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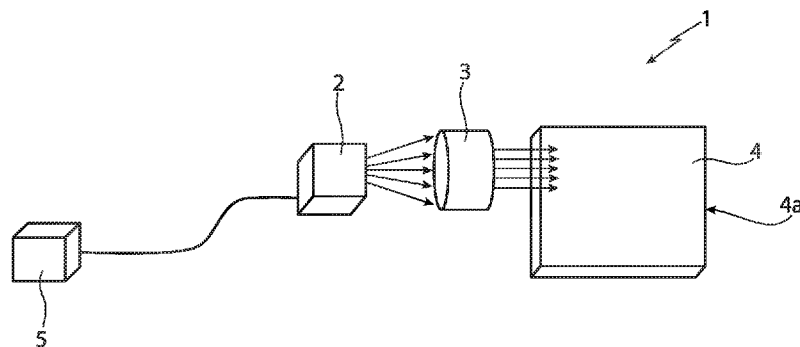


FIG. 2

(57) Abstract: The present invention concerns a projection-based display system (1) including: a light source (2) that is a light engine based on a RGB microled array, a coupling optics (3) and a diffractive waveguide (4) that comprises a dark, reflective rear face and a transparent front face (4a); wherein the light source (2) is configured to inject one or more light beams/signals carrying one or more given images into the diffractive waveguide (4) via the coupling optics (3), whereby the injected light beams/signals impinge on the dark, reflective rear face, the given image(s) are focused on said dark, reflective rear face, and said injected light beams/signals are reflected by said dark, reflective rear face thus reaching the transparent front face (4a) where said given image(s) is/are displayed.

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## INNOVATIVE PROJECTION-BASED DISPLAY SYSTEM WITH ADJUSTABLE GEOMETRY

### CROSS-REFERENCE TO RELATED APPLICATIONS

5           This Patent Application claims priority from Italian Patent Application No. 102023000011475 filed on June 6, 2023, the entire disclosure of which is incorporated herein by reference.

### TECHNICAL FIELD OF THE INVENTION

10           The present invention relates, in general, to an innovative display system with adjustable geometry and, in particular, to a geometrically resizable waveguide integrated/embedded in a projection-based display system.

### STATE OF THE ART

15           Nowadays, in avionic sector, several information items (e.g., parameters, data, etc.) are displayed on Liquid Crystal Displays (LCDs) installed on cockpits. In principle, LCDs are fitted into fixed slots of different geometries because of space constraints. However, it is worth noting that LCD market has no geometrical flexibility since it offers only predefined shapes and aspect ratios. In many cases, a mismatch arises between the allocated space geometry for displays and available mechanical characteristics of commercial LCDs. In this context, customized displays must be developed ad hoc in order to fit the defined space constraints leading to high costs with relative loss in competitiveness. Furthermore, the required numbers for a customized unit may far exceed the needs (e.g., in avionic market, etc.).

20           US 2006/132914 A1 discloses an incident image displaying device for displaying at least one incident image against a scene image of a scene, the incident image displaying device including at least one light guide, at least one input beam

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transforming element, at least one output beam transforming element and a scene image reflector, each of the input beam transforming element and the output beam transforming element being incorporated with a respective light guide, the scene image reflector being located behind the light guide, the input beam transforming element receiving incident light beams respective of the incident image from a respective one of at least one image source, the output beam transforming element being associated with a respective input beam transforming element, the scene image reflector reflecting the scene image through at least a portion of the output beam transforming element, wherein the input beam transforming element couples the incident light beams into the respective light guide as a set of coupled light beams, the set of coupled light beams is associated with the respective input beam transforming element, wherein the output beam transforming element receives from the respective light guide and decouples as decoupled light beams, the set of coupled light beams, thereby forming a set of output decoupled images, and wherein each output decoupled image of the set of output decoupled images is representative of a sensor fused image of the incident image.

US 2016/377862 A1 discloses a system to be used with an aircraft or other vehicle and including a waveguide disposed above and below a top surface of a glare shield. The waveguide can be part of a head up display (HUD) and can be disposed to cover at least part of the head down display to provide an integrated display.

US 2016/170212 A1 discloses an optical device that includes a light waves-transmitting substrate having two major surfaces and edges, optical means for coupling light into the substrate by total internal reflection, and a plurality of partially reflecting surfaces carried by the substrate. The partially reflecting surfaces are parallel to each other and are not parallel to any of the edges of the

substrate, one or more of the partially reflecting surfaces being an anisotropic surface. The optical device has dual operational modes in see-through configuration. In a first mode, light waves are projected from a display source through the substrate to an eye of a viewer. In a second mode, the display source is shut off and only an external scene is viewable through the substrate.

