



US012282171B2

(12) **United States Patent**  
**Marcellin-Dibon et al.**

(10) **Patent No.:** **US 12,282,171 B2**  
(45) **Date of Patent:** **Apr. 22, 2025**

(54) **SPECTACLES WITH OPTICAL DISPLAY SYSTEM**

(71) Applicant: **MICROOLED**, Grenoble (FR)

(72) Inventors: **Eric Marcellin-Dibon**, Vaucresson (FR); **François Boubel**, Saint-Egrève (FR); **Antoine Simon Turquet**, Grenoble (FR); **Cédric Siourakan**, Grenoble (FR)

(73) Assignee: **MICROOLED**, Grenoble (FR)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 33 days.

(21) Appl. No.: **16/472,738**

(22) PCT Filed: **Dec. 21, 2017**

(86) PCT No.: **PCT/FR2017/053764**

§ 371 (c)(1),

(2) Date: **Jun. 21, 2019**

(87) PCT Pub. No.: **WO2018/115762**

PCT Pub. Date: **Jun. 28, 2018**

(65) **Prior Publication Data**

US 2020/0355927 A1 Nov. 12, 2020

(30) **Foreign Application Priority Data**

Dec. 22, 2016 (FR) ..... 1663159

(51) **Int. Cl.**  
**G02B 27/01** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **G02B 27/0176** (2013.01); **G02B 27/0172** (2013.01); **G02B 2027/015** (2013.01);  
(Continued)

(58) **Field of Classification Search**

CPC ..... G02B 27/0176; G02B 27/0172; G02B 2027/015; G02B 2027/0161;

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,547,049 A \* 10/1985 Cotie ..... G02C 7/086  
351/159.08

6,394,601 B1 5/2002 Bettinger  
(Continued)

FOREIGN PATENT DOCUMENTS

EP 2698662 A1 2/2014  
WO WO-2016135727 A1 \* 9/2016 ..... G02B 27/0172

OTHER PUBLICATIONS

International Search Report and Written Opinion dated Mar. 21, 2018, for corresponding International Application No. PCT/FR2017/053794, International Filing Date Dec. 21, 2017, consisting of 11-pages.

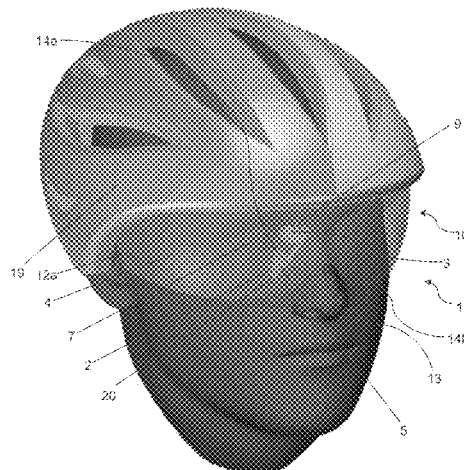
*Primary Examiner* — Henry Duong

(74) *Attorney, Agent, or Firm* — Gearhart Law, LLC

(57) **ABSTRACT**

Spectacles (1) comprising a face (10) that is provided with at least one lens-type optical unit (4), said face defining a passage (13) for the nose of the user, said passage for the nose being defined by first and second so-called internal edges (14a, b) of the face, said edges being turned toward first and second lateral edges (12a, b) of the face (10), respectively, the spectacles (1) furthermore comprising: —a module (2) for emitting visual information, comprising an element for emitting said visual information; —and a geometric element (3) for returning the converted visual information, which is able to return the converted visual information toward a target zone (6) of the optical unit (4), characterised in that: —the emitting module (2) is placed in the bottom or top portion of a first internal edge (14a) of the face (10), whereas the geometric return element (3) is placed

(Continued)



in the top or bottom portion of the first internal edge (14a), the geometric return element (3) being placed in the top portion of the first internal edge (14a) when the emitting module (2) is placed in the bottom portion of the first internal edge (14a) of the face, and the geometric return element (3) being placed in the bottom portion of the first internal edge (14a) when the emitting module (2) is placed in the top portion of the first internal edge (14a) of the face.

### 19 Claims, 8 Drawing Sheets

- (52) **U.S. Cl.**  
CPC ..... G02B 2027/0161 (2013.01); G02B  
2027/0178 (2013.01)
- (58) **Field of Classification Search**  
CPC ..... G02B 2027/0178; G02B 27/0101; G02B  
2027/0145

USPC ..... 359/633  
See application file for complete search history.

(56)

### References Cited

#### U.S. PATENT DOCUMENTS

10,025,093	B2 *	7/2018	Wall .....	G02B 27/0081
11,227,294	B2 *	1/2022	Nortrup .....	G06F 3/03545
2003/0184868	A1	10/2003	Geist	
2013/0222214	A1 *	8/2013	Takeda .....	G02B 5/18 345/8
2015/0042544	A1 *	2/2015	Sugihara .....	G02B 27/017 345/8
2015/0205112	A1 *	7/2015	Border .....	G02B 27/01 359/630
2015/0309316	A1 *	10/2015	Osterhout .....	G06F 3/03547 345/8
2016/0306171	A1	10/2016	Rudolph et al.	
2018/0011322	A1 *	1/2018	Leighton .....	G02B 27/0172

