des Rasters bei frontaler und lateraler Bewegung verschlechtern. Das „Matching" (die optisch-geometrische Zuordnung) der Pixel- und Linsenraster ist bei feinen Strukturen sehr problematisch. Auch die Ausbildung eines 3D-Monitors auf der Grundlage von Flachdisplays mit

Microsoft Exhibit 1002 - Page 1539
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

getracktem Linsenraster ist bekannt. Das mit den erwähnten Lösungen realisierte laterale Tracking erlaubt weiträumige Betrachterbewegungen. Nur die letztgenannte Lösung, die Ausbildung eines 3D-Monitors aus Flachdisplay mit getracktem Linsenraster, ermöglicht auch ein frontales Tracking, das durch die Veränderung der Gegenstandsweite des Linsenrasters erreicht wird. Die hiermit einhergehende Änderung der Bildweite begrenzt jedoch den frontalen Trackbereich, denn durch unscharfe Abbildung der Pixel am Betrachterort entsteht Übersprechen. Außerdem begrenzt die rückseitige Schnittweite des Linsenrasters das Tracking im Nahbereich, aber auch der Luftspalt selbst, wenn sein Wert 0 ist und die Display-Scheibe z.B. recht dick ist.

Wie beim natürlichen Sehen sollen bei Bewegungen eines Betrachters vor dem 3D-Monitor wechselnde Ansichten sichtbar werden. Nur dann können statisch wiedergegebene Objekte bei Betrachterbewegungen unverzerrt wiedergegeben werden. Stehen viele perspektivische Ansichten zur Verfügung, könnte man auch seitliche Ansichten der Objekte erhalten. Steht jedoch nur eine perspektivische Stereoansicht zur Verfügung oder sollen bei statischer Betrachterposition die gedrehten Ansichten durch Aufruf dargestellt werden, so treten bei Kopfbewegungen windschiefe Objektverzeichnungen auf. Diese können nur vermieden werden, wenn der Bildschirm nachgeführt wird.

Eine Vorrichtung, mit der ein kleiner Flachbildschirm der Bewegung des Betrachters nachgeführt wird, ist in SPIE, Vol. 2409, 1995, Seiten 6 bis 9 beschrieben. Diese Vorrichtung weist ein Infrarot-Kopf-Detektionssystem auf, das die Kopfposition des Betrachters lateral zum Bildschirm bestimmt. Zunächst wurde das Linsenraster bezüglich des LCD-Schirms mittels eines piezo-elektrischen Stellgliedes oder eines Miniatur-Schrittmotors um ± 2 mm verstellt. Damit konnte der Betrachter eine Position in eine zweite verändern. Wesentlich günstiger erwies sich eine andere Lösung, nämlich nunmehr den gesamten Flachbildschirm, d.h. Linsenraster und LCD-Flachdisplay, mittels eines Schrittmotors zu drehen, so daß ein größerer Bereich gebildet wird, in dem der Betrachter, der sich üblicherweise während einer Video-Telefon-Übertragung nicht weiter als ± 250 mm von seiner Ausgangsposition und nicht schneller als 1,35 m/s bewegt, ein korrektes Bild wahrnehmen kann. Die zuletzt genannte Vorrichtung zur Drehung des gesamten Monitors erlaubt nur

Microsoft Exhibit 1002 - Page 1540
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

ein laterales Nachführen, wodurch der Bewegungsspielraum des Betrachters bezüglich des Abstandes doch wieder sehr eingeschränkt ist.

Deshalb ist es Aufgabe der Erfindung, eine Vorrichtung anzugeben, die sowohl ein laterales als auch ein frontales Nachführen eines autostereoskopischen Flachbildschirms bezüglich der Bewegung des Betrachters ermöglicht und damit einen größeren Betrachtungsbereich erlaubt. Außerdem soll die Vorrichtung in diesem größeren Betrachtungsbereich die beschriebenen Bildstörungen vermeiden.

Erfindungsgemäß wird die Aufgabe durch eine Vorrichtung der eingangs genannten Art dadurch gelöst, daß der Flachbildschirm als Einheit aus einem Linsenraster mit extrem kleinen Linsenpitches von optimal korrigierter Linsenstruktur und einem Flachdisplay gebildet ist und der Antrieb zum Nachführen des Flachbildschirms ein mehrstufiges Gelenkgetriebe ist, das translatorische und/oder rotatorische Bewegungen ausführt und den Flachbildschirm bei einer Kopfbewegung des Betrachters in konstanter Betrachtungsentfernung und konstantem Betrachtungswinkel nachführt.

Die erfindungsgemäße Vorrichtung gewährleistet durch das definierte Nachführen des Bildschirms bei Beibehaltung eines konstanten Abstands und unter konstanter Ausrichtung einen Einblick in den Bildschirm immer senkrecht zur Bildschirmebene, d.h. stets aus zentraler Position, wodurch Bildstörungen vermieden werden. Aufgrund dieser zentralen Position des Betrachters bezüglich des Bildschirms, die durch das Nachführen des Bildschirms garantiert ist, kann eine optimal an eine hohe Bildauflösung angepaßte Linsenstruktur gewählt werden.

Ein derartig nachgeführter Stereo-Monitor ist für spezielle Anwendungen, z.B. wenn nur eine bestimmte Stereoansicht präzise interpretiert werden soll, besonders attraktiv, wobei zusätzlich - wie bereits erwähnt - wegen des konstanten Betrachtungsabstandes die Bildauflösung immer optimal bleibt. Dieser nachgeführte 3D-Stereo-Monitor mit höchster Auflösung und korrekter Perspektive ist für verschiedene Einsatzgebiete, wie z.B. in Simulatoren (Maschine, Fluggerät, Schiff, Fahrzeug), in Leitwarten (Flugsicherung, Fabrikationsüberwachung), in der Kommunikation (Multimedia, Bildtelefon, Landkarten, Luftbild), in der Medizin (Mikrochirurgie, Röntgen, Ultraschall,

Microsoft Exhibit 1002 - Page 1541
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Tomographie), in der Werbung (Schaukasten, Diorama, Werbefläche) und für Arbeitsplatz-Computer (Laptop, Navigation, CAD/CAM, Flugüberwachung, Video Conferencing) sowie für Game Machines in Spielhallen und als Handgerät geeignet.

Ausgestaltungen der Erfindung betreffen zunächst die Ausführungen der Gelenkglieder.

Zwei rotatorische Bewegungen in einer horizontalen Ebene zum Nachführen des Flachbildschirms unter Beibehaltung des Abstandes und der Ausrichtung des Betrachters zum Schirm, damit sich der Betrachter immer in der Betrachtungszone befindet, sind durch Gelenkglieder, die einen eingliedrigen horizontalen Schwenkarm mit zwei Drehgelenken aufweisen, wobei ein Drehgelenk den horizontalen Schwenkarm mit dem Flachbildschirm und das andere Drehgelenk eine um 180° bezüglich des Flachbildschirms versetzt angeordnete Grundplatte mit dem horizontalen Schwenkarm drehbar verbindet, realisiert.

Für drei rotatorische Bewegungen in einer horizontalen Ebene zum Nachführen des Flachbildschirms sind die Gelenkglieder als zweigliedriger horizontaler Schwenkarm mit drei Drehgelenken ausgebildet, wobei die beiden äußeren die - wie bei dem eingliedrigen Schwenkarm - bereits beschriebenen Bewegungen ausführen und das mittlere Drehgelenk die beiden Glieder des horizontalen Schwenkarms drehbar miteinander verbindet.

Die folgende Ausführungsform gestattet drei Drehbewegungen in zwei zueinander senkrechten Ebenen. Auch mit dieser Ausführungsform, bei der das Getriebegelenk als Gelenkglieder ein Paar vertikaler, eingliedriger, parallel zueinander angeordneter Schwenkarme aufweist, wobei je ein Ende der beiden Schwenkarme mit je einer Seitenfläche des Flachbildschirms drehbar verbunden ist und das jeweils andere der Enden des Paares vertikaler Schwenkarme mit einer drehbar ausgebildeten, horizontal angeordneten, scheibenförmigen Grundplatte drehbar verbunden ist. Diese „Aufhängung" des Flachbildschirms zwischen die vertikalen Schwenkarme garantiert immer eine senkrechte Anordnung des Schirms. Diese

Microsoft Exhibit 1002 - Page 1542
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Ausführungsform der Erfindung kann auf einem Tisch „stehend" oder an der Decke „hängend" betrieben werde.

In einer anderen Ausgestaltung ist auf einer als Schubgelenk ausgebildeten horizontal angeordneten Schiene der Flachbildschirm drehbar angeordnet. Damit ist es möglich, mit dem Schirm eine translatorische und eine rotatorische Bewegung in der horizontalen Ebene zu realisieren.

Mit der folgenden Ausführungsform wird im Vergleich zu der zuvor beschriebenen eine weitere translatorische Bewegung, die senkrecht zu der ersten verläuft, realisiert. Hierbei weist das Gelenkgetriebe als Gelenkglieder ein Paar als Schubgelenk horizontal und parallel zueinander angeordneter Schienen auf, senkrecht zu diesem Paar Schienen ist eine als Schubgelenk ausgebildete Einzelschiene ausgebildet, in der der Flachbildschirm drehbar angeordnet ist. Damit kann der Flachbildschirm in der horizontalen Ebene zwei translatorische - ähnlich einem x-y-Tisch - und eine rotatorische Bewegung ausführen.

Da jede der genannten Ausführungsformen der Erfindung das Nachführen des Flachbildschirms unter Beibehaltung eines konstanten Abstands und einer konstanten Ausrichtung des Betrachters zum Flachbildschirm garantiert, wird mit der erfindungsgemäßen Vorrichtung der mögliche Bereich, in dem sich der Betrachter bewegen kann, durch Nachführen der trapezoidförmigen Betrachtungszone, in der die erforderliche Bildtrennung der Stereoteilbilder für das rechte und das linke Auge gewährleistet ist, vergrößert.

Andere Ausführungsformen beziehen sich auf das Flachdisplay und die Anordnung des Linsenrasters. So ist vorgesehen, daß das Flachdisplay ein Flüssigkristall-, Elektrolumineszenz- oder Plasmadisplay ist. Das Linsenraster kann direkt auf dem Flachdisplay oder mit der strukturierten Fläche zum Flachdisplay hin bzw. zum Betrachter hin angeordnet sein.

In einer weiteren Ausgestaltung der Erfindung führt das mehrstufige Gelenkgetriebe den Flachbildschirm bei Bewegung des Betrachters in konstantem Betrachtungsabstand nach und das Linsenraster ist derart ausgebildet ist, daß es zusätzlich bei seitlicher Bewegung parallel (lateral)

Microsoft Exhibit 1002 - Page 1543
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

zum Flachdisplay verfahren wird. Mit dieser Ausgestaltung wird eine Kombination aus Display- und Rasterplatten-Tracking realisiert.

Weitere Einzelheiten der Erfindung und ihrer vorteilhaften Ausführungsformen werden im Zusammenhang mit der folgenden Beschreibung der Figuren näher erläutert.

Dabei zeigen:

Fig. 1 eine schematische Ansicht eines Flachbilddisplays mit Linsenraster, angeordnet auf einem eingliedrigen horizontalen Schwenkarm mit zwei Drehgelenken;

Fig. 2 schematisch die erforderlichen Bewegungsabläufe der Vorrichtung gemäß Fig. 1;

Fig. 3 schematisch den in Abhängigkeit der Stellung des Flachbildschirms entstehenden möglichen Bewegungsbereich des Betrachters, in dem die trapezoidförmige Betrachtungszone gemäß Fig. 1 nachgeführt ist;

Fig. 4 schematisch die möglichen Bewegungsabläufe eines Flachbildschirms, angeordnet auf einem zweigliedrigen horizontalen Schwenkarm mit drei Drehgelenken;

Fig. 5 schematisch eine Ausführungsform, bei der der Flachbildschirm zwischen einem Paar vertikaler, eingliedriger, paralleler Schwenkarme, die mit einer drehbaren horizontalen Basisplatte verbunden sind, drehbar angeordnet ist;

Fig. 6 schematisch den frontalen Schwenkbereich des gemäß Fig. 5 angeordneten Flachbildschirms in Seitenansicht;

Fig. 7 schematisch die möglichen Bewegungsabläufe eines Flachbildschirms, drehbar angeordnet auf einer horizontalen Schiene;

Microsoft Exhibit 1002 - Page 1544
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Fig. 8 schematisch die möglichen Bewegungsabläufe eines Flachbildschirms, drehbar angeordnet auf senkrecht zueinander befindlichen horizontalen Schienen.