US 2006/215244 A1 discloses a system for displaying an incident image for an operator of a vehicle, the system including an optical assembly receiving the incident image from an image source, and a planar optical module optically coupled with the optical assembly, the optical assembly producing a collimated light beam according to the incident image, the planar optical module being located in a line of sight of the operator, the planar optical module displaying a set of output decoupled images, each of the output decoupled images being similar to the incident image, and each of the output decoupled images having a focal point substantially located at an infinite distance from the operator.

#### **OBJECT AND SUMMARY OF THE INVENTION**

The Applicant has felt the need to solve the problem of potential mismatch between the cockpit space allocated for displays and the LCDs available on the market, thereby achieving the present invention.

Therefore, an object of the present invention is that of providing a solution to potential mismatch between the cockpit space allocated for displays and the LCDs available on the market.

This and other objects are achieved by the present invention in that it relates to a projection-based display system, as defined in the appended claims.

In particular, a projection-based display system according to the present invention includes:

- a light source that is a light engine based on a RGB microled array,
- a coupling optics and
- a diffractive waveguide that comprises a dark,

5 reflective rear face and a transparent front face.

The light source is configured to inject one or more light beams/signals carrying one or more given images into the diffractive waveguide via the coupling optics, whereby

- the injected light beams/signals impinge on the dark,

10 reflective rear face,

- the given image(s) are focused on said dark, reflective rear face, and
- said injected light beams/signals are reflected by said dark, reflective rear face thus reaching the transparent

15 front face (4a) where said given image(s) is/are displayed.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

For a better understanding of the present invention, preferred embodiments, which are intended purely by way of non-limiting, non-binding examples, will now be described with reference to the attached drawings (all not to scale), wherein Figures 1 and 2 schematically illustrate a projection-based display system according to an embodiment of the present invention.

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#### **DESCRIPTION OF EMBODIMENTS OF THE INVENTION**

The following description is presented to enable a person skilled in the art to comprehend, make and use the invention. Various modifications to the embodiments will be readily apparent to those skilled in the art, without departing from the scope of the present invention as claimed. Thence, the present invention is not intended to be limited to the embodiments shown and described but is to be accorded the widest scope of protection consistent with the features

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35 defined in the appended claims.

The present invention concerns a projection-based display system that includes a light source, a coupling optics and a diffractive waveguide, wherein the light source is a light engine based on RGB microscopic Light Emitting Diode (microled) array; the diffractive waveguide comprises transparent material having a transparent front face and a dark, reflective rear surface (i.e., an absorbing surface but still with the capability to reflect a percentage of wavelengths - in particular, including visible wavelengths).

Said light source injects images to be displayed into the diffractive waveguide by means of the coupling optics, wherein the images are projected on the front face of the diffractive waveguide that is designed to present a distortion-free image by maintaining phase and intensity relations of the input signal.

Figures 1 and 2 schematically illustrate a projection-based display system 1 according to an embodiment of the present invention, wherein said projection-based display system 1 includes a light engine 2 (preferably a microled array, conveniently a RGB microled array), a coupling optics 3 (preferably including one or more lenses) and a diffractive waveguide 4 that includes a dark, reflective rear face (or wall) and a transparent front face (or wall) 4a. In use, the light engine 2 injects one or more light beams/signals carrying one or more given images into the diffractive waveguide 4 via the coupling optics 3, in particular via a side wall of said diffractive waveguide 4. Then, the injected light beam(s)/signal(s) impinge on the dark, reflective rear face, whereby said light beam(s)/signal(s) is/are reflected by said dark, reflective rear face so as to reach the transparent front face 4a where the given image(s) is/are displayed.

In this respect, it is worth noting that dotted lines shown in Figure 1 represent different combinations between waveguide shape and optical coupling.

Moreover, with reference to Figure 2, the light engine 2 receives from a processing device/system 5 (e.g., a Personal Computer - PC) digital data (preferably, a digital video signal) indicative of the given image(s) to be displayed and generates corresponding divergent light beam(s)/signal(s) based on said digital data. Then, the coupling optics 3 converges said divergent light beam(s)/signal(s) in paraxial rays parallel to a given optical axis, whereby the light beam beam(s)/signal(s) enter(s) the diffractive waveguide 4 via the side wall thereof.

It is worth noting that the waveguides, thanks to the variation of refractive index of their own transparent material, have the capability to guide input light waves through the transparent material without losing wave spatial coherence.

The geometrical variation of size and form factor of the diffractive waveguide 4 allows to have display with different sizes and form factors.