\* cited by examiner

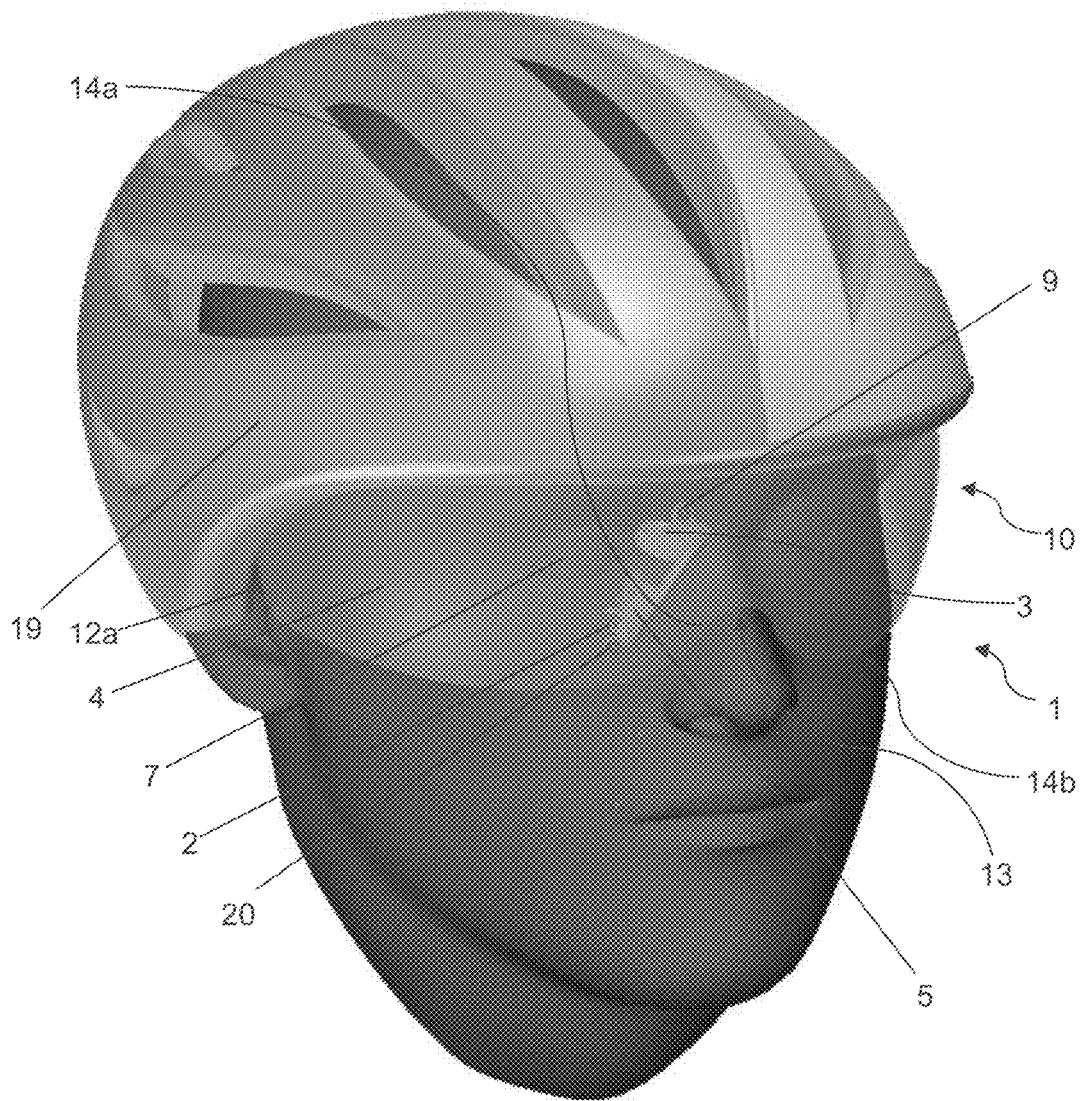


Figure 1

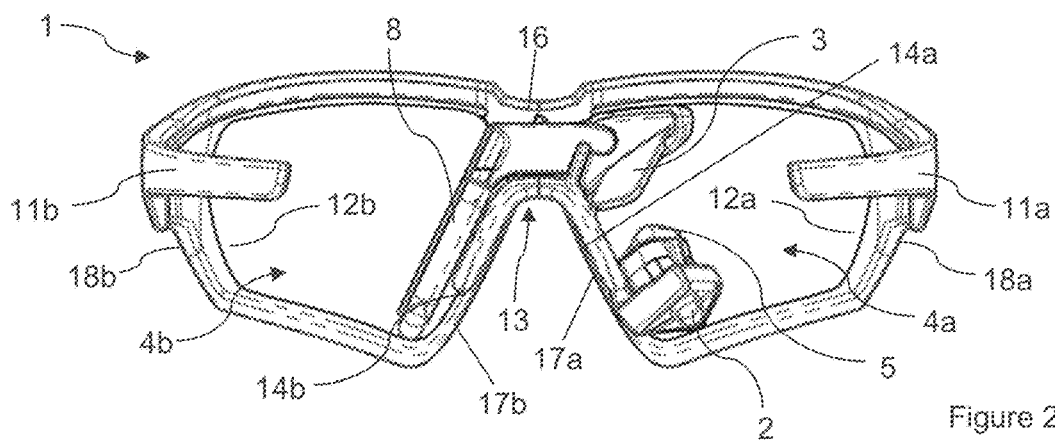


Figure 2a

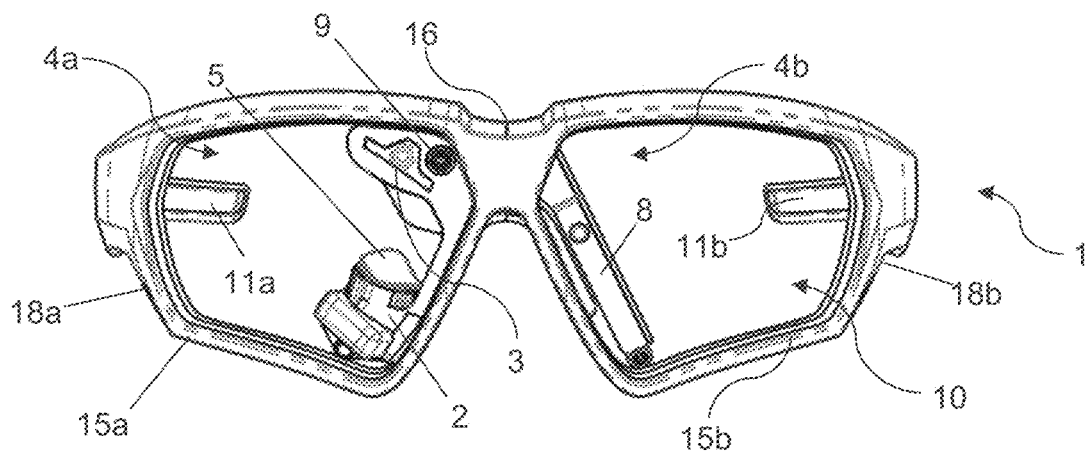


Figure 2b