Der in Fig. 1 schematisch auf einem horizontal angeordneten Schwenkarm dargestellte Flachbildschirm ist ein Flüssigkristalldisplay **D** mit feinem Linsenraster **R** in Querformat (3 : 4) mit einer Bildschirmdiagonale von z.B. 330 mm (13 inches) und einer Auflösung von z.B. 1024 x 768. Das Kopfdetektionssystem **KD** erfaßt ständig die Kopfposition des Betrachters **B**. Diese Daten werden in einem - hier nicht dargestellten - Regler derart verarbeitet, daß die Sollposition des Flachbildschirms **FB** eingestellt wird, bei der immer garantiert ist, daß der Betrachter sich in dem Bereich befindet, in dem die durch den Linsenrasterbildschirm örtlich getrennten Bildstrahlen der linken und rechten Stereoteilbilder zur Bildtrennung die Pupillen der Augen treffen werden. Der Bildschirm ist in diesem sowie in den folgenden Ausführungsformen gemäß der Erfindung auf Mitteln zum Nachführen angeordnet, so daß dieser lateral und frontal korrespondierend mit den Bewegungen des Kopfes verfahren wird unter Beibehaltung der erwähnten Bedingung, getrennte Stereoteilbilder zu erzeugen und deren Bildstrahlen nachzuführen.

Der in Fig. 1 dargestellte, eingliedrig horizontale Schwenkarm **S** mit zwei Drehgelenken **DG1, DG2** ermöglicht das Nachführen des Flachbildschirmes **FB**; gebildet aus Flüssigkistalldisplay **D** und Linsenraster **R**, durch zwei rotatorische Bewegungen.

In Fig. 2 sind die möglichen Nachführpositionen des Flachbildschirms **FB** dargestellt, wenn sich der Betrachter **B** in dem ebenfalls eingezeichneten Bereich bewegt. Der Flachbildschirm **FB** befindet sich auf einem horizontalen Schwenkarm **S** gem. Fig 1 und ist mit einer Grundplatte **GP** verbunden ist, wenn sich der Betrachter **B** in dem ebenfalls eingezeichneten Bereich bewegt.

Fig. 3 macht die Bewegungsmöglichkeit eines Betrachters deutlich, bei der durch das Nachführen des Flachbildschirms **FB** immer ein konstanter Abstand **E** zwischen Betrachter **B** und Flachbildschirm **FB** und eine konstante Ausrichtung des Flachbildschirms zum Betrachter **B** ermöglicht wird. Ist das

Microsoft Exhibit 1002 - Page 1545
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Drehgelenk **DG2** (Grundplatte **GP**/Schwenkarm **S**) für eine Drehung des Schwenkarms **S** von ± 30 °, das Drehgelenk **DG1** (Flachbildschirm **FB**/Schwenkarm **S**) für eine Drehung von ± 24 ° bei einer Länge des horizontalen Schwenkarms von 600 mm ausgelegt, so kann sich der Betrachter in einem lateralen Bereich von 500 mm und in einem frontalen Bereich von 500 mm bewegen, und durch das Nachführen des Bildschirms **FB** wird immer ein Abstand von E = 750 mm eingehalten.

Der in Fig. 4 dargestellte zweigliedrige horizontale Schwenkarm **S'** garantiert die in entsprechenden Bereichen geforderte Nachführung des Flachbildschirm **FB** über die drei Drehgelenke **DG1**, **DG2**, **DG3**. Drehgelenk **DG1** verbindet die Grundplatte **GP** mit dem ersten Glied des Schwenkarms **S'**, Drehgelenk **DG2** ermöglicht die Drehung des Flachbildschirms **FB** bezüglich des zweiten Gliedes des Schwenkarms **S'** und Drehgelenk **DG 3** die Drehung der beiden Glieder des Schwenkarms **S'** zueinander. Damit ist wieder ein lateraler und ein frontaler Bereich garantiert, indem sich der Betrachter bewegen kann.

In der Fig. 5 ist ein Flachbildschirm **FB** dargestellt, der drehbar zwischen zwei vertikalen Schwenkarmen **S1**, **S2** „aufgehängt" ist. Die beiden Schwenkarme **S1**, **S2** sind über je ein weiteres Drehgelenk **DG2**, **DG2'** mit der Grundplatte **GP** verbunden, die selbst drehbar ausgebildet ist. Damit wird der Flachbildschirm **FB** durch drei rotatorische Bewegungen in zwei zueinander senkrechten Ebenen der Bewegung des Betrachters nachgeführt.

In Fig. 6 ist eine konkrete Ausführung gemäß Fig. 5 in der Seitenansicht in zwei Positionen des Schwenkarmpaares gezeigt. Hierbei beträgt die Länge der vertikalen Schwenkarme **S1** und **S2** je 450 mm. Wenn sich das Paar Schwenkarme **S1**, **S2** mittels der Drehgelenke **DG2**, **DG2'** um einen Winkel von ± 27,5 ° (max. ± 30 °) von der Vertikalen entfernt, kann ein Betrachter seinen Entfernungsabstand bis zu ± 200 mm verändern.

Die in Fig. 7 dargestellte Ausführung der Erfindung zeigt eine horizontale Schiene **H**, auf der der Flachbildschirm **FB** linear beweglich und drehbar angeordnet ist. Durch die Realisierung einer rotatorischen und einer translatorischen Bewegung des Flachbildschirms **FB** kann sich der Betrachter

Microsoft Exhibit 1002 - Page 1546
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

B wieder in einem größeren Bereich bewegen unter Beibehaltung seiner zentralen Position zum Flachbildschirm **FB**.

Einige der möglichen Positionen in den Bewegungsabläufen eines Flachbildschirms **FB**, der sich auf einer horizontalen Schiene **H1** befindet, die senkrecht zu einem Paar horizontaler, paralleler Schienen **H2**, **H3** angeordnet ist, sind in Fig. 8 dargestellt. Durch zwei translatorische Bewegungen des Flachbildschirms **FB**, ähnlich einem x-y-Tisch, steht dem Betrachter **B** wieder ein größerer - auch in dieser Figur eingezeichneter - Bewegungsraum zur Verfügung.

Microsoft Exhibit 1002 - Page 1547
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Patentansprüche

1. Vorrichtung zum Nachführen eines autostereoskopischen Flachbildschirms, bestehend aus einem Detektionssystem, das die Kopfposition des Betrachters in Bezug auf die Flachbildschirmebene bestimmt, einem Regler, der die gemessenen Daten verarbeitet und diese Steuer-/Antriebsdaten auf mindestens einen Antrieb überträgt, der den Flachbildschirm den Kopfbewegungen des Betrachters nachführt,
dadurch gekennzeichnet, daß
der Flachbildschirm (FB) als Einheit aus einem Linsenraster (R) mit extrem kleinen Linsenpitches von optimal korrigierter Linsenstruktur und einem Flachdisplay (D) gebildet ist und der Antrieb zum Nachführen des Flachbildschirms ein mehrstufiges Gelenkgetriebe ist, das translatorische und/oder rotatorische Bewegungen ausführt und den Flachbildschirm (FB) bei einer Kopfbewegung des Betrachters (B) in konstanter Betrachtungsentfernung und konstantem Betrachtungswinkel nachführt.

2. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Gelenkgetriebe als Gelenkglieder einen eingliedrigen horizontalen Schwenkarm (S) mit zwei Drehgelenken (DG1, DG2) aufweist, wobei ein Drehgelenk (DG1) den horizontalen Schwenkarm (S) mit dem Flachbildschirm (FB) und das andere Drehgelenk (DG2) eine um 180° bezüglich des Flachbildschirms (FB) versetzt angeordnete Grundplatte (GP) mit dem horizontalen Schwenkarm (S) drehbar verbindet.

3. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Gelenkgetriebe als Gelenkglieder einen zweigliedrigen horizontalen Schwenkarm (S) mit drei Drehgelenken (DG1; DG2, DG3) aufweist, wobei ein äußeres Drehgelenk (DG2) den horizontalen Schwenkarm (S) mit dem Flachbildschirm (FB), das andere äußere Drehgelenk (DG1) eine um 180° bezüglich des Flachbildschirms (FB) versetzt angeordnete Grundplatte (GP) mit dem horizontalen Schwenkarm (S) und das mittlere Drehgelenk (DG3) die beiden Glieder des horizontalen Schwenkarms (S) drehbar miteinander verbindet.

Microsoft Exhibit 1002 - Page 1548
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

4. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Gelenkgetriebe als Gelenkglieder ein Paar vertikaler, eingliedriger, parallel zueinander angeordneter Schwenkarme (S1, S2) aufweist, wobei je ein Ende der beiden Schwenkarme (S1, S2) mit je einer Seitenfläche des Flachbildschirms (FB) drehbar verbunden ist und das jeweils andere der Ende des Paares vertikaler Schwenkarme (S1, S2) mit einer drehbar ausgebildeten, horizontal angeordneten, scheibenförmigen Grundplatte (GP) drehbar hängend oder stehend verbunden ist.

5. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Gelenkgetriebe als Gelenkglieder eine als Schubgelenk ausgebildete, horizontal angeordnete Schiene (H) aufweist, mit der der Flachbildschirm (FB) drehbar verbunden ist.

6. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Gelenkgetriebe als Gelenkglieder ein Paar als Schubgelenk horizontal und parallel zueinander angeordnete Schienen (H2, H3) aufweist, daß als senkrecht zu diesem Paar Schienen bewegliches Schubgelenk eine Einzelschiene (H1), die in dem Paar angeordneter Schienen (H2, H3) senkrecht zu diesen geführt ist, ausgebildet ist, wobei die Einzelschiene (H1) als Schubgelenk für den Flachbildschirm (FB) ausgebildet ist, der auf der Einzelschiene angeordnet ist.

7. Vorrichtung nach Anspruch 6,
dadurch gekennzeichnet, daß
der Flachbildschirm (FB) auf der Einzelschiene (H1) drehbar angeordnet ist.

8. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Flachdisplay (D) ein Flüssigkristall-Display ist.

Microsoft Exhibit 1002 - Page 1549
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

9. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Flachdisplay (D) ein Plasma-Display ist.

10. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Flachdisplay (D) ein Elektrolumineszenz-Display ist.

11. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
das Linsenraster (R) direkt auf dem Flachdisplay (D) aufgebracht ist.

12. Vorrichtung nach Anspruch 11,
dadurch gekennzeichnet, daß
das Linsenraster (R) mit der strukturierten Fläche zum Flachdisplay (D) hin auf diesem angeordnet ist.

13. Vorrichtung nach Anspruch 11,
dadurch gekennzeichnet, daß
das Linsenraster (R) mit der strukturierten Fläche auf dem Flachdisplay (D) zum Betrachter hin angeordnet ist.

14. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
die Pixelstruktur des Flachdisplays (D) als Referenzsystem zur Erzeugung der Linsenstruktur (R) ausgebildet ist.

15. Vorrichtung nach mindestens einem der vorangehenden Ansprüche,
dadurch gekennzeichnet, daß
das mehrstufige Gelenkgetriebe den Flachbildschirm bei Bewegung des Betrachters in konstantem Betrachtungsabstand nachführt und das Linsenraster derart ausgebildet ist, daß es zusätzlich bei seitlicher Bewegung parallel zum Flachdisplay verfahren wird.

Microsoft Exhibit 1002 - Page 1550
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

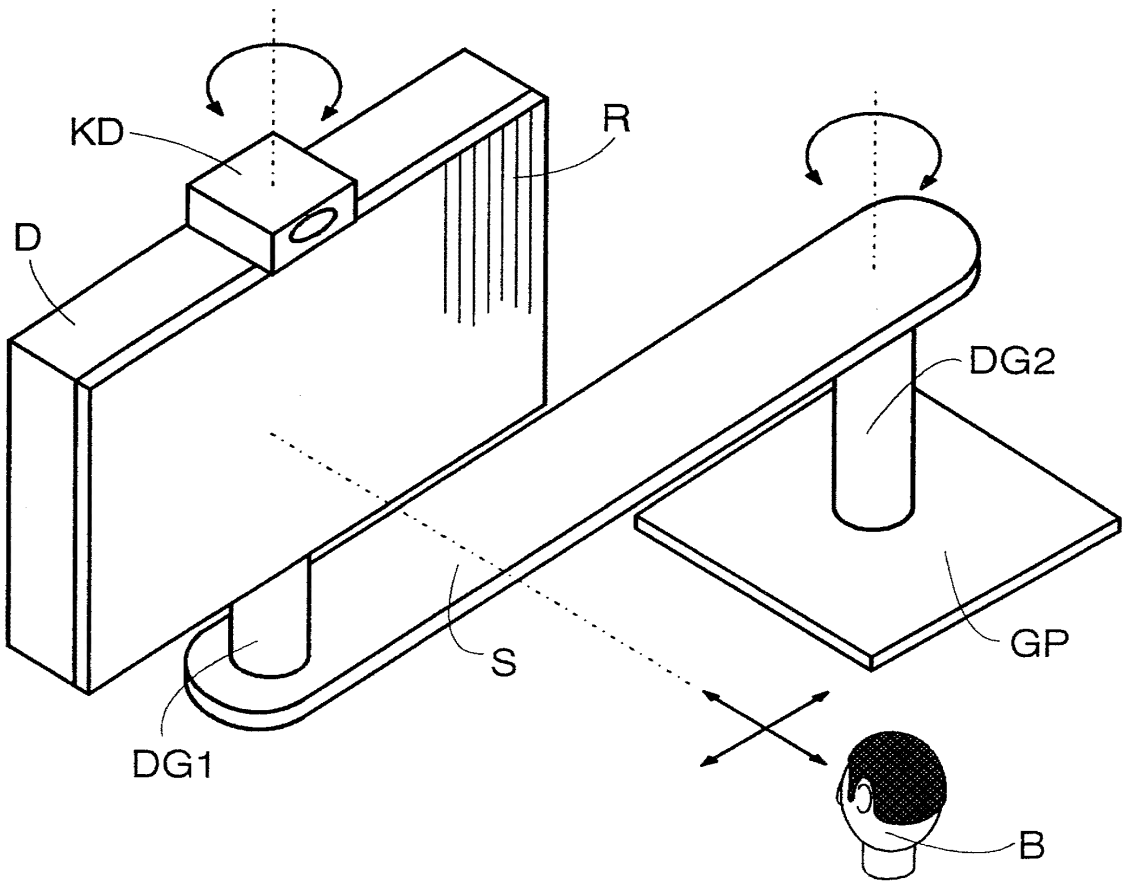


Fig.1

Microsoft Exhibit 1002 - Page 1551
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