In this context, by making a parallelism, said projection-based display system 1 is equivalent to a transmissive LCD, wherein the light engine 2 is equivalent to a picture generator that is within common consumer projectors, the coupling optics 3 is an output optics of said common consumer projectors and the diffractive waveguide 4 corresponds to a white wall where pictures are projected.

The present invention allows to make a projective flat panel display visually appearing as a transmissive LCD that can be tailored by simply resizing the diffractive waveguide 4 and changing the coupling optics 3 so as to fit the allocated space on a cockpit.

In view of the foregoing, the projection-based display system 1 has a geometrical flexibility, namely: by resizing and shaping the diffractive waveguide 4 and consequently

adapting the lenses of the optical coupler 3, different shapes can be achieved, whereby with one and the same light engine 1 it is possible to have several differently-shaped flat panel displays.

5 From the foregoing, the innovative features and the technical advantages of the present invention are immediately clear to a skilled person.

In particular, some advantages of the present invention are:

- 10 • money saving due to the fact that no customized display has to be developed;
- space optimization; and
  - less weight than a commercial LCD.

Moreover, it is worth noting that the present invention  
15 can be advantageously exploited on board aircraft, helicopters, terrestrial vehicles, naval units, trains or the like.

In conclusion, it is clear that numerous modifications and variants can be made to the present invention, all  
20 falling within the scope of the invention, as defined in the appended claims.

**CLAIMS**

1. Projection-based display system (1) including:

- a light source (2) that is a light engine based on  
5 a RGB microled array,
- a coupling optics (3) and
- a diffractive waveguide (4) that comprises a dark,  
reflective rear face and a transparent front face (4a);  
wherein the light source (2) is configured to inject  
10 one or more light beams/signals carrying one or more  
given images into the diffractive waveguide (4) via the  
coupling optics (3), whereby
  - the injected light beams/signals impinge on the  
dark, reflective rear face,
  - 15 • the given image(s) are focused on said dark,  
reflective rear face, and
  - said injected light beams/signals are reflected  
by said dark, reflective rear face thus reaching the  
transparent front face (4a) where said given image(s)  
20 is/are displayed.

2. The projection-based display system (1) of claim  
1, wherein the light source (2) is configured to generate  
one or more divergent light beams/signals, and wherein  
25 the coupling optics (3) is configured to converge said  
divergent light beam(s)/signal(s) in paraxial rays  
parallel to a given optical axis, whereby the light beam  
beam(s)/signal(s) enter(s) the diffractive waveguide (4)  
via a side wall thereof.

3. The projection-based display system of claim 2,  
wherein the coupling optics (3) includes one or more  
lenses.

4. The projection-based display system according to

any preceding claim, further including a processing device/system (5) configured to provide the light source (2) with digital data indicative of the given image(s) to be displayed; wherein the light source (2) is configured to  
5 generate corresponding light beam(s)/signal(s) based on said digital data.

5. Aircraft equipped with the projection-based display system (1) as claimed in any preceding claim.

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6. Helicopter equipped with the projection-based display system (1) as claimed in any claim 1-4.