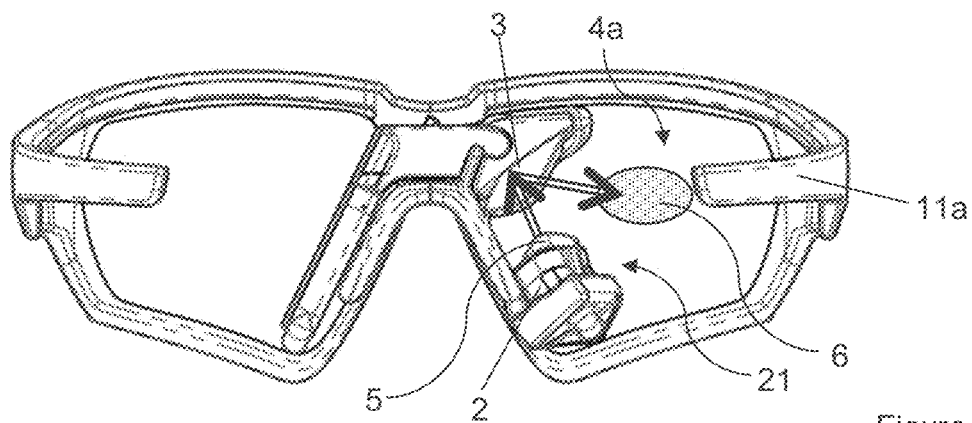


Figure 2c

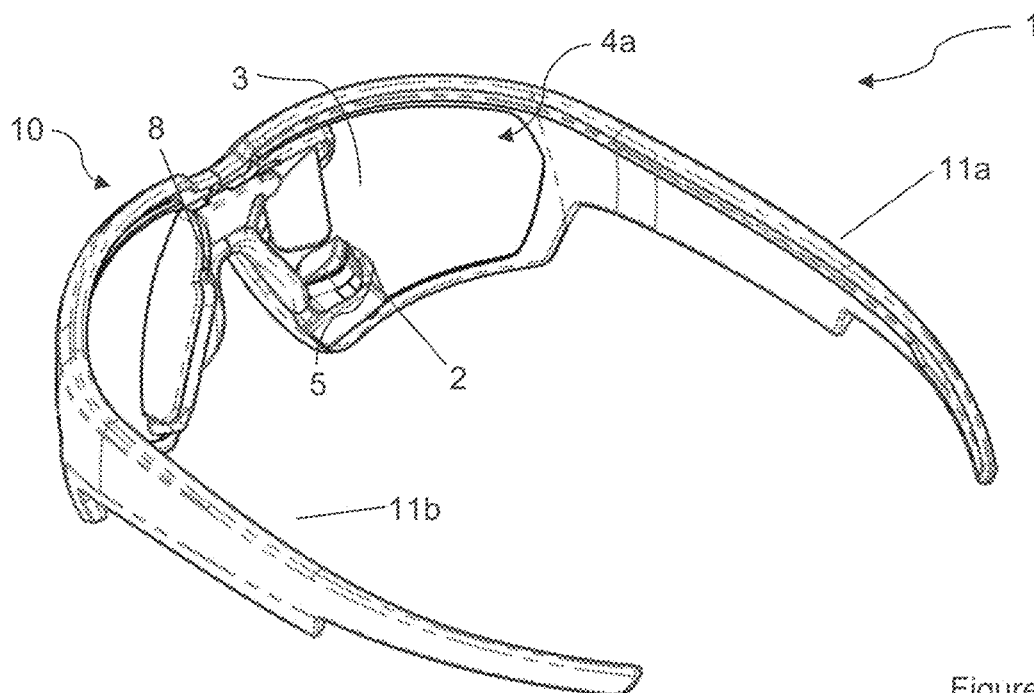


Figure 2d

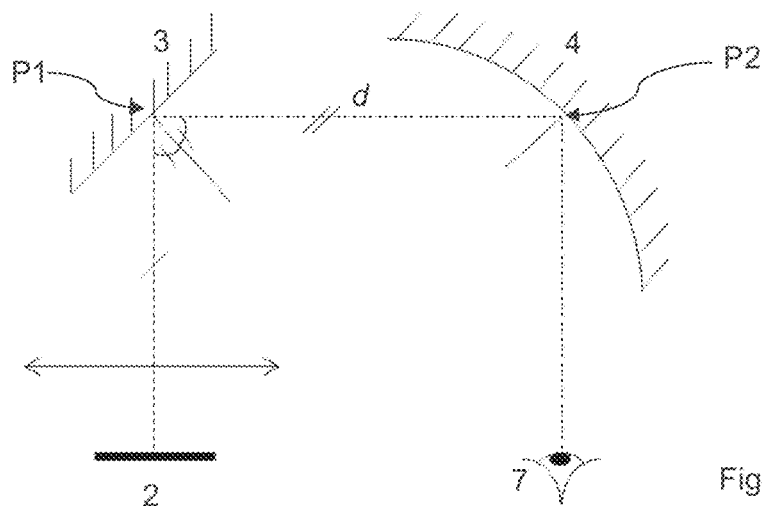


Figure 3a

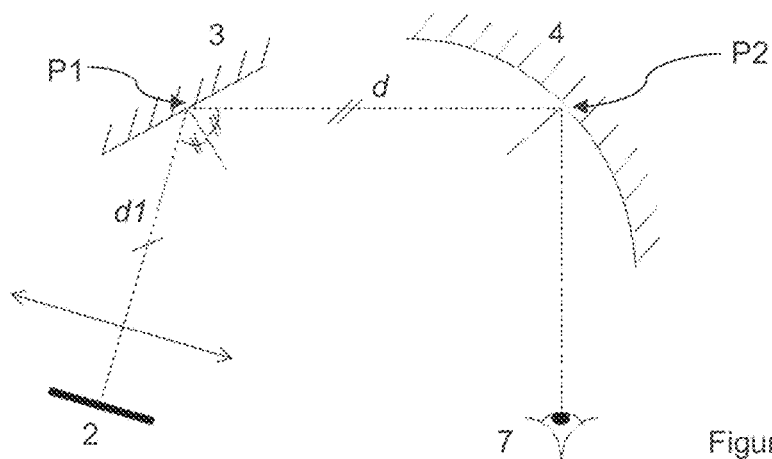