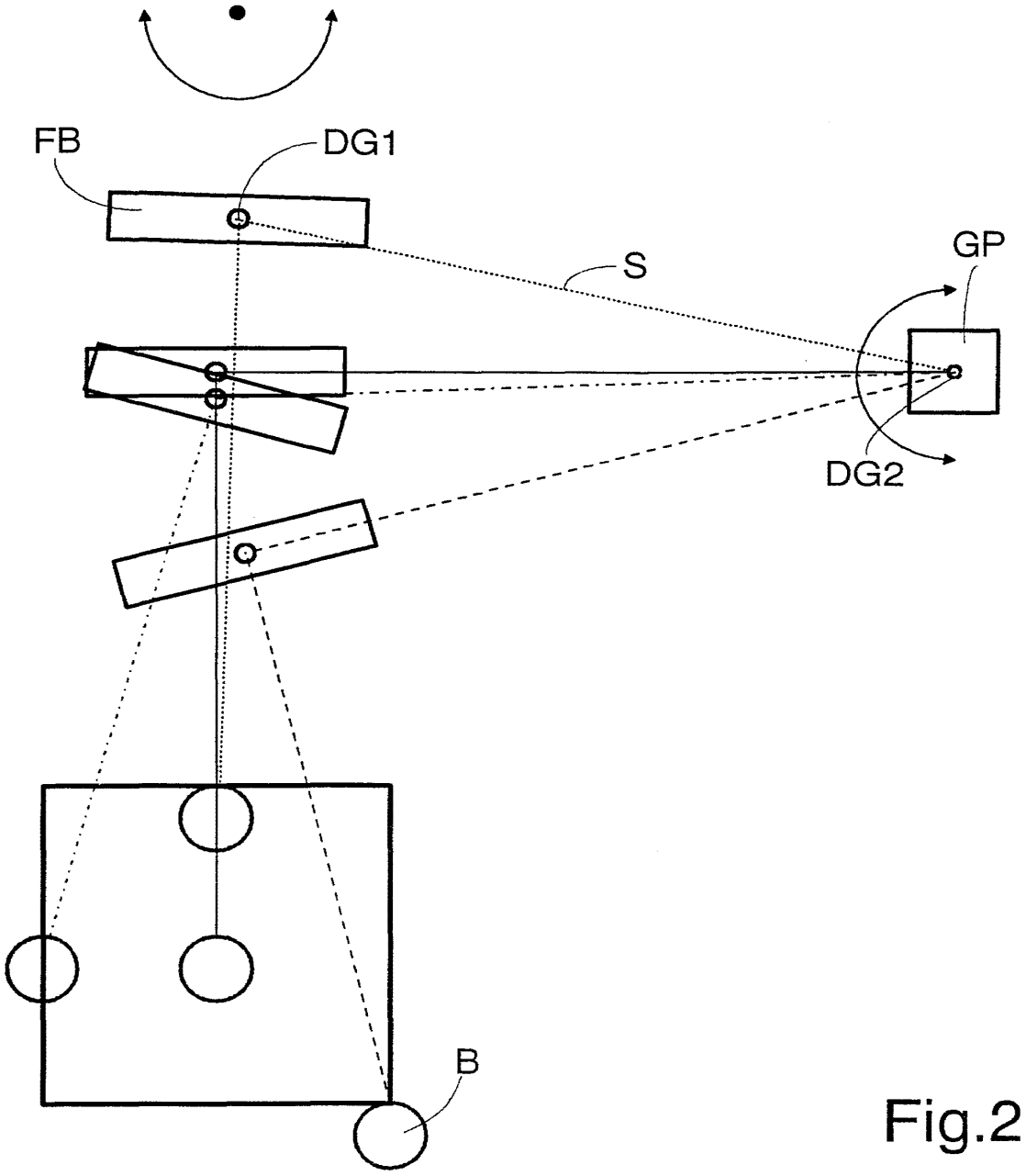


Fig.2

Microsoft Exhibit 1002 - Page 1552
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

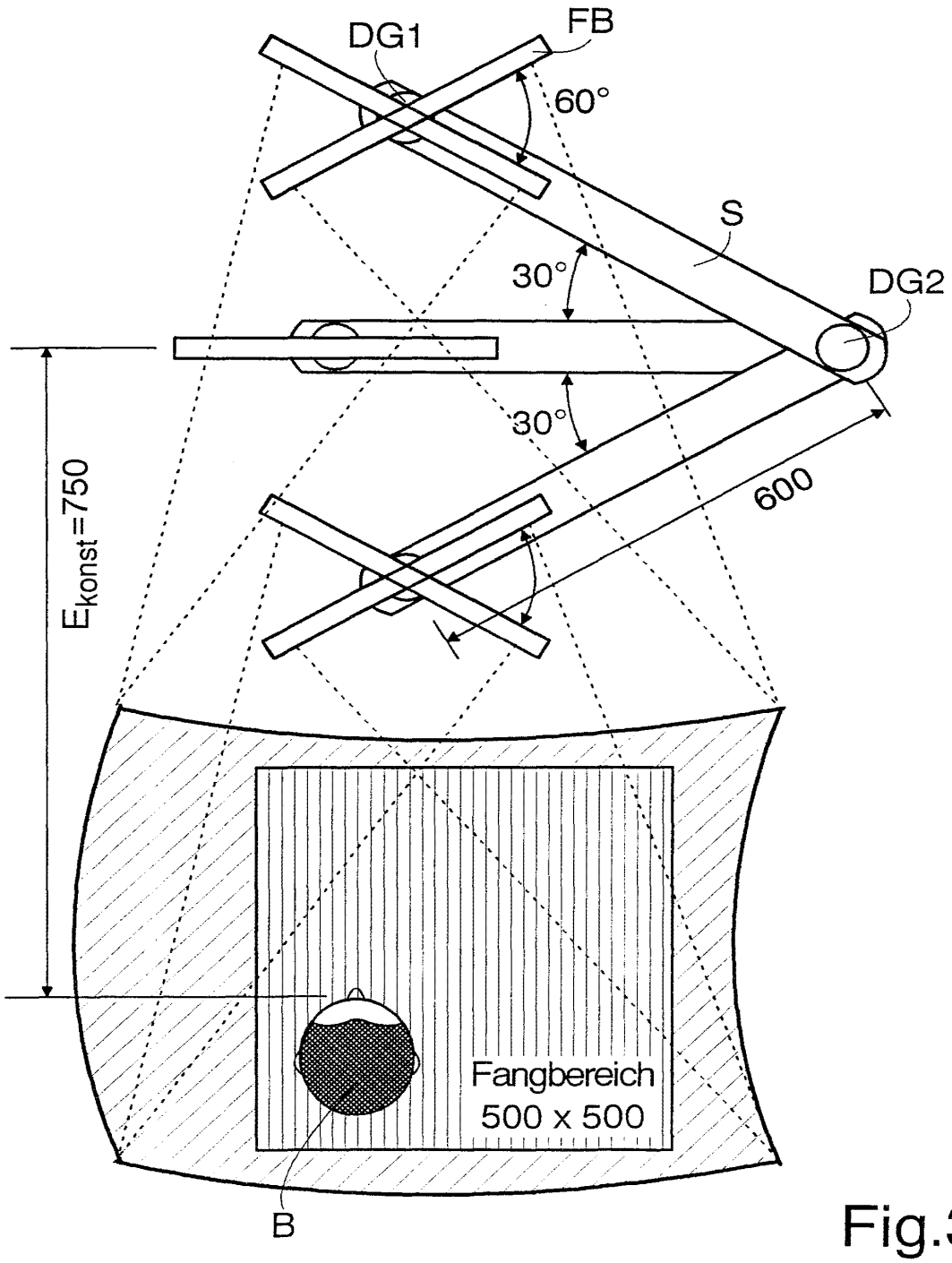


Fig.3

Microsoft Exhibit 1002 - Page 1553
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

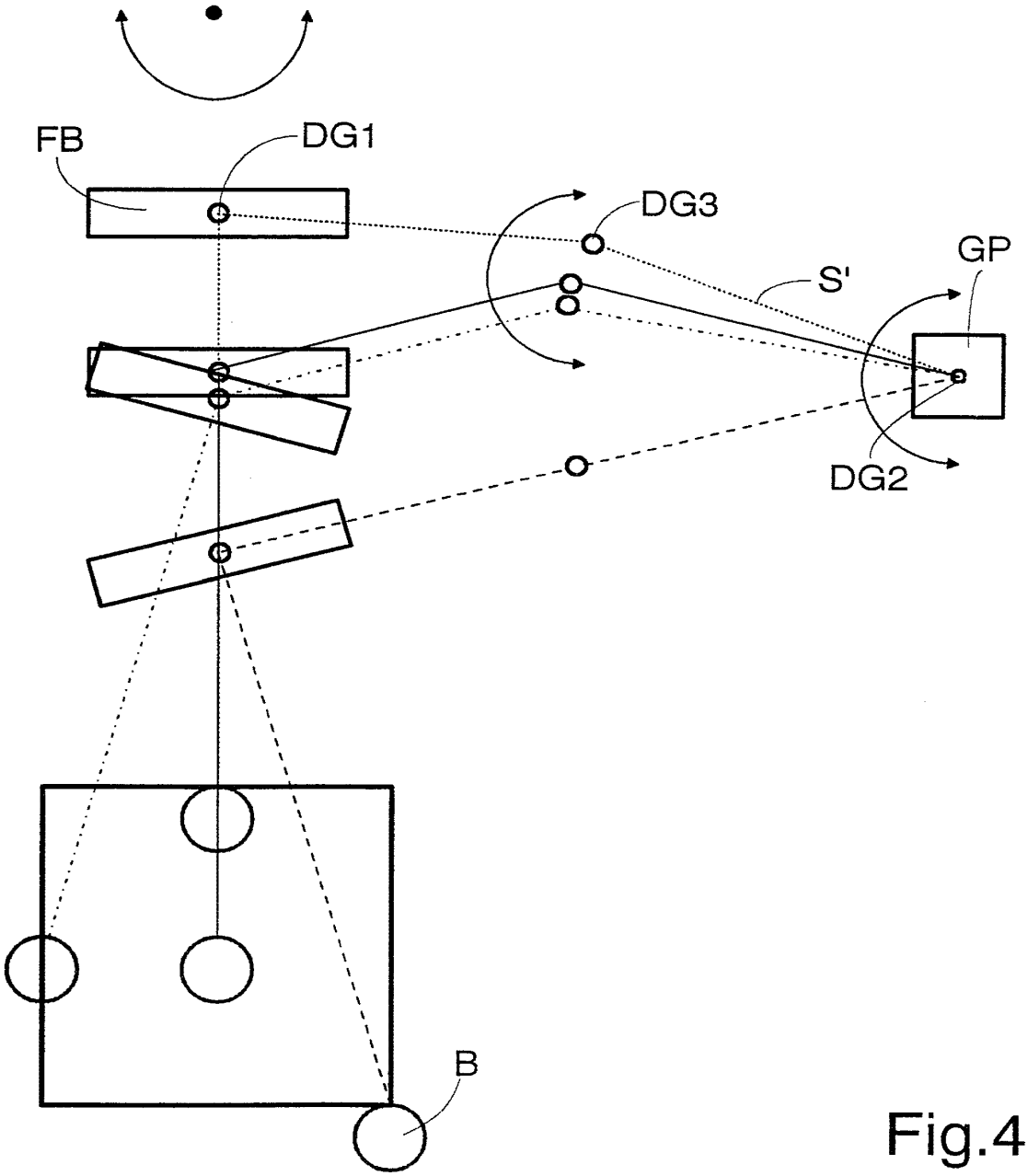


Fig.4

Microsoft Exhibit 1002 - Page 1554
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