7. Terrestrial vehicle equipped with the projection-  
15 based display system (1) as claimed in any claim 1-4.

8. Naval unit equipped with the projection-based display system (1) as claimed in any claim 1-4.

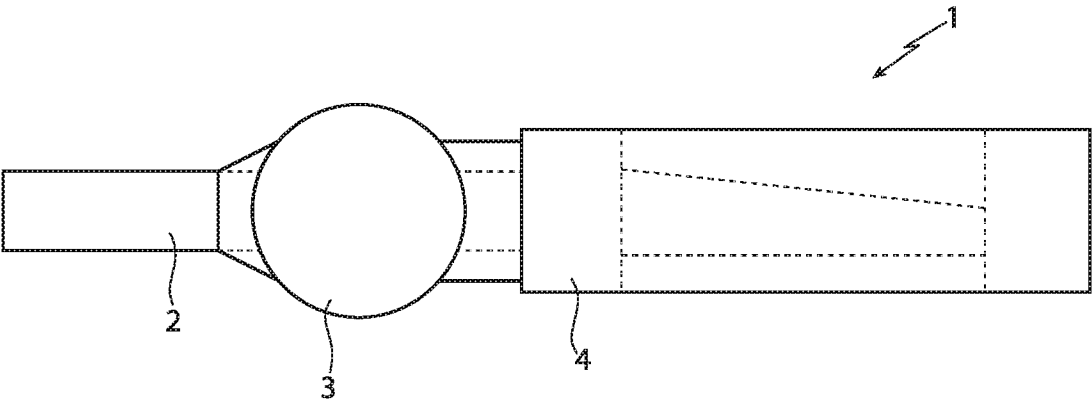


FIG. 1

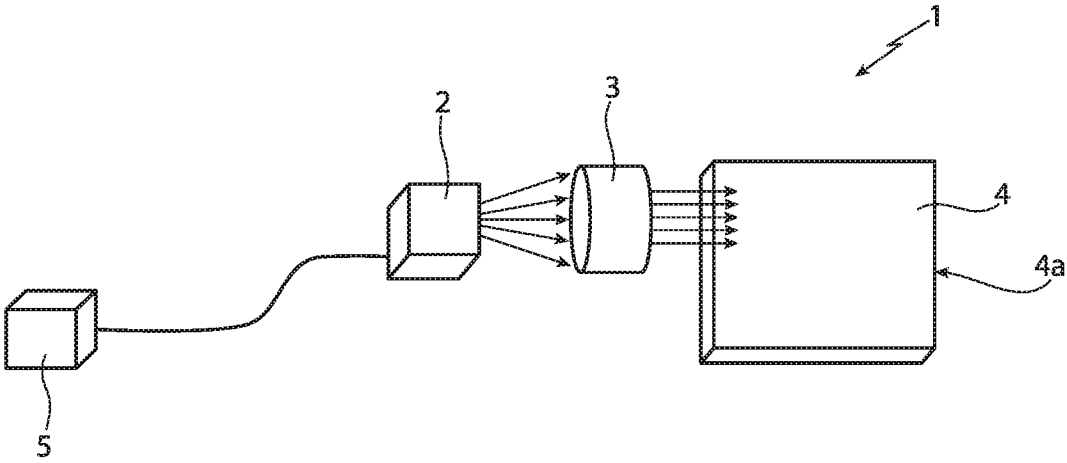


FIG. 2

## INTERNATIONAL SEARCH REPORT

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|                                                                                                                                                                         |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------|
| <b>A. CLASSIFICATION OF SUBJECT MATTER</b>                                                                                                                              |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| INV.                                                                                                                                                                    | G03B21/28                                                                                                                              | B64D43/00 | G02B27/42                                                                                                                                                                                                                                         | G03B21/56 | G03B21/60             |
|                                                                                                                                                                         | F21V8/00                                                                                                                               | B60W50/14 |                                                                                                                                                                                                                                                   |           |                       |
| ADD.                                                                                                                                                                    |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| According to International Patent Classification (IPC) or to both national classification and IPC                                                                       |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| <b>B. FIELDS SEARCHED</b>                                                                                                                                               |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| Minimum documentation searched (classification system followed by classification symbols)                                                                               |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| G02B B60W G03B B64D                                                                                                                                                     |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| 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)                                            |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| EPO-Internal                                                                                                                                                            |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                           |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| Category*                                                                                                                                                               | Citation of document, with indication, where appropriate, of the relevant passages                                                     |           |                                                                                                                                                                                                                                                   |           | Relevant to claim No. |
| Y                                                                                                                                                                       | US 2002/008854 A1 (LEIGH TRAVIS ADRIAN ROBERT [GB]) 24 January 2002 (2002-01-24) paragraphs [0034] - [0046]; figures 2, 8<br>-----     |           |                                                                                                                                                                                                                                                   |           | 1 - 8                 |
| Y                                                                                                                                                                       | US 2013/010355 A1 (CHEN LIYING [US] ET AL) 10 January 2013 (2013-01-10) paragraph [0015]; figure 2<br>-----                            |           |                                                                                                                                                                                                                                                   |           | 1 - 8                 |
| Y                                                                                                                                                                       | US 2016/377862 A1 (ZIMMERMAN KENNETH A [US] ET AL) 29 December 2016 (2016-12-29) paragraphs [0021] - [0043]; figures 1, 2, 4A<br>----- |           |                                                                                                                                                                                                                                                   |           | 1 - 8                 |
| <input type="checkbox"/> Further documents are listed in the continuation of Box C.                                                                                     |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
| <input checked="" type="checkbox"/> See patent family annex.                                                                                                            |                                                                                                                                        |           |                                                                                                                                                                                                                                                   |           |                       |
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| Date of the actual completion of the international search                                                                                                               |                                                                                                                                        |           | Date of mailing of the international search report                                                                                                                                                                                                |           |                       |
| 20 September 2024                                                                                                                                                       |                                                                                                                                        |           | 04/10/2024                                                                                                                                                                                                                                        |           |                       |
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
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| -----                                     |                     |                            |                     |