Figure 3b

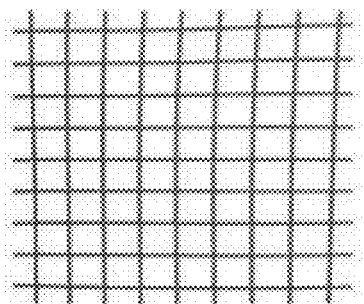


Figure 8a

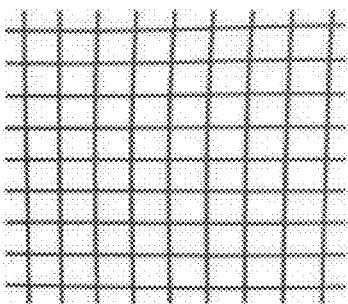


Figure 8b

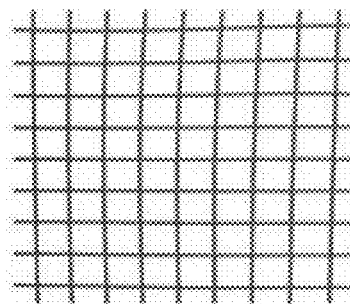


Figure 8c

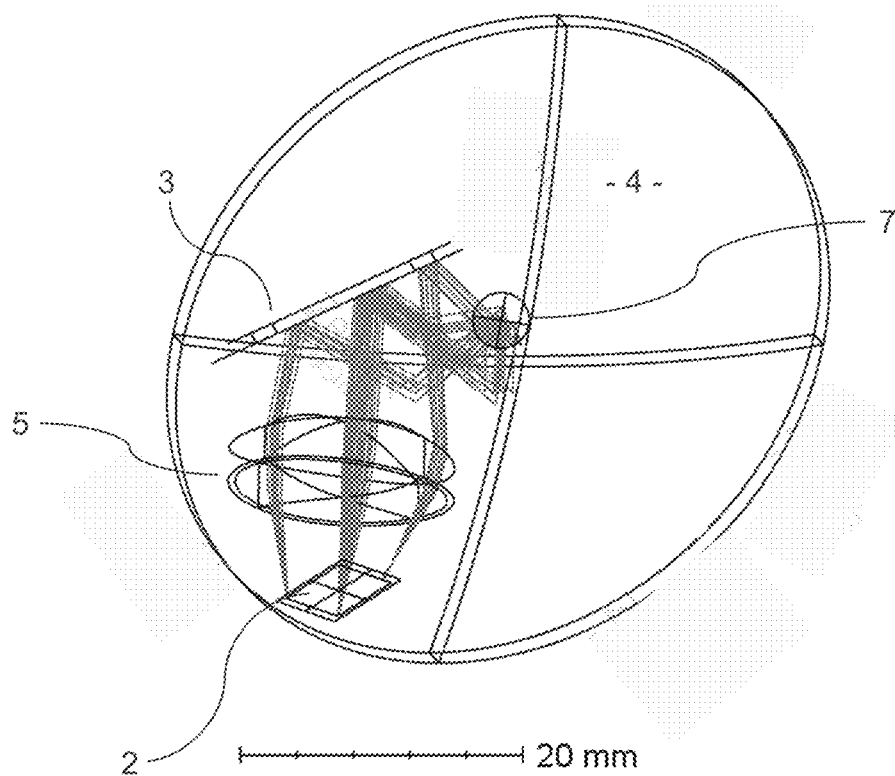


Figure 4a

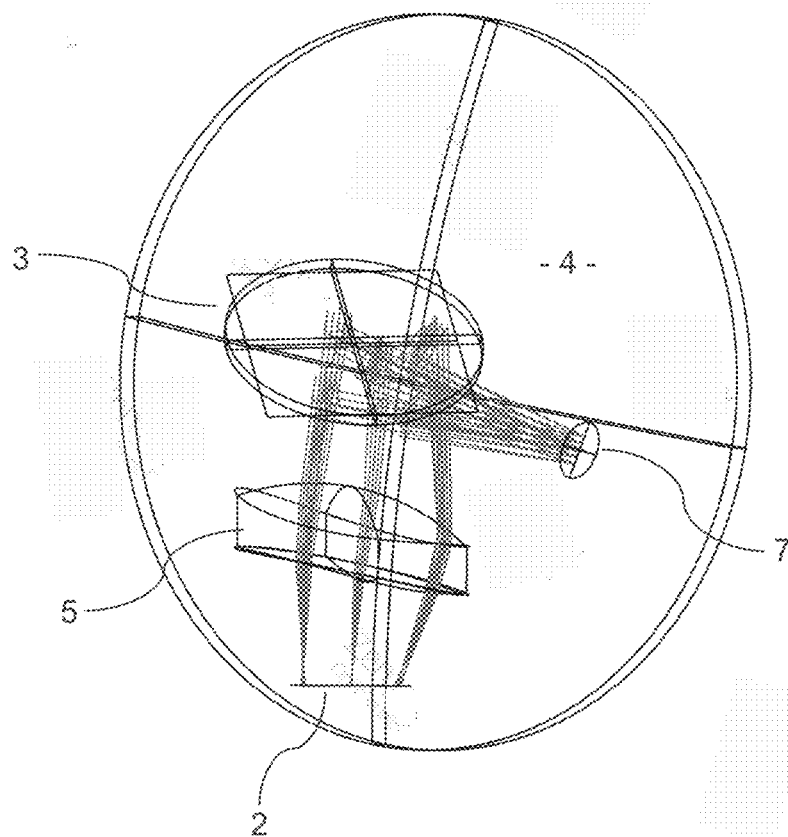
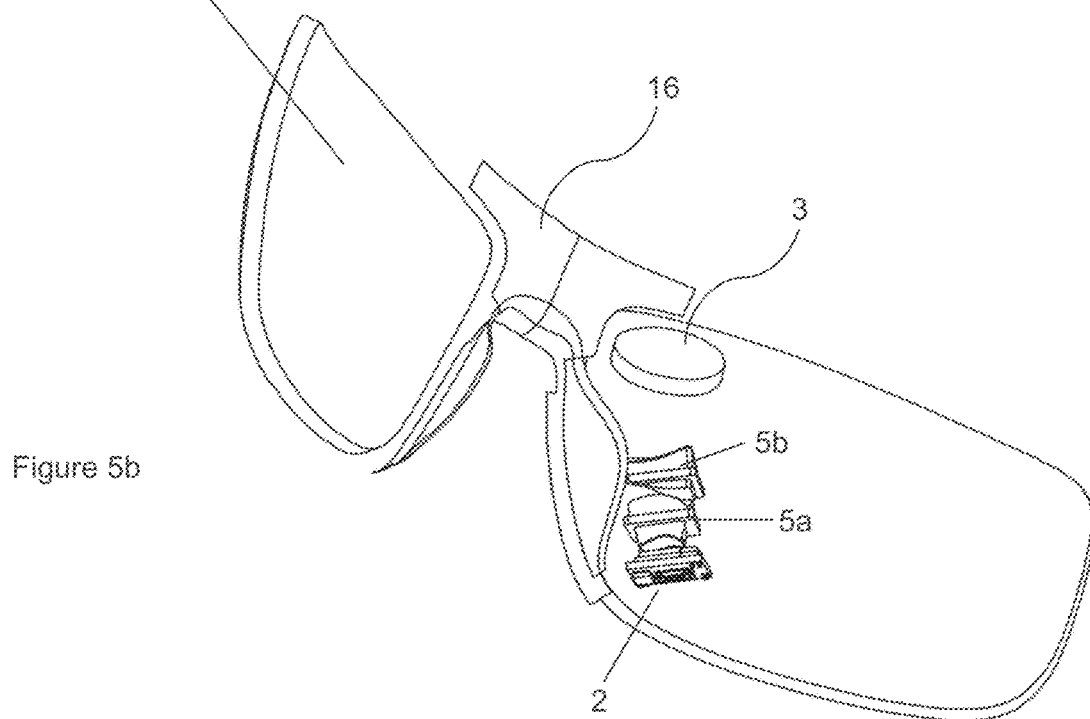
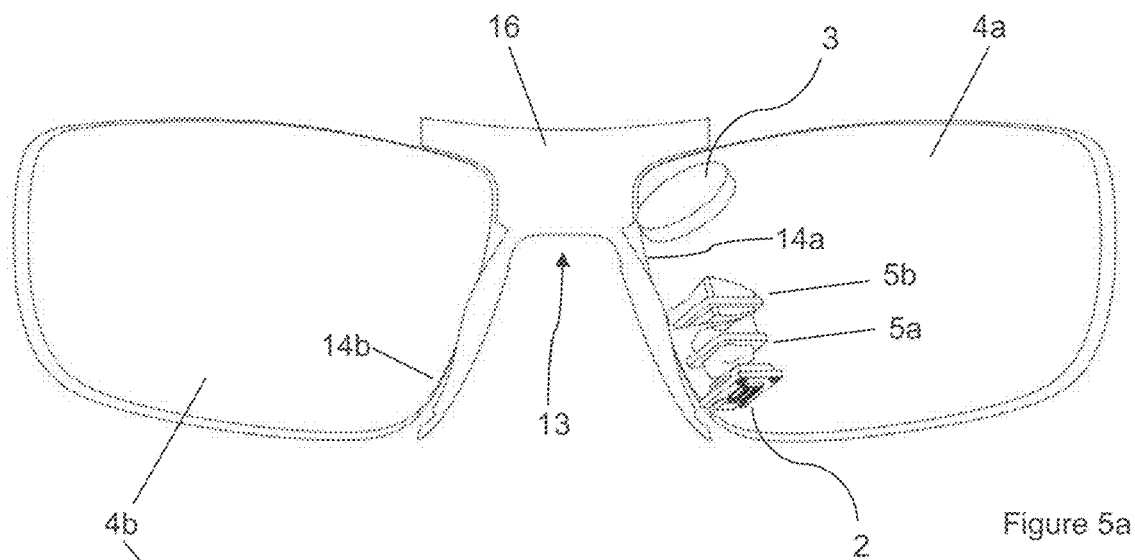