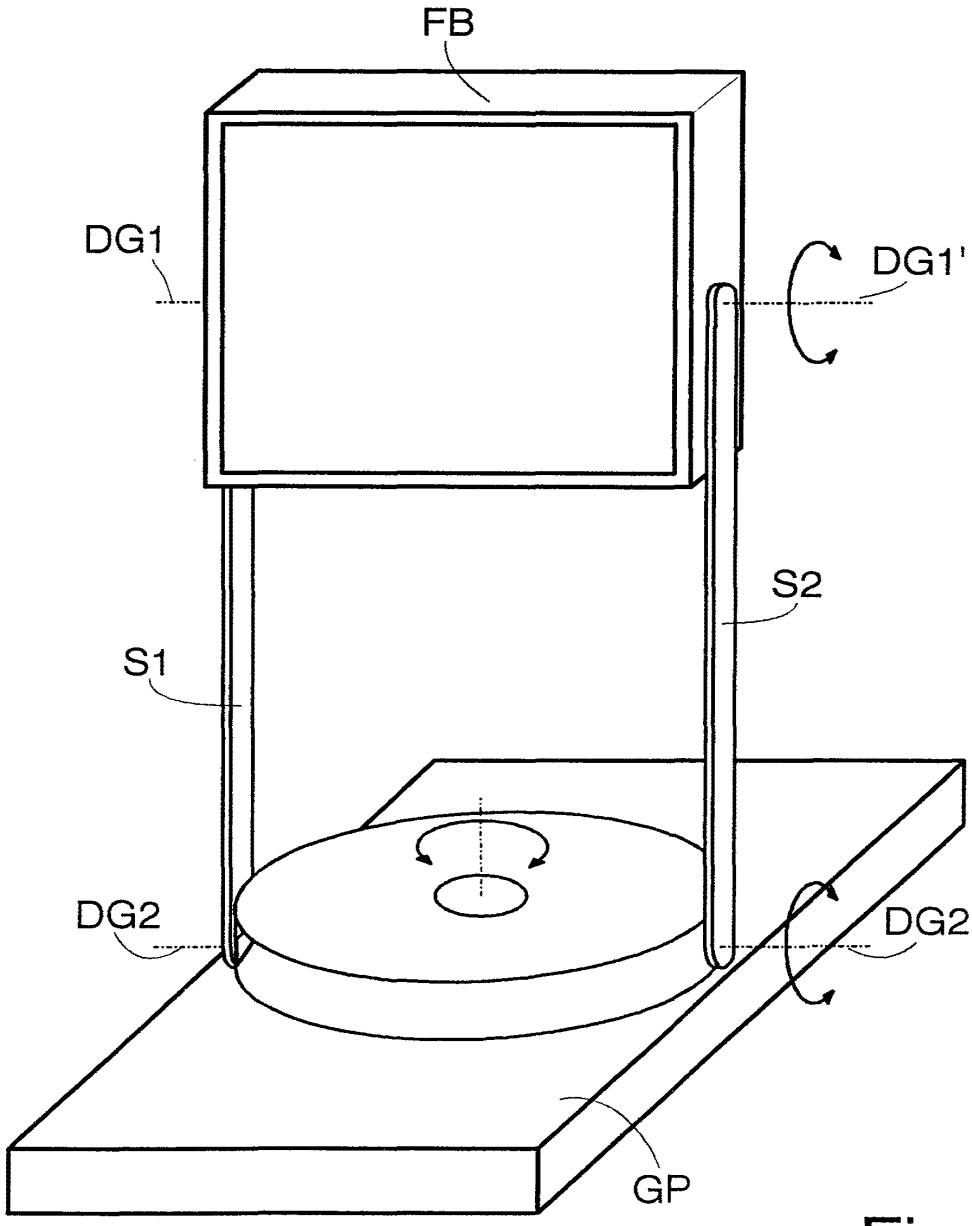


Fig.5

Microsoft Exhibit 1002 - Page 1555
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

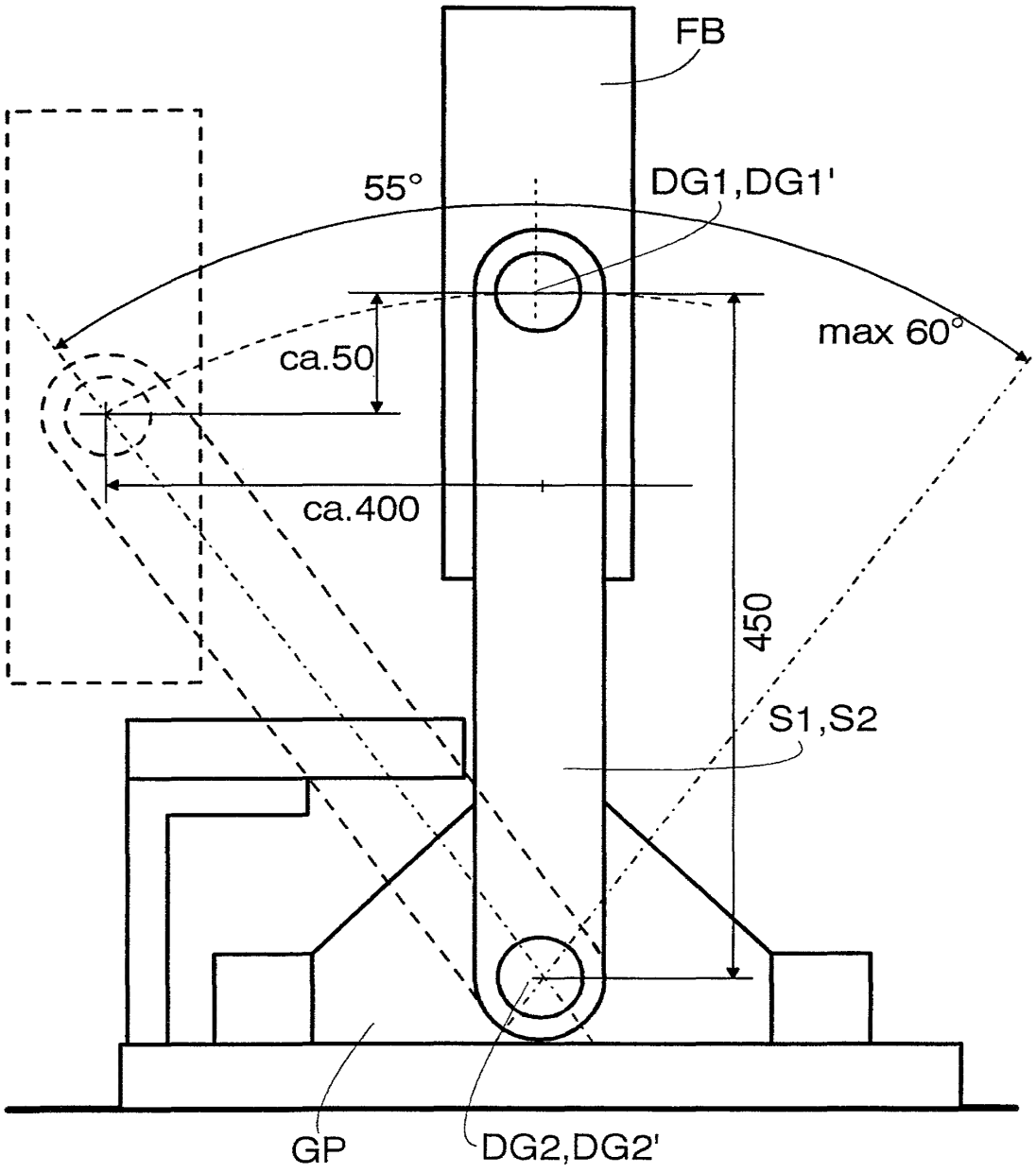


Fig.6

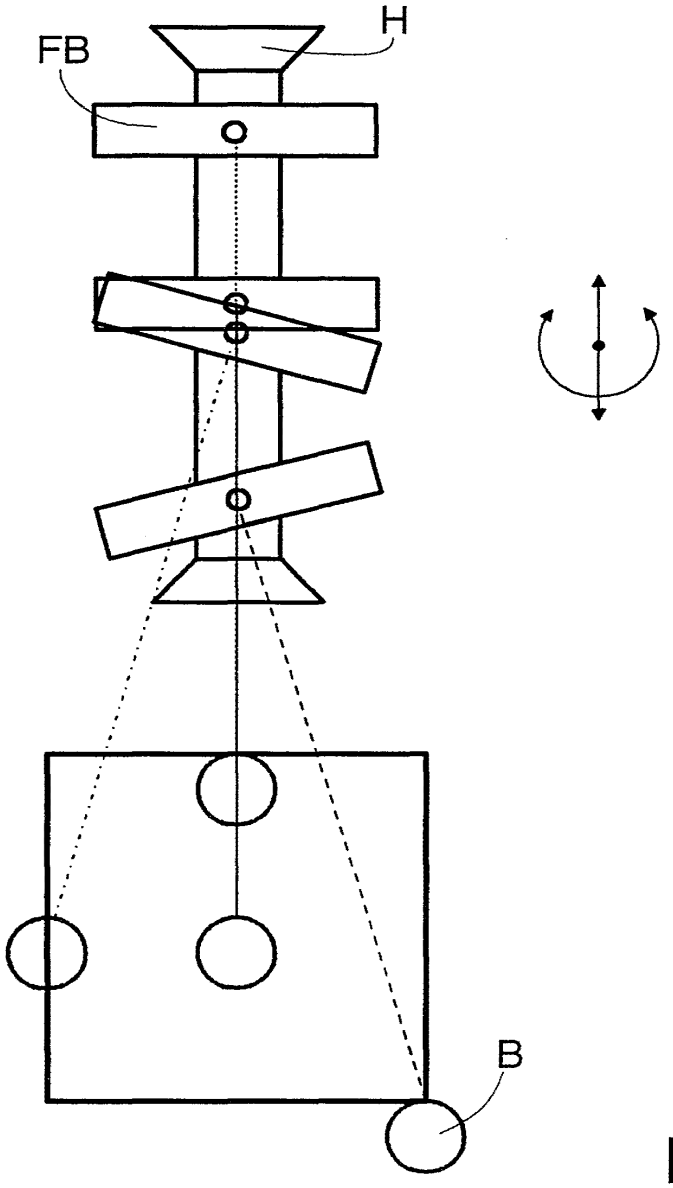


Fig.7

Microsoft Exhibit 1002 - Page 1557
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

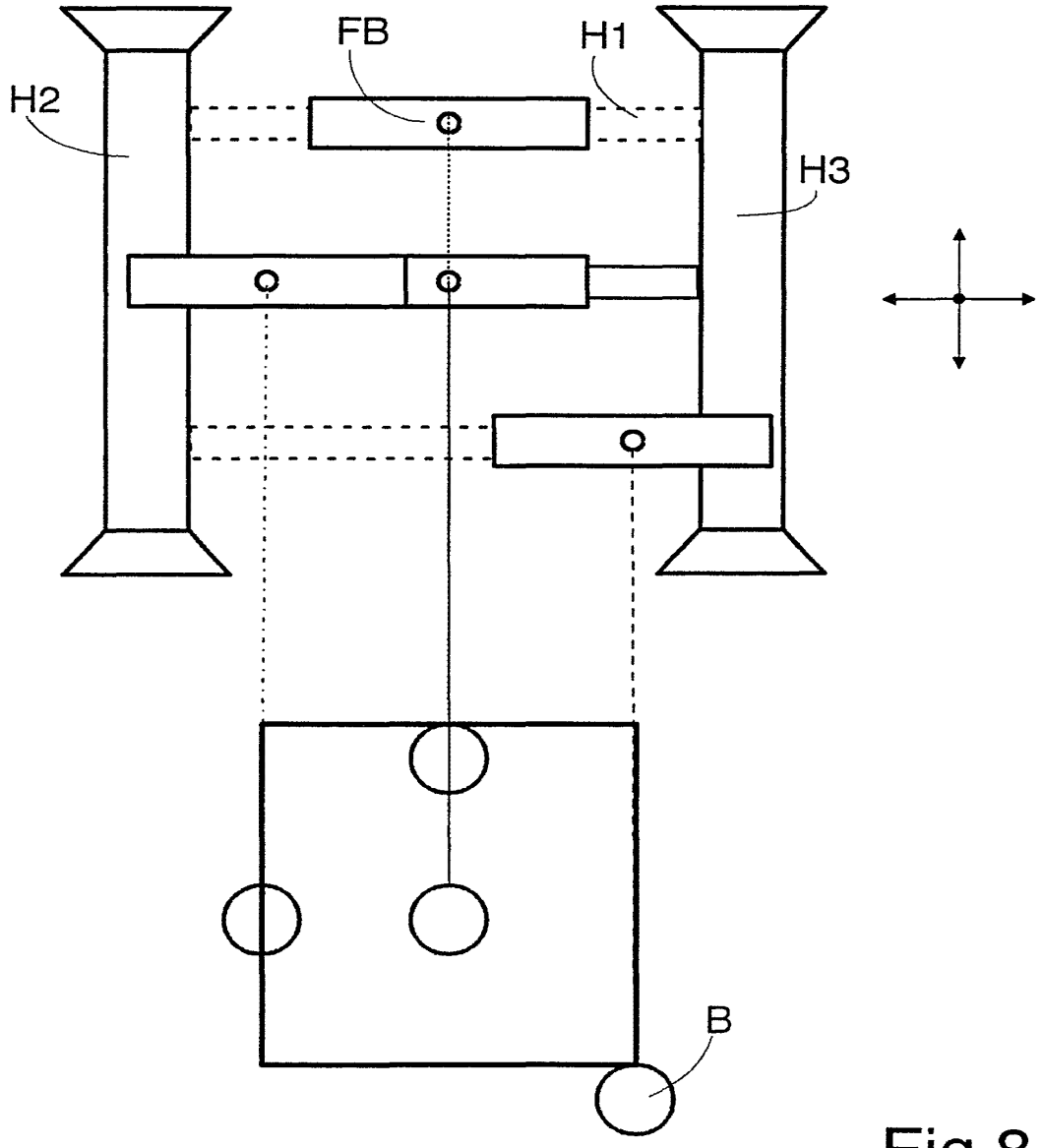


Fig.8

Microsoft Exhibit 1002 - Page 1558
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONAL SEARCH REPORT

Inter ›nal Application No
PCT/DE 98/02576

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N13/04

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 6 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)

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 0 702 494 A (MATSUSHITA ELECTRIC IND CO LTD) 20 March 1996 see page 6, line 54 - page 7, line 40; figures 4,5 see page 8, line 36 - line 46; figure 7 see page 8, line 47 - page 10, line 54; figures 8-12	1,2,4,8, 11,15 3,9,10, 12-14
A	WO 96 22660 A (FARIS SADEG M ;REVEO INC (US); SWIFT DAVID C (US)) 25 July 1996 see page 5, line 14 - line 18; figure 1	1

☐ Further documents are listed in the continuation of box C.

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° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
22 December 1998	30/12/1998

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	De Paepe, W

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Microsoft Exhibit 1002 - Page 1559
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0702494 A	20-03-1996	JP 8086977 A	02-04-1996
		JP 8088870 A	02-04-1996
		US 5742331 A	21-04-1998
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Microsoft Exhibit 1002 - Page 1560
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONALER RECHERCHENBERICHT

Inte onales Aktenzeichen
PCT/DE 98/02576

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
IPK 6 H04N13/04

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
IPK 6 H04N

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X A	EP 0 702 494 A (MATSUSHITA ELECTRIC IND CO LTD) 20. März 1996 siehe Seite 6, Zeile 54 - Seite 7, Zeile 40; Abbildungen 4,5 siehe Seite 8, Zeile 36 - Zeile 46; Abbildung 7 siehe Seite 8, Zeile 47 - Seite 10, Zeile 54; Abbildungen 8-12	1,2,4,8, 11,15 3,9,10, 12-14
A	WO 96 22660 A (FARIS SADEG M ;REVEO INC (US); SWIFT DAVID C (US)) 25. Juli 1996 siehe Seite 5, Zeile 14 - Zeile 18; Abbildung 1	1

☐ Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

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Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
22. Dezember 1998	30/12/1998

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	De Paepe, W

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Microsoft Exhibit 1002 - Page 1561
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Inter nales Aktenzeichen
PCT/DE 98/02576

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
EP 0702494 A	20-03-1996	JP 8086977 A	02-04-1996
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Microsoft Exhibit 1002 - Page 1562
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

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(51) International Patent Classification[7]: F21V 8/00

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(26) Publication Language: English

(30) Priority Data:
09/505,312 16 February 2000 (16.02.2000) US

(71) Applicant: 3M INNOVATIVE PROPERTIES COMPANY [US/US]; 3M Center, P.O. Box 33427, Saint Paul, MN 55133-3427 (US).

(72) Inventors: BOYD, Gary, T.; P.O. Box 33427, Saint Paul, MN 55133-3427 (US). MILLER, Richard, A.; P.O. Box 33427, Saint Paul, MN 55133-3427 (US). WHITNEY, Leland, R.; P.O. Box 33427, Saint Paul, MN 55133-3427 (US).

(74) Agents: BUCKINGHAM, Stephen, W. et al.; Office of Intellectual Property Counsel, P.O. Box 33427, Saint Paul, MN 55133-3427 (US).

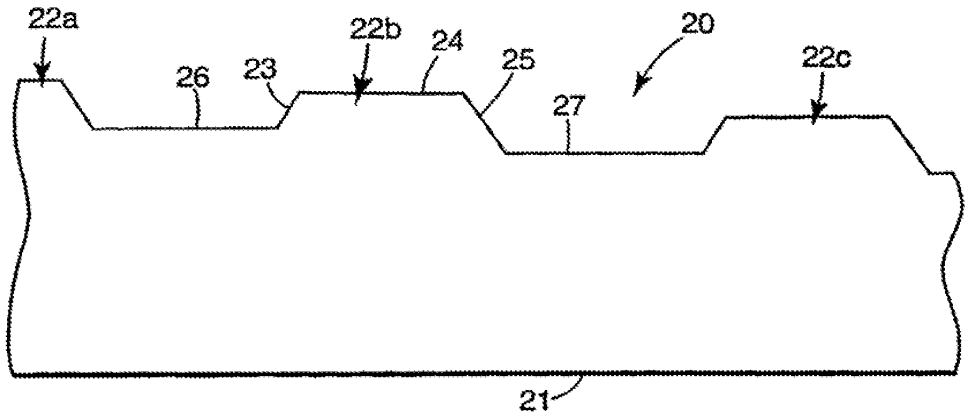
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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

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.

(54) Title: WEDGE LIGHT EXTRACTOR WITH RISERS



(57) Abstract: A wedge-shaped light extractor (20) having a light-redirecting surface comprising a plurality of projections (22a, 22b, 22c). The projections (22a, 22b, 22c) include risers (23) that improve extraction efficiency of the facets (25), thereby facilitating efficient use of available light from a light source.

WO 01/61241 A1

Microsoft Exhibit 1002 - Page 1563
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

WEDGE LIGHT EXTRACTOR WITH RISERS

Technical Field

This invention relates to electronic displays, and to point to line, line to area or point to area converters for illuminating displays.

Background Art

A variety of devices have been proposed for illuminating electronic displays. These devices include backlighting panels, front lighting panels, concentrators, reflectors, structured-surface films and other optical devices for redirecting, collimating, distributing or otherwise manipulating light. Efficient use of the light is particularly important in battery powered electronic displays such as those used in cell phones, personal digital assistants and laptop computers.

U.S. Patent No. 4,751,615 (Abrams) shows a tapering wedge transparent page lighting device. U.S. Patent No. 4,811,507 (Blanchet) shows a front light illuminating panel having light-emitting striations whose depth increases with distance from the light source. U.S. Patent Nos. 5,005,108 (Pristash et al.); 5,050,946 (Hathaway et al.) and 5,594,830 (Winston et al.) show structured-surface panel illuminators whose panel depth varies along the length of the panel. U.S. Patent Nos. 4,799,137 (Aho); 4,874,228 (Aho et al.); 5,054,885 (Melby); and 5,190,370 (Miller et al.) show various light fixtures having inclined or curved prismatic structured surface films.

U.S. Patent Nos. 5,359,691 and 5,608,837 (both to Tai et al.); U.S. Patent No. 5,485,354 (Ciupke et al.); and U.S. Patent Nos. 5,608,550 and 5,894,539 (both to Epstein et al.) show structured-surface backlighting or front lighting devices having triangular microprisms or microgrooves separated by flat land areas or lands. European Patent Application EP 0 802 446 A1 (Seiko Epson) shows a structured-surface backlighting device having rectangular projections separated by lands. U.S. Patent No. 5,671,994 (Tai et al) shows a structured-surface front lighting device having trapezoidal projections separated by lands.

U.S. Patent No. 5,396,350 (Beeson et al.); U.S. Patent Nos. 5,428,468 and 5,555,109 (both to Zimmerman et al.) and U.S. Patent No. 5,555,329 (Kuper et al.) show

Microsoft Exhibit 1002 - Page 1564
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

various structured-surface backlighting devices having an array of microprisms with tilted sidewalls.

U.S. Patent Nos. 5,506,929, 5,668,913 and 5,835,661 (all to Tai et al.) and U.S. Patent No. 5,613,751 (Parker et al.) show light-expanding systems for converting a point light source into a linear or planar light beam.

Summary of Invention

Although a number of backlight and front light guide devices have been proposed, there is an ongoing need for more efficient designs and for reduced power consumption.

Many current designs do not use all of the light supplied by the light source. If such unused light could be channeled to the display, then power consumption could be further reduced and display brightness could be increased.

Several of the above-mentioned designs have a more or less constant thickness and a generally flat structured surface. These designs may fail to extract light that travels to the end of the device without striking (and thereby being reflected from or extracted by) the structured surface.

A wedge-shaped design can reduce the amount of (and thus the loss of) light that travels the length of the device without being reflected or extracted. However, some current wedge designs are difficult to manufacture. For example, if the device tapers to a thin edge at its distal end, the edge can be difficult to mold and may fracture or craze in use. If instead a mirrored surface is employed at the distal end, some light will be lost due to inefficient reflection at the mirror, and other light will be lost due to reduced efficiency of extraction for reflected light returning towards the input end of the device. Addition of a mirror can also increase manufacturing costs or lower manufacturing yields.

The efficiency and evenness of light extraction by wedge-shaped backlight or front light guide devices generally is governed in part by the gross overall dimensions and shape of the wedge, and by the fine-featured (usually microscopic) dimensions and shapes of any structured-surface features on the device. For example, the design shown in the above-mentioned Hathaway et al. patent has an inclined structured-surface face in the form of a series of descending steps. Each step has a flat land area and an inclined facet. Light typically is extracted from such a device at the facets. Light typically is redistributed

Microsoft Exhibit 1002 - Page 1565
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

within such a device by total internal reflection or "TIR" of light striking the lands or by TIR of light striking an opposing surface of the device. The reflected light travels toward the narrow or distal end of the device and may eventually emerge from the device by extraction at a facet. However, some of the reflected light will be lost at the distal end of the device and thus is not available for display illumination.

Several of the other constant thickness or wedge-shaped backlight or light guide devices mentioned above can also be regarded as having facets and lands, although other terms may have been used to describe the parts of these devices. In general, the overall shape of the backlight or light guide and the geometry of the structured surface will affect the ratio of extracted light to reflected light for these devices as well.

We have found that by using a wedge design having a structured surface that includes risers which serve to increase the portion of the facet area available for light extraction, we can obtain improvements in uniformity of illumination, control over light extraction, efficiency, or in more than one or even all of these factors. The present invention provides, in one aspect, a light extraction device having:

a) a light input end;

b) a generally planar light output surface that can deliver light to a display; and

c) a structured light-redirecting surface located generally opposite the light output surface;

wherein the light output surface and light-redirecting surface define a generally wedge-shaped profile that decreases in thickness from the light input end towards the center of the device; the light-redirecting surface reflects light towards the light output surface and thence to the display; and the light-redirecting surface comprises a plurality of projections comprising a riser segment, plateau segment, and facet segment, with land segments flanking the projections.

Without risers, the amount of extracted light will be determined by the orientation and size of the facets and lands. When risers are added to the design, the size of each facet (and thus the facet area available for extraction) is in effect increased. The overall wedge-shaped extractor profile permits all or a significant portion of the total facet area to participate in extraction. Thus, inclusion of a riser and use of an overall wedge shape enables alteration of the extractor design to increase light extraction to a display. This can

Microsoft Exhibit 1002 - Page 1566
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

enable improvements in the overall size and efficiency of the device and can make better use of the available light.

The present invention also provides point to line converters, backlights and front light guides comprising the above-described wedge-shaped light extraction device, and displays containing such extraction devices.

Brief Description of the Drawing

Fig. 1a is a schematic view of a front light guide.

Fig. 1b is a schematic view of a backlight.

Fig. 2 is a magnified cross-sectional side view of a light extraction device of the invention.

Fig. 3 is a magnified cross-sectional side view of a light extraction device of the invention, showing descriptive angle β.

Fig. 4 is a magnified cross-sectional side view of a light extraction device of the invention, showing descriptive angles ρ, θ, ϕ, and γ and descriptive heights $\mathbf{r_h}$ and $\mathbf{f_h}$.

Fig. 5 is a perspective view of another light extraction device of the invention.

Fig. 6 is a perspective view of yet another light extraction device of the invention.

Fig. 7 is a perspective view of a further light extraction device of the invention.

Fig. 8 is a magnified view of the device of **Fig. 7**, showing the paths taken by two light rays.

Fig. 9 is a cross-sectional view of an additional light extraction device of the invention.

Detailed Description

The wedge-shaped light extraction devices of the invention provide point to line, line to area or point to area light conversion that collimates or redirects light from a light source. The extraction device (which for brevity will sometimes be referred to as the extractor) can be used to illuminate a display. If the light source is a point light source, then typically the source has a relatively small cross-sectional area compared to the cross-sectional area of the display (e.g., on the order of less than 1/100 of the area of the display). If the light source is an elongated (e.g., a line) light source, then typically the source has a rectangular cross-sectional area whose long dimension is approximately ten

Microsoft Exhibit 1002 - Page 1567
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

or more times its short dimension, and which may approximate a short or long dimension of the face of the display.