Figure 4b



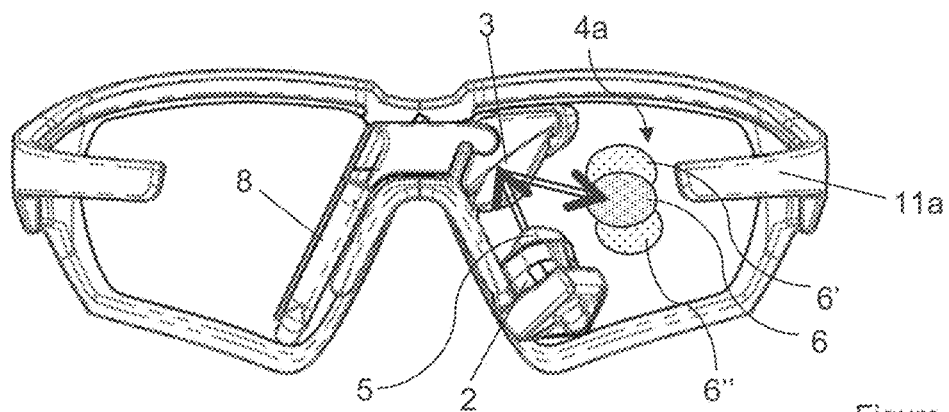


Figure 6a

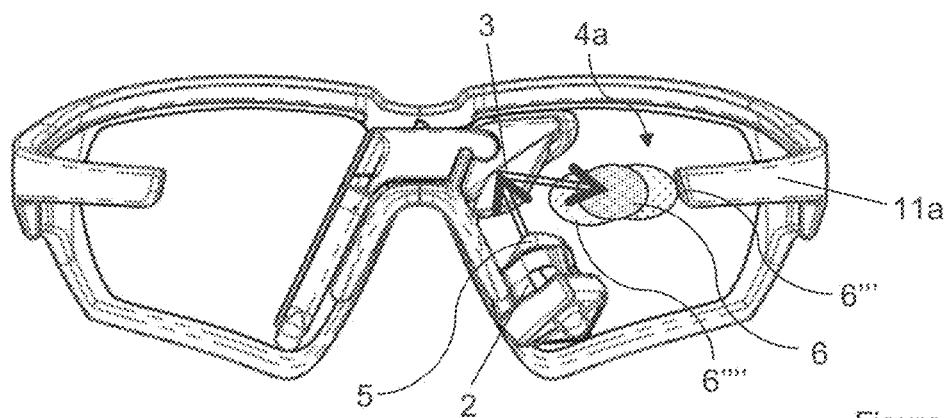


Figure 6b

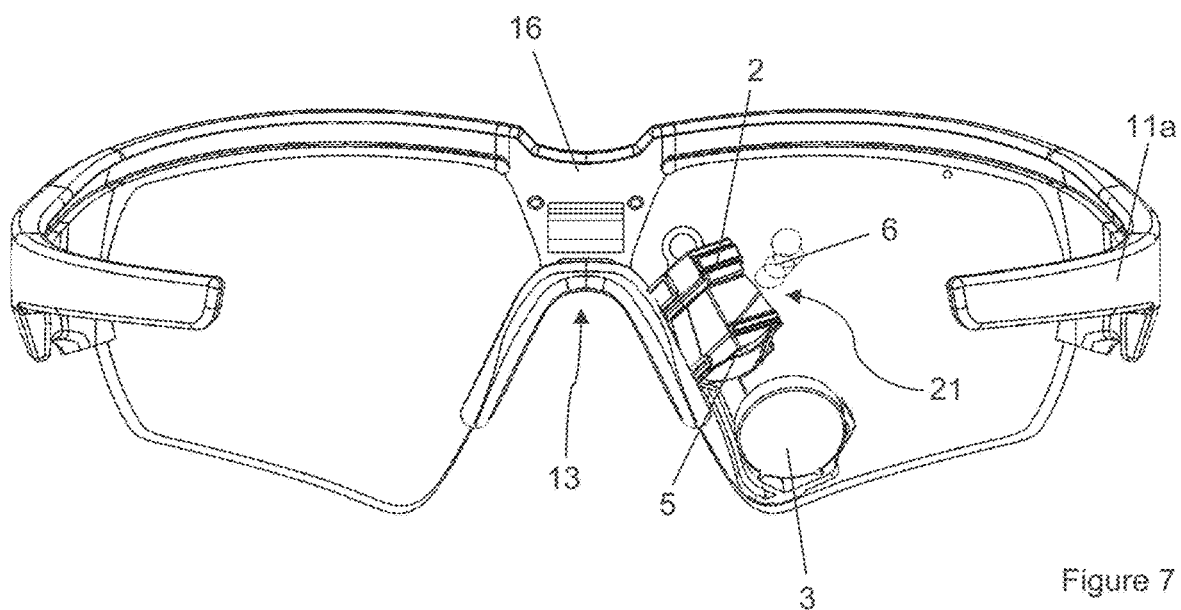


Figure 7



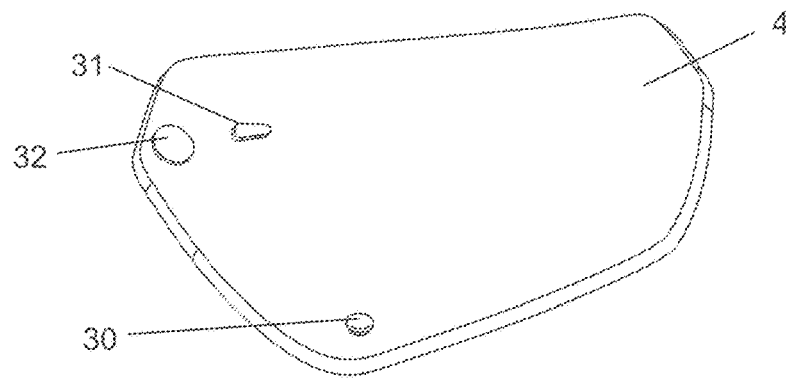


Figure 10

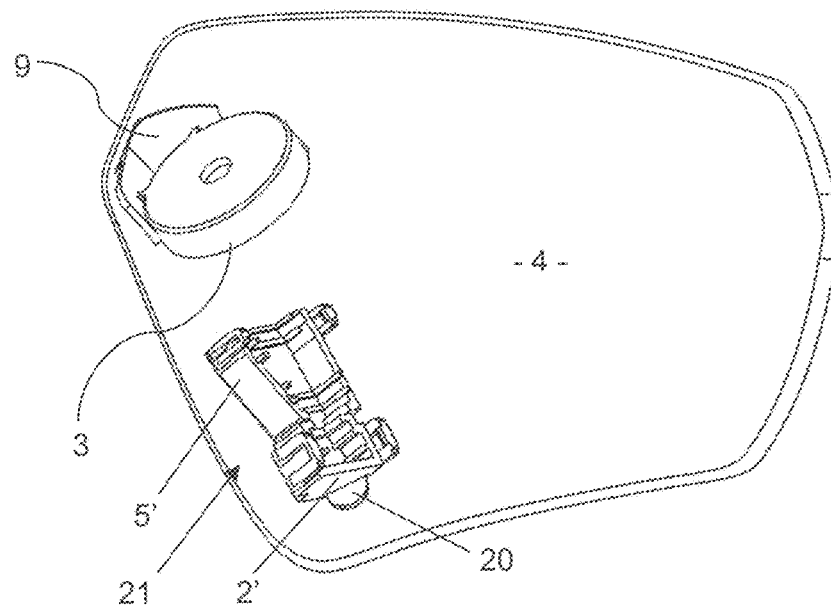


Figure 11

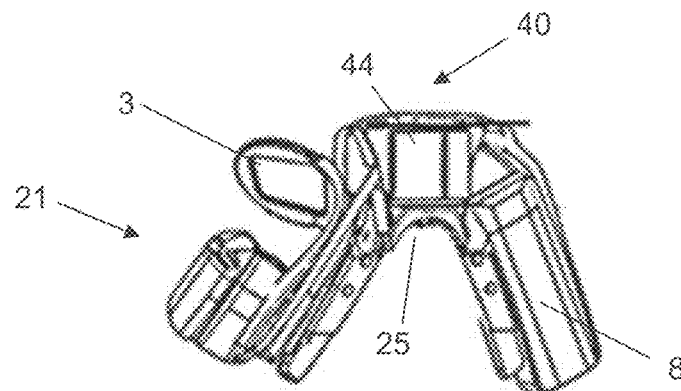


Figure 13

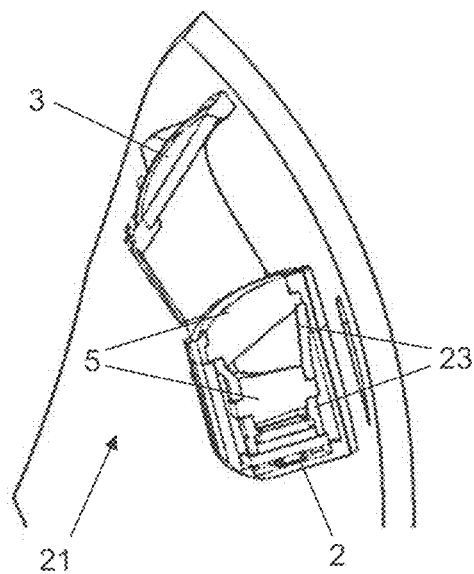


Figure 12(a)

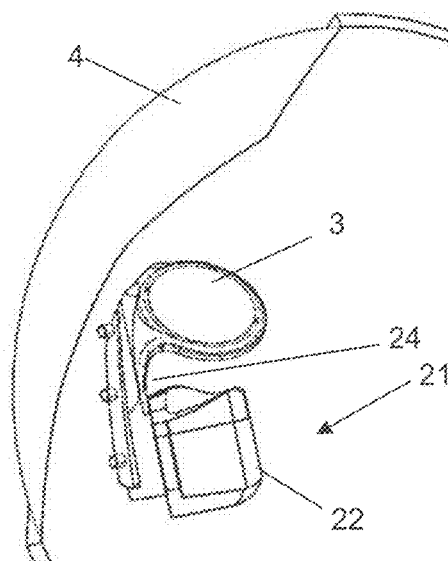


Figure 12(b)

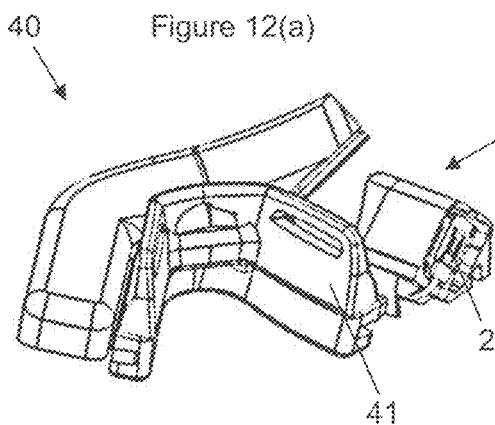


Figure 14(a)

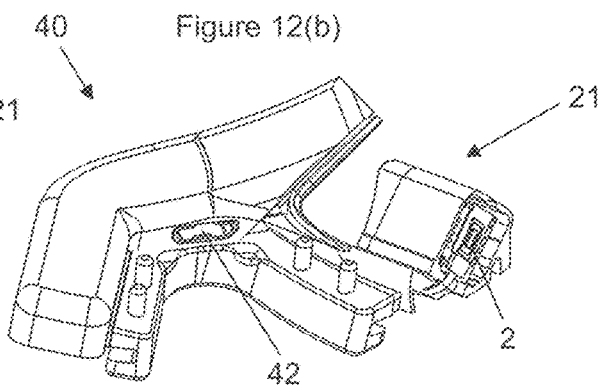


Figure 14(b)

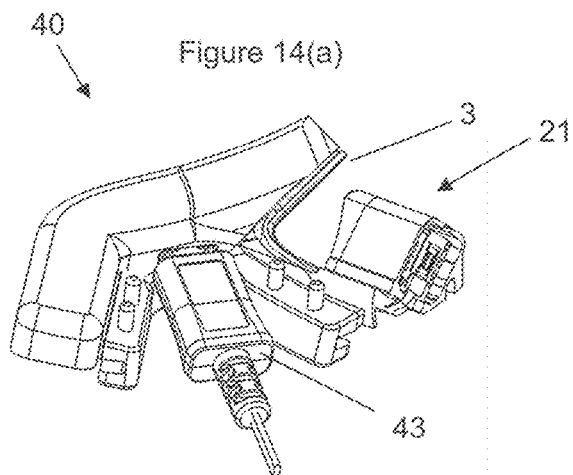


Figure 15

1

## SPECTACLES WITH OPTICAL DISPLAY SYSTEM

This application is a national stage application of PCT-application number PCT/FR2017/053764 filed on Dec. 21, 2017, which claims priority of French patent application No. 1663159 filed on Dec. 22, 2016, both of which disclosures are incorporated herein by reference.

### TECHNICAL FIELD OF THE INVENTION

The invention relates to the field of optical systems, and more specifically optical display systems integrated in a helmet or a pair of spectacles (called “connected spectacles”).

### PRIOR ART

Various models of head-mounted displays that make it possible to view “virtual reality” are known, such as the Oculus Rift™ system on the market. They are bulky and do not make it possible to view the external environment at the same time. Helmets with a so-called head-up display are also known, which make it possible to view external reality at the same time. So-called connected spectacles with an optical display system are also known. The optical principles of these devices are presented in the article “Head-Worn Displays: A Review” by O. Cakmakci and J. Rolland, published in 2006 in the Journal of Display Technology 2 (3), pages 199-216. A large number of patent documents propose different configurations.

These spectacles are generally rather bulky and heavy. They are specific objects that are unsuitable for common use. Their design is significantly different from that of common spectacles, whether spectacles with corrective lenses or sunglasses. As an example, the documents WO 2016/135 727 (Elbit Systems) and US 2009/0231 722 (Day & Night Display Systems) propose positioning the display system horizontally over the bridge of the nose. This positioning is incompatible with common spectacles. Spectacles with waveguides in the stems have been described in WO 2015/075206 (Carl Zeiss Optics); they require the use of a set of prisms in order to extract light from the spectacle lenses, which downgrade transparent vision.

Numerous documents describe displays integrated in spectacles in which the frames are more similar to those of common spectacles for seeing.

The document FR 3 017 966 (O. Cecconi) proposes integrating a micro-screen in each of the two pads intended to hold the frame on the nose; each screen projects an image into the eye of the spectacle wearer by means of the internal (rear) diopter of the spectacle lens, which must then have a very specific curve.

The document US 2003/0184 868 (Geist) describes a system in which the display, arranged on the stem of a pair of spectacles, sends an image to a first mirror attached to one of the pads of the spectacles, then to a second mirror attached to the spectacle lens, from which the image is projected into the user’s eye. This second mirror, close to the pad, is at a distance from the center of the spectacle lens, and thereby requires significant movement of the eyes in order to see the image coming from the system.

The document U.S. Pat. No. 6,394,601 (Bettinger) describes a system including a display, attached to the top portion of the spectacle lens with its emitting surface positioned perpendicularly to the plane of the lens, which sends an image to a mirror located at the bottom portion of the

2

lens, from which the image is reflected into the eye of the user. No concrete example is presented, and it may be thought that the display located at the upper edge of the spectacle lenses is rather bulky. This system also has the disadvantage of the image always being perceived at the periphery of the spectacle lens, requiring eye movements that obstruct a clear view of the environment.

The problem to be solved by the present invention is that of providing a spectacle system in which the optical system allowing the display is designed so as to reduce the space occupied by the optical system ensuring the display function, while optimizing the usual characteristics (size, compactness, lightness, curve of the lenses, frame, design) of a pair of common spectacles, and in particular a pair of sports glasses, and so as not to obstruct the view of the environment.