Some of the extractor's components and their relationship to one another can conveniently be described by comparison to a reference plane. Usually the light output surface of the extractor is planar or nearly planar. For purposes of this invention, the reference plane will be taken to be the plane formed by (or closely approximating) the light output surface of the extractor.

Referring now to Figure **1a,** a front light guide and display generally identified as **10a** is shown in schematic form. Front light guide **11a** lies above display **12a**. Light ray **16a** enters light guide **11a** through light input surface **13a**. Light ray **16a** strikes light-redirecting surface **14a** on a light-reflecting facet segment (not shown), passes downward as reflected light ray **17a** towards display **12a,** and exits light guide **11a** through light output surface **15a**. Upon striking display **12a** (and assuming that display **12a** is suitably modulated to reflect light), light ray **17a** is reflected upward as light ray **18a** towards viewer **19a**. Light ray **18a** passes through surface **15a** (which, although identified as a light output surface, also serves in this front light guide design as a surface through which reflected light ray **18a** can reenter the light guide), passes through light guide **11a** and exits through light-redirecting surface **14a** at a land, facet or plateau segment (not shown).

Referring to **Fig. 1b**, a backlight and display generally identified as **10a** is shown in schematic form. Front light guide **11b** lies below display **12b**. Light ray **16b** enters backlight **11b** through light input surface **13b**. Upon striking light-redirecting surface **14b** at a facet segment (not shown), light ray **16b** is reflected upwards as light ray **17b**. Light ray **17b** exits backlight **11b** through light output surface **15b** and (assuming that display **12a** is suitably modulated to transmit light) passes through display **12b** towards viewer **19b**.

Referring to **Fig. 2,** front light guide **20** of the invention has a generally wedge-shaped cross section that diminishes in thickness from left to right in the figure. Light output surface **21** is located generally opposite a light-redirecting surface having a plurality of projections **22a, 22b** and **22c** and intervening lands such as lands **26** and **27**. Projection **22b** has riser **23** adjoining plateau **24**, which in turn adjoins facet **25**. Lands **26** and **27** flank projection **22b**. For purposes of discussion, projections such as projection **22b** can be referred to as "generally trapezoidal", even though the projection has only

Microsoft Exhibit 1002 - Page 1568
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

three sides and even though a quadrilateral formed by drawing an imaginary line to complete the fourth side of the projection might not have two parallel sides.

Fig. 3 shows front light guide **30** of the invention and an imaginary line **36** constructed by drawing a line through vertices **35a** through **35e** formed at the respective intersections of risers **33a** through **33e** with plateaus **34a** through **34e** of projections **32a** through **32e**. Imaginary line **36** forms an angle β (beta) with a line **37** drawn through the plane formed by generally planar light output surface **31**.

Referring to **Fig. 4**, front light guide **40** of the invention has light output surface **41** and projection **42**. Again for purposes of discussion, projection **42** can be referred to as "generally trapezoidal", even though it has only three sides and even though a quadrilateral formed by drawing an imaginary line to complete the fourth side of projection **42** might not have two parallel sides. Imaginary lines **48a** and **48b** are drawn parallel to light output surface **41** through the respective upper and lower vertices of riser **43**. Riser **43** has height $\mathbf{r_h}$, and forms angle ρ (rho) with imaginary line **48b** (and, if projected, with surface **41**). Plateau **44** slopes downward toward light output surface **41**, forming angle θ (theta) with imaginary line **48a** (and, if projected, with surface **41**). Facet **45** has height $\mathbf{f_h}$ measured between imaginary lines **48c** and **48d** which are drawn parallel to surface **41** through the respective lower and upper vertices of facet **45**. Facet **45** slopes downward toward light output surface **41**, forming angle ϕ (phi) with imaginary line **48d** (and, if projected, with surface **41**). Lands **46** and **47** flank projection **42**. Land **47** slopes upward away from light output surface **41**, forming angle γ (gamma) with imaginary line **48c** (and, if projected, with surface **41**).

Fig. 5 shows a point to line converter **51** of the invention incorporating a wedge-shaped extractor. For purposes of illustration, surface structures such as projections **52a**, **52b** and **52c** are shown in exaggerated scale. Preferably such projections would be much smaller as described in more detail below. Light rays emitted from point light source **50** enter light input surface **54** of beam collector **55** and travel down the length of light pipe **56**. Light rays striking facets such as **55a**, **55b**, **55c** and **55d** will be extracted by TIR through light output surface **58**. Light striking lands such as **57a**, **57b**, **57c** and **57d** will be reflected by TIR within light pipe **56** towards surface **58** and distal end **59** of point to line converter **56**. Upon striking surface **58**, these latter light rays will be further reflected by TIR from surface **58** towards other projections (not labeled) in light pipe **56**. Substantially

Microsoft Exhibit 1002 - Page 1569
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

all the light rays will eventually exit light pipe **56** through generally planar light output surface **58** and will form a generally evenly distributed rectangular light beam.

Fig. 6 shows a point to line converter **61** of the invention having two light sources **60a** and **60b**. As with the converter of **Fig. 5**, the projections in the converter of **Fig. 6** are shown in exaggerated scale. Light rays from light sources **60a** and **60b** enter input surfaces **64a** and **64b** of beam collectors **65a** and **65b** and travel down light pipe **66**. The thickness of light pipe **66** decreases along the length of the device, reaching a minimum at narrow portion **67**. Light is extracted or reflected from projections such as **62a** through **62d**, eventually exiting light pipe **66** through light output surface **68** as a generally evenly distributed rectangular light beam.

Fig. 7 shows a front light guide and display assembly **70** of the invention. Light guide **71** lies atop display **79**, separated slightly by optional air gap **78**. Light enters light guide **71** through light input surface **76** and travels along the guide to strike facets on projections such as **72a** through **72d**.

Fig. 8 shows a magnified view of a portion of the front light guide **71** of **Fig. 7**. Light ray **81a** strikes facet **75** and is reflected downward as light ray **81b** through output surface **78** towards display **79**. Upon striking display **79** (and assuming that display **79** is suitably modulated), light ray **81b** will be reflected upwards as light ray **81c**, reentering light guide **71** through surface **78** and then exiting light guide **71** through land **76**. Light ray **83a**, which approaches the structured surface of light guide **71** along a different path than light ray **81a**, strikes land **77** and is reflected as light ray **83b** towards surface **78** and distal end (not shown) of light guide **71**. Owing to the slight upward tilt of land **77**, ray **83a** will strike land **77** (and reflected ray **83b** will strike surface **78**) at a higher angle of incidence than would be the case if land **77** were parallel to surface **78**. For the same reason, reflected ray **83b** will strike surface **78** at a point located closer to the distal end of light guide **71** than would be the case if land **77** were parallel to surface **78**. This aids in the improved efficiency of extraction of light from light guide **71**, by increasing the angle of incidence for light eventually reaching the facets.

Fig. 9 shows the light path traveled by two light rays **91a** and **93a** traveling through a backlight **94** of the invention. Light ray **91a** strikes land **96** and is reflected towards the distal end (not shown) of backlight **91** as light ray **91b**. Light ray **93a** strikes facet **95** and is reflected upwards towards display **99** as light ray **93b**. If display **99** is

Microsoft Exhibit 1002 - Page 1570
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

suitably modulated, then light wave **93b** will pass through display **99** towards a viewer (not shown).

Overall, the light extractor has a wedge-shaped profile. The vertices between the risers and plateaus can if desired lie along a straight line. If the vertices lie along a straight line, and if the light output surface is designated as a reference plane, and if an imaginary straight line is drawn through the vertices between risers and plateaus, then the angle β between the reference plane and the imaginary line preferably is about 0.1 to about 6 degrees, more preferably about 0.4 to about 4 degrees. In one embodiment of the invention having riser-plateau vertices that lie along a straight line, the facet heights are constant along the length of the extractor. In another such embodiment, the facet heights diminish from the input end of the extractor towards the distal or narrow end. In a further embodiment, the facet heights diminish from the input end of the extractor towards the distal or narrow end, the plateau segment lengths are constant along the length of the extractor, and the riser heights diminish from the distal end of the extractor towards the input end by an amount sufficient so that the riser-plateau vertices lie along a straight line.

The vertices between risers and plateaus can if desired lie along a curved path. In one such embodiment, the facet heights diminish from the input end of the extractor towards the distal or narrow end and the land segment lengths remain constant along the length of the extractor. In another such embodiment, the facet heights are constant and the land lengths diminish from the input end of the extractor towards the distal or narrow end. In any event, the angle β for an extractor whose riser plateau vertices lie along a curved path should be approximated by calculating the arctangent of the (difference between the input end and distal end thicknesses of the extractor, divided by the length of the extractor), as shown in the following formula:

$$\beta = \arctan((\text{input end thickness} - \text{distal end thickness})/\text{extractor length}).$$

The individual projections need not all be identical and need not all have the same angular orientation, shape or dimensions. However, for ease of manufacturing, generally it will be preferred to form projections whose riser, plateau and facet segments have the same angular orientation and segment length from projection to projection. The land segments also can if desired be similar to one another in angular orientation and segment lengths. Preferably however the projections are spaced at a relatively coarser pitch near the light input end of the extractor, and at a relatively finer pitch towards the narrowest

Microsoft Exhibit 1002 - Page 1571
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

portion (as in the narrow central isthmus of the point to line converter of **Fig. 6**) or distal end (as in end opposite the light input end in the extractors of **Figs. 5, 7 and 9**) of the extractor. This change in spacing can conveniently be accomplished by progressively decreasing the length of the land segments from the input end to the distal end (or narrowest portion) of the extractor.

Each riser segment preferably is planar although other shapes such as convex or concave shapes can be used if desired. The risers do not ordinarily reflect or transmit light rays from inside the light extractor, and thus can have a less than optically smooth surface. However, care should be taken to avoid excessive riser surface roughness. That will help avoid ghosting and other visual artifacts that may arise due to backscattering of light within the light extractor and consequent weak transmission of backscattered light through the risers. The riser heights r_h preferably are about 0.001 to about 0.5 mm, more preferably about 0.002 to about 0.02 mm. The angle ρ between the reference plane and a riser preferably is about 90 to about 45 degrees, more preferably about 85 to about 65 degrees.

Usually a portion of each plateau segment will lie in the shadow cast by light rays striking the adjoining riser and thus will not participate in light reflection or extraction. In a front light guide construction, the unshadowed portions of the plateaus can serve as upper viewing ports for extracted light. Preferably, the plateaus are planar although they can have other shapes such as convex or concave shapes if desired. Preferably however the plateaus have flat, optically smooth surfaces so as not to induce distortion in the extracted light. The plateau segment lengths preferably are about 0.001 to about 1.5 mm, more preferably about 0.004 to about 0.12 mm. The angle θ between the reference plane and a plateau preferably is about 0 to about 10 degrees, more preferably about 0 to about 2 degrees, with the plateau segments most preferably being parallel to the reference plane (or in other words, θ most preferably is zero).

The facet or ramp segments direct light toward the display whereupon it can be extracted (sometimes following one or more further reflections) and suitably modulated by the display. Preferably, the facets are planar although they can have other shapes such as convex or concave shapes if desired. Preferably the facets have flat, optically smooth surfaces so as not to induce scattering of the reflected light. The facet heights f_h preferably are greater than the riser heights, and more preferably are about 0.001 to about

Microsoft Exhibit 1002 - Page 1572
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

1.5 mm, most preferably about 0.002 to about 0.12 mm. The angle ϕ between the reference plane and a facet preferably is about 20 to about 50 degrees, more preferably about 25 to about 45 degrees.

The land segments of the light-redirecting surface reflect light by TIR toward the narrow portion or distal end of the extractor. The lands can also serve as a lower viewing port for extracted light. Preferably, the lands are planar although they can have other shapes such as convex or concave shapes if desired. Preferably the lands have flat, optically smooth surfaces so as not to induce scattering of the reflected light. As noted above, the land segments preferably decrease in length along the length of the extractor. A preferred pitch is from about 0.06 to about 12 projections per mm at the light input end to about 250 to about 1 projection per mm at the distal end or narrowest portion of the extractor. A preferred land segment length is about 0.003 to about 15 mm, more preferably about 0.003 to about 1.2 mm. The angle γ between the reference plane and a land preferably is about 0 to about 5 degrees, more preferably about 0.5 to about 2 degrees. Most preferably, the lands are tilted in the opposite direction from the wedge. When so tilted, light that comes from the input end of the extractor and strikes the lands will tend subsequently to strike the facets at a higher angle of incidence, thereby increasing extraction efficiency.

The projections can extend across the full width of the light-redirecting surface (as is shown, for example, in **Fig. 7**) or can be in the form of shorter, less than full width segments, which can be aligned with one another in rows and columns or staggered from row to row. Rows of projections can be arranged in parallel to the light input surface or at an angle with respect to that surface. Preferably, the projections extend across the full width of the light-redirecting surface and are generally parallel to the light input surface.

The light input surface and light output surface can be planar or have a convex or concave curvature. When the light source is a point source, the light input surface preferably has a convex curvature. If the incoming light is not evenly distributed along the width of the input surface, then lenslets, prisms, a roughened surface or other microstructures can be added to the light input surface to more evenly distribute the light. The light output surface preferably has an optically smooth finish, in order to minimize transmission losses, undesired scattering and distortion.

Microsoft Exhibit 1002 - Page 1573
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

The light extractor can have any desired overall size and thickness but preferably it is as thin as possible, e.g., 5 mm or less at the thickest portion of the extractor. The light extractor can be square, rectangular, oval or any other desired shape when viewed from the intended display observation point. The size and shape of the extractor usually will be dictated by the size and shape of the desired display device and by whether the extractor is intended to function as a point to line, line to area or point to area converter. The light extractors of the invention are particularly useful as point to area or line to area front light guides for subminiature or miniature display devices illuminated with light emitting diodes (LEDs) powered by small batteries. Suitable display devices include color or monochrome LCD devices for cell phones, pagers, personal digital assistants, clocks, watches, calculators, laptop computers, vehicular displays and the like. The display can also be a fixed graphic such as a poster or sign, or a variable-appearance substrate such as "Gyricon" electronic display material (under development by Xerox Corporation). In addition to LEDs, other suitable illumination sources include fluorescent or incandescent lamps, electroluminescent lights and the like.

The light extractors of the invention can be fabricated from a wide variety of optically suitable materials including polycarbonate; polyacrylates such as polymethyl methacrylate; polystyrene and glass, with high refractive index plastics such as polycarbonate being preferred. The light extractors preferably are made by molding, embossing, curing or otherwise forming an injection moldable resin against a lathe-turned tool or other formed surface, made of metal or other durable material that bears a negative replica of the desired structured surface. Methods for making such formed surfaces and for molding, embossing or curing the extractor will be familiar to those skilled in the art. Individual light extractor designs can if desired be evaluated without the need for actual extractor fabrication, by using suitable ray-tracing modeling software such as "ASAP" from Breault Research Organization, Inc., "Code V" and "Light Tools" from Optical Research Associates, "Optica" from Wolfram Research, Inc. and "ZEMAX" from Focus Software, Inc..

The invention is further illustrated in the following non-limiting examples.

Microsoft Exhibit 1002 - Page 1574
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Examples

Two generally planar and three generally wedge-shaped extractors were simulated using CAD software and evaluated using ASAP ray tracing software. This approach gives generally good agreement with observed actual results without the need to mold and fabricate prototypes. Each extractor would be made from 1.58 refractive index polycarbonate plastic. All would have a 30 mm width, 40 mm length, and 1 mm thick input aperture. The distal ends of Extractors 1 and 2 would be 1 mm thick. The distal ends of Extractors 3, 4 and 5 would be 0.2 mm thick. The light sources were assumed to be rectangular, 30 mm long, 1 mm high, and with a Lambertian light distribution.

The general shapes of the steps or projections in Extractors 1 through 5 are shown in **Figs. 10a** through **10e**, respectively. The dashed lines in **Figs. 10a** through **10e** are drawn parallel to the reference plane. Extractors 4 and 5 would be extractors of the invention. The angles and dimensions of the segments for each extractor are listed below in Table I. For Extractors 1 through 4, the lands (and plateaus if present) would be horizontal (γ is zero). For Extractor 5, the lands would tilt slightly upward at an angle γ of 0.75 degrees. For all extractors, the risers (if present) would be tilted at an angle ρ of 90 degrees. The facets in each extractor would be tilted at an angle ϕ of 30 degrees.

For Extractors 1 through 3, the riser height and facet height values shown in Table I would apply to the entire extractor. For Extractors 4 and 5, Table I shows the height of the facet nearest the input end of the extractor. The facet heights for Extractors 4 and 5 would decrease from the input end towards the distal end of each extractor. For Extractor 5, Table I shows the height of the riser nearest the distal end of the extractor. The riser heights for Extractor 5 would decrease from the distal end towards the input end of the extractor. These variations in facet or riser height permit the riser-plateau vertices of Extractors 4 and 5 to lie along a straight line.

The pitch between projections was varied for each extractor in order to optimize predicted light output to a display to within about ±10% over the area of the extractor's light output surface. The predicted light extraction efficiency for each extractor was then calculated and recorded.

Extractors 1 and 3 through 5 were assumed to have 200 steps or projections along the length of the extractor. Extractor 2 was assumed to have 400 projections along the length of the extractor. This provided an increase in efficiency compared to Extractor 2,

Microsoft Exhibit 1002 - Page 1575
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

but uniformity of light output decreased and the large number of projections would make Extractor 2 more difficult to manufacture.

Microsoft Exhibit 1002 - Page 1576
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

TABLE I

Extractor No.	β	γ	ρ	θ	ϕ	Riser Height, mm	Plateau Length, mm	Facet Height, mm	Total No. of Projections	Starting Pitch, mm	ΔPitch, mm	Minimum Pitch, mm	Extractor Efficiency
1	0°	0°	90°	0°	30°	0.005	0.01768	0.005	200	0.30	1.00363×10^{-3}	0.06	27%
2	0°	0°	90°	0°	30°	0.005	0.01768	0.005	400	0.175	4.151×10^{-4}	0.06	42%
3	1.45°	0°	NA	0°	30°	NA	NA	0.004	200	0.21832	0	0.21832	40%
4	1.45°	0°	90°	0°	30°	0.005	0.01768	0.013	200	0.4	2.077855×10^{-3}	0.06	56%
5	1.45°	0.75°	90°	0°	30°	0.0046	0.01768	0.0138	200	0.44	2.56236×10^{-3}	0.06	59%

14

Notes:

"NA" = Not Applicable

Microsoft Exhibit 1002 - Page 1577
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

As shown in Table I, the extractors of the invention (Extractor 4 and Extractor 5) had a considerably better overall efficiency than extractors without risers (Extractor 1 and Extractor 2). The extractors of the invention also had considerably better overall efficiency than a step-wedge style extractor (Extractor 3). This improved efficiency should help provide significantly increased battery life in a battery-powered display.

Further increases in efficiency may be available via further adjustment of the land tilt angle γ but at a potential decrease in overall uniformity of illumination.

Various modifications and alterations of this invention will be apparent to those skilled in the art without departing from the scope and spirit of this invention. It should be understood that this invention is not limited to the illustrative embodiments set forth above.

Microsoft Exhibit 1002 - Page 1578
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

Claims

1. A light extraction device having:
   a) a light input end;
   b) a generally planar light output surface that can deliver light to a display; and
   c) a structured light-redirecting surface located generally opposite the light output surface;

wherein the light output surface and light-redirecting surface define a generally wedge-shaped profile that decreases in thickness from the light input end towards the center of the device; the light-redirecting surface reflects light towards the light output surface and thence to the display; and the light-redirecting surface comprises a plurality of projections comprising a riser segment, plateau segment, and facet segment, with land segments flanking the projections.

2. A light extraction device according to claim 1, wherein the presence of the riser segments increases the extraction of light from the device by the facet segments.

3. A light extraction device according to claim 1, wherein variation in the height of the riser segments will alter the ratio of light that is reflected by the facet segments to light that is reflected by the land segments.

4. A light extraction device according to claim 1, wherein if an imaginary line is drawn from the vertex between a land segment and an adjoining riser segment on a projection to the vertex between a facet segment on that projection and an adjoining land segment, in order to form an imaginary quadrilateral, the quadrilateral is generally trapezoidal in cross-section.

5. A light extraction device according to claim 1, wherein the device decreases in thickness from the light input end along the entire length of the device.

6. A light extraction device according to claim 1, wherein if an imaginary line is drawn through the vertices between riser segments and adjoining plateau segments, and the light output surface is designated as a reference plane, then the angle β between the reference plane and the imaginary line is about 0.4 to about 4 degrees.

Microsoft Exhibit 1002 - Page 1579
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

7. A light extraction device according to claim 6, wherein the angle ρ between the reference plane and a riser segment is about 85 to about 65 degrees, the angle θ between the reference plane and a plateau segment is about 0 about 2 degrees and the angle ϕ between the reference plane and a facet segment is about 20 to about 60 degrees.

8. A light extraction device according to claim 6, wherein the angle γ between the reference plane and a land segment is about 0.5 to about 2 degrees.

9. A light extraction device according to claim 6, wherein the land segments and the imaginary line are tilted in opposite directions with respect to the reference plane.

10. A light extraction device according to claim 6, wherein the vertices lie along a straight line.

11. A light extraction device according to claim 6, wherein the vertices lie along a curved line.

12. A light extraction device according to claim 1, wherein the lengths of the land segments diminish from the input end of the extractor towards the narrowest portion or distal end of the extractor.

13. A light extraction device according to claim 1, wherein the projections are spaced at a relatively coarser pitch near the light input end of the extractor, and at a relatively finer pitch towards the narrowest portion or distal end of the extractor.

14. A light extraction device according to claim 1, wherein the riser segment heights $\mathbf{r_h}$ are about 0.001 to about 0.5 mm, the plateau segment lengths are about 0.002 to about 1.5 mm, the facet segment heights $\mathbf{f_h}$ are about 0.001 to about 1.5 mm and the land segment lengths are about 0.003 to about 15 mm.

15. A light extraction device according to claim 14, wherein the facet segment heights are greater than the riser segment heights.

Microsoft Exhibit 1002 - Page 1580
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

16. A light extraction device according to claim 1, wherein the projections extend across the full width of the light-redirecting surface and are generally parallel to the light input surface.

17. A display device comprising a point or elongated light source optically coupled to a light extraction device according to claim 1, the extraction device being optically coupled to a light valve that modulates light from the light extraction device.

18. A display device according to claim 17, wherein the light extraction device is a front light guide.

19. A display device according to claim 17, wherein the light extraction device is a backlight.

20. A display device according to claim 17, wherein the device comprises a cellular telephone, pager, personal digital assistant, clock, watch, calculator, laptop computer or transportation vehicle.

Microsoft Exhibit 1002 - Page 1581
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

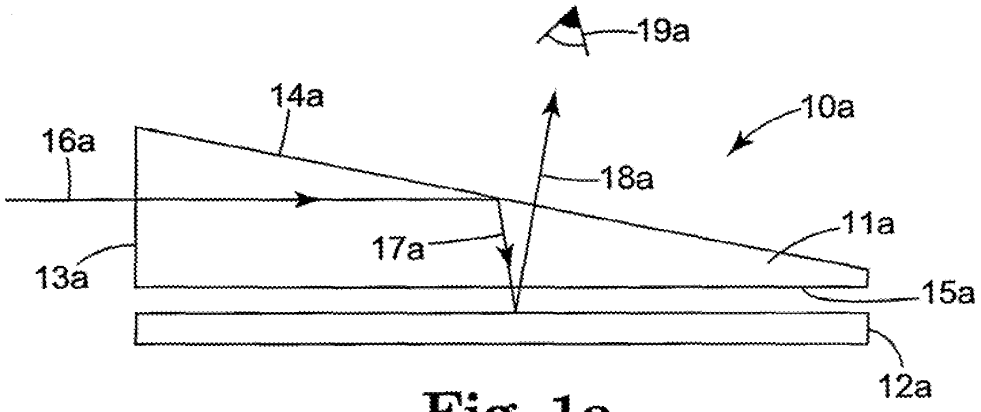


Fig. 1a

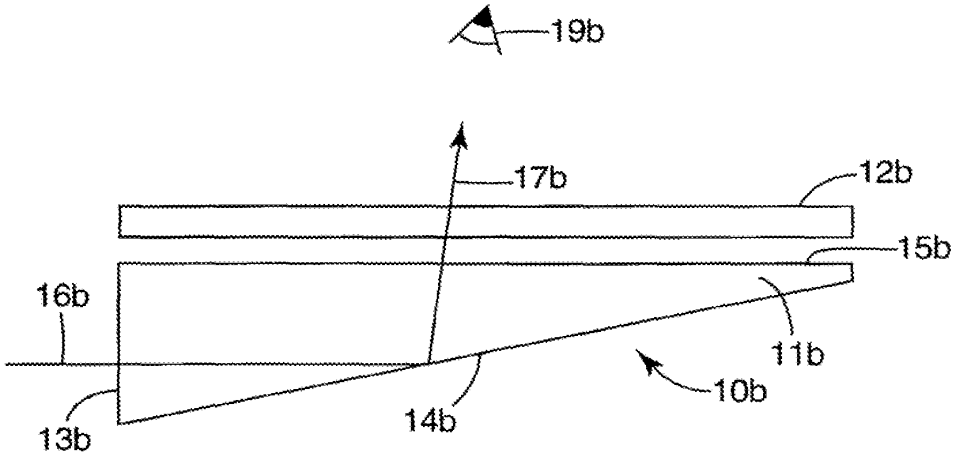


Fig. 1b

Microsoft Exhibit 1002 - Page 1582
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

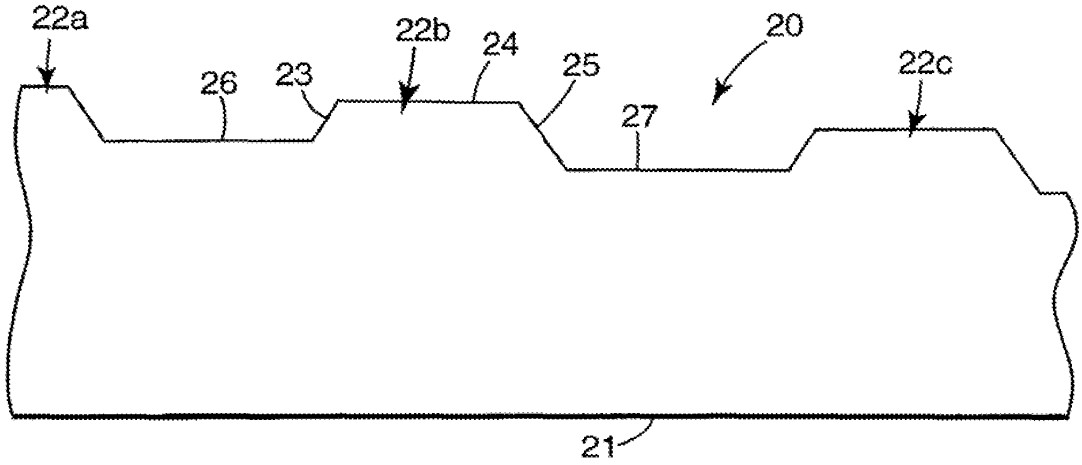


Fig. 2

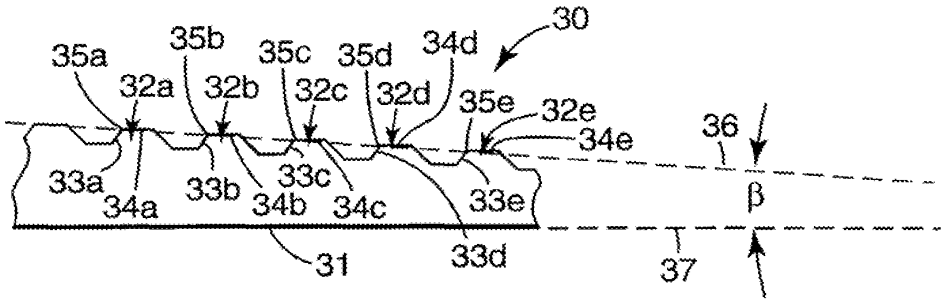


Fig. 3

Microsoft Exhibit 1002 - Page 1583
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

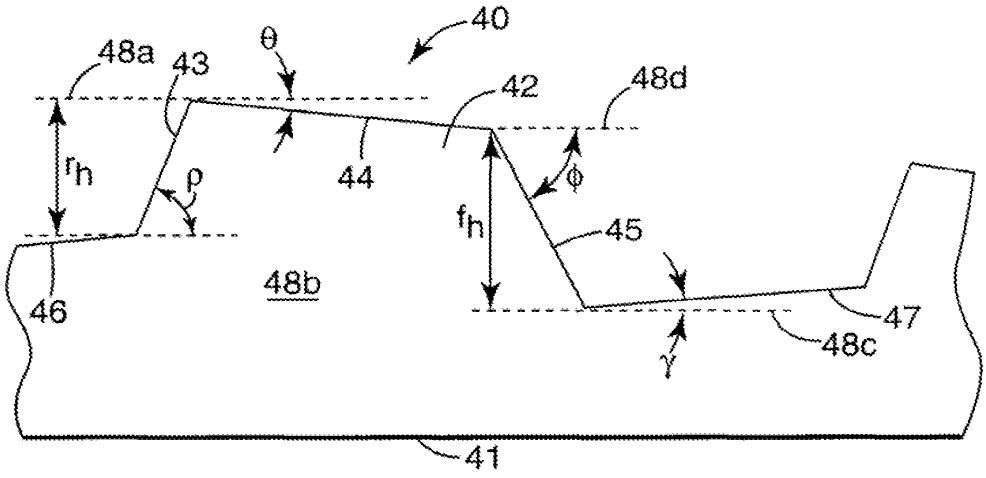

40
θ
48a
43
42
48d
r_h
ρ
44
f_h
ϕ
45
48b
46
47
48c
γ
41

Fig. 4

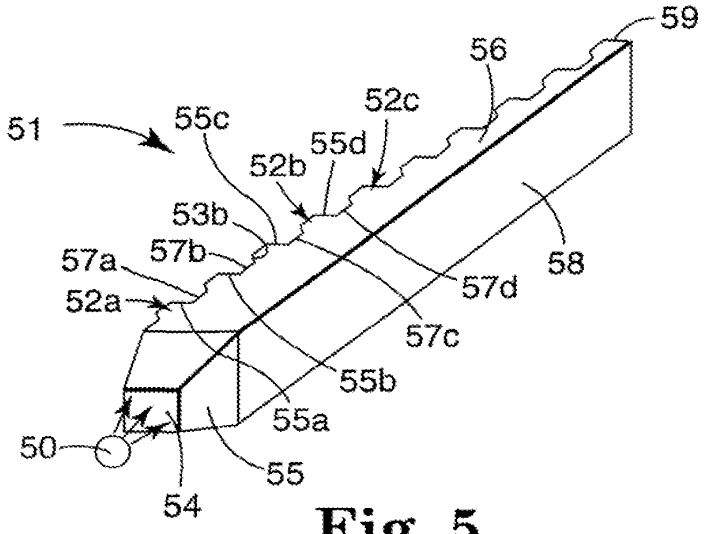

59
56
51
55c
52c
55d
52b
53b
57a
57b
57d
58
52a
57c
55b
55a
50
55
54

Fig. 5

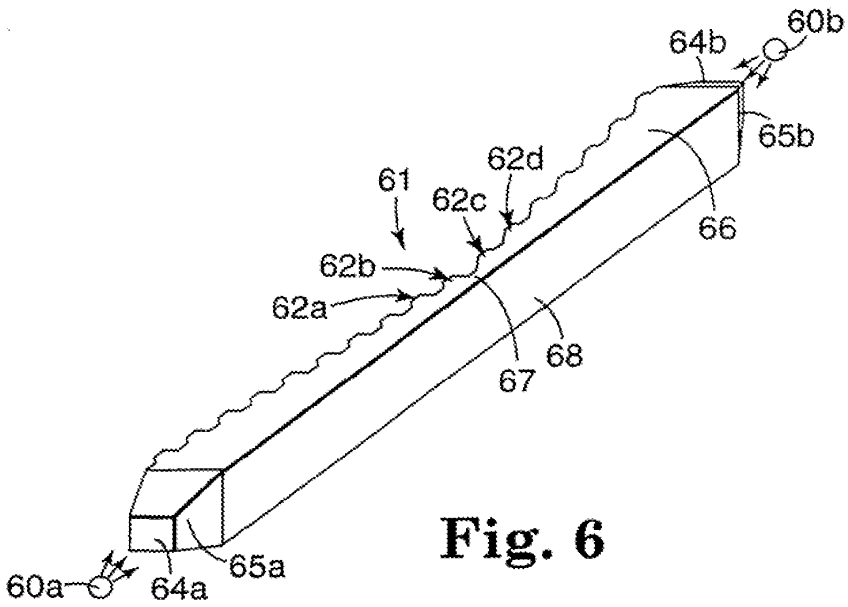


Fig. 6

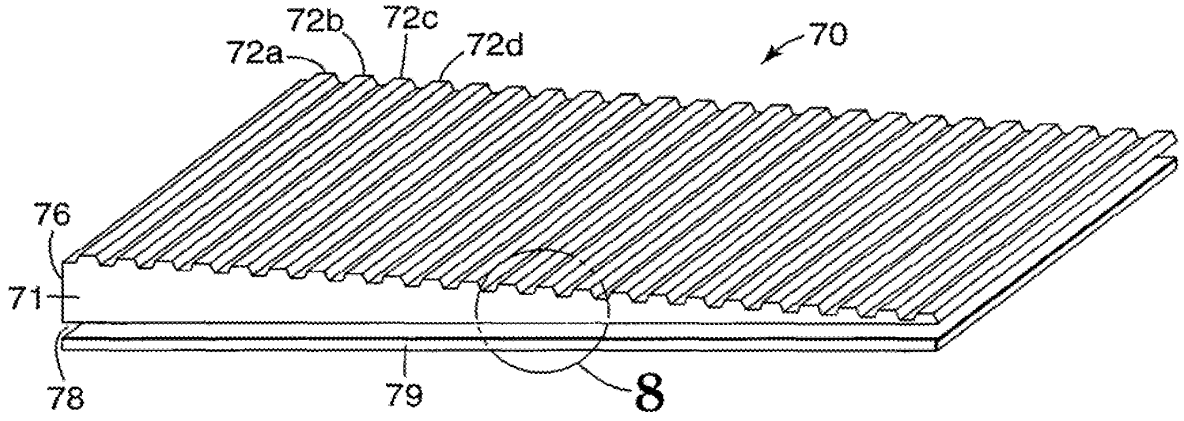


Fig. 7

Microsoft Exhibit 1002 - Page 1585
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

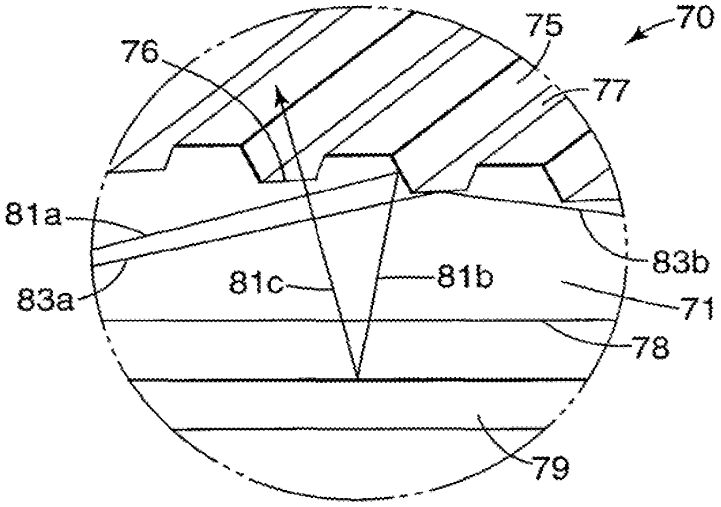


Fig. 8

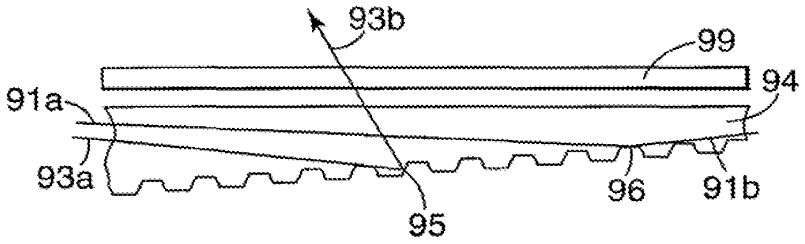


Fig. 9

Microsoft Exhibit 1002 - Page 1586
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

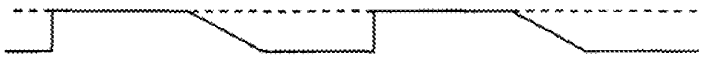


Fig. 10a

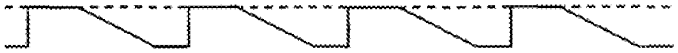


Fig. 10b

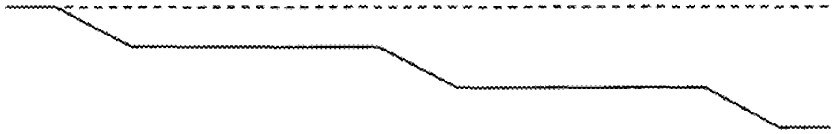


Fig. 10c

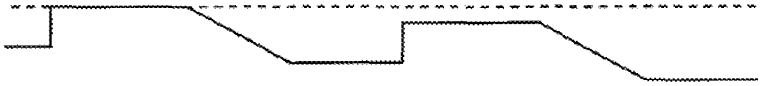


Fig. 10d

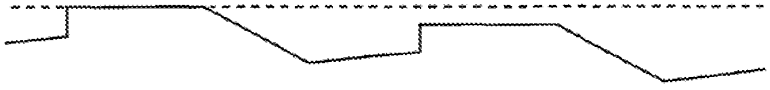


Fig. 10e

Microsoft Exhibit 1002 - Page 1587
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/00873

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F21V8/00

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 F21V

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 940 706 A (MINEBEA) 8 September 1999 (1999-09-08) column 9; claims 1-3; figures 1,5-10	1,5, 15-19

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

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 June 2001	22/06/2001

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	Malic, K

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Microsoft Exhibit 1002 - Page 1588
Microsoft Corporation v. RealD Spark, LLC
IPR2023-01046 - U.S. Patent No. 10,740,985

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte. onal Application No
PCT/US 01/00873

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0940706 A	08-09-1999	JP 11260128 A	24-09-1999
		US 6088074 A	11-07-2000

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