### OBJECT OF THE INVENTION

The invention is based on a “pair of spectacles” having at least one spectacle lens-type optical unit including a face defining a passage for the user’s nose and means for attachment to the user’s head. Said optical unit has a front diopter for “external” diopter, seen from the front) and a rear diopter (or “internal” diopter, directed toward the user’s face). The attachment means may be spectacle stems or any other suitable means.

According to the invention, these objectives are achieved with spectacles including a face provided with at least one lens-type optical unit, said face defining a passage for the user’s nose, said passage for the nose being defined by first and second so-called internal edges of the face,

said spectacles also including:

- a module for emitting visual information, including an element for emitting said display-type visual information,

- optionally an element for optical transformation of said emitted visual information, in particular of the lens type,

- a mirror-type element for geometric reflection of the transformed visual information, capable of reflecting said transformed visual information to a target area of said lens-type optical unit,

said emitting module being arranged at the bottom or top portion of a first internal edge of the face, while the geometric reflection element is arranged at the top or bottom portion of said first internal edge, with the understanding that when said emitting module is arranged at the bottom portion of said first internal edge of the face, then the geometric reflection element is arranged at the top portion of said first internal edge, and when said emitting module is arranged at the top portion of a first internal edge of the face, then the geometric reflection element is arranged at the bottom portion of said first internal edge.

Typically, said first and second internal edges of the face are turned respectively toward the first and second lateral edges of the face.

In one embodiment, the spectacles include stems mounted on said face (for example on first and second lateral edges of said face), in particular in a pivoting manner. In another embodiment, they are integrated, in a fixed or pivoting manner, in a helmet for protecting the head, in particular in an approved bicycle helmet or in an approved motorcycle helmet.

Advantageously, the main surface of the display-type emitting element is oblique (in particular substantially perpendicular) to the main surface of said face.

The invention uses the available space near the joint of the nose in order to position the emitting module and/or the geometric reflection element. More specifically, one or the other of these two devices (namely the emitting module or the geometric reflection element) may be positioned below the eyebrow, near the nasal bone, and the other may be positioned near the lower lacrimal punctum. This positioning of the emitting module and the geometric reflection element makes it possible to minimize the bulk and the obstruction that they cause for the user. This positioning also promotes the projection of a high-quality image with a sufficiently wide field, and prevents direct vision from being obstructed by the emitting module or the geometric reflection element.

Said target area is located on the rear diopter of said optical unit. It is preferably located at the median portion of said first lateral edge, thereby preventing the direct vision of the eye from being obstructed by the display.

In one embodiment, said face includes two rims and a bridge connecting said rims, each rim including attachment means, in particular removable, for said lens-type optical unit, each rim including a lateral edge and an internal edge, respectively forming one of said lateral edges and one of said internal edges of the face. Said rims connected by the bridge may form a known type of spectacle frame.

In a first alternative ("alternative 1"), said emitting module and/or said geometric reflection element is mounted on the rim.

In a second alternative ("alternative 2"), said emitting module and/or said geometric reflection element is (are) mounted not on the rim, but attached directly to said lens.

In a third alternative ("alternative 3"), capable of being combined with alternatives 1 or 2, said frame is designed to receive in each rim a lens-type optical unit.

In a fourth alternative ("alternative 4"), capable of being combined with alternatives 1 or 2, said frame is designed to hold a single optical unit that extends over the two rims.

In a fifth alternative ("alternative 5"), capable of being combined with all of the above alternatives, the stems and/or the bridge are mounted directly on said optical unit(s).

In another embodiment, said face includes an optical unit, the lateral edges of said optical unit forming said lateral edges of the face, said stems being mounted directly on the lateral edges of said optical unit.

In particular, the emitting module may be mounted on the rim, at the bottom portion of a first edge of the face, or directly on the lens-type optical unit. Similarly, the geometric reflection element may be mounted on the rim, at the bottom portion of a first edge of the face, or directly on the lens-type optical unit. In one embodiment, the emitting module and the geometric reflection element are both mounted on the rim, one at the bottom portion, the other at the top portion (in a first alternative, the emitting module is at the top portion, in a second alternative it is at the bottom portion). In another embodiment, the emitting module and the geometric reflection element are both mounted on the lens-type optical unit (by assembly techniques known as such), one at the bottom portion, the other at the top portion (in a first alternative, the emitting module is at the top portion, in a second alternative, it is at the bottom portion). In another embodiment, the emitting module is mounted on the rim while the geometric reflection element is mounted on the lens-type optical unit, one at the top portion, the other at the bottom portion (in a first alternative, the emitting module

is at the top portion, in a second alternative, it is at the bottom portion). In yet another embodiment, the emitting module is mounted on the lens-type optical unit while the geometric reflection element is mounted on the rim, one at the top portion, the other at the bottom portion (in a first alternative, the emitting module is at the top portion, in a second alternative it is at the bottom portion).

According to an advantageous feature of the invention, said bridge forms part of a bridge module to which said optical block is attached. Said bridge module advantageously includes an electrical connection socket. Said frame may also have an element for optical transformation of said emitted visual information, in particular of the lens type; it is possible to use a number of these elements, for example two.

According to an advantageous feature of the invention, the spectacles also include an optical block, said block including holding means, in particular removable, for the emitting module and/or the optical transformation element and/or the geometric reflection element, said optical unit being provided with positioning means capable of positioning said optical block with respect to said optical unit.

In a first embodiment, the positioning means include at least one positioning element integrated, in particular integrally molded, with said optical unit, said positioning element being capable of cooperating with said optical block, in particular by a mortise and tenon-type connection, or by a resilient snap-lock connection.

In another embodiment, said optical block is integrated, in particular integrally molded, with said optical unit.

Another object of the invention is a frame belonging to spectacles according to the invention, said frame including two rims and a bridge connecting said rims, each rim including attachment means, in particular removable, for a lens-type optical unit, said frame also including:

a visual information emitting module, including a display-type visual information emitting element, an element for optical transformation of said emitted visual information, in particular of the lens type,

a mirror-type element for geometric reflection of the transformed visual information, capable of sending said transformed information to a target area of said lens, said emitting module being mounted at the bottom or top portion of a first internal edge of the frame, while the geometric reflection element is mounted at the top or bottom portion of said first internal element, with the understanding that when said emitting module is mounted at the bottom portion of said first internal edge of the frame, then the geometric reflection element is mounted at the top portion of the first internal edge, and when said emitting module is mounted at the top portion of a first internal edge of the frame, then the geometric reflection element is mounted at the bottom portion of said first internal edge.

The target area is advantageously located at the median portion of the lateral edge of said first rim. The main surface of the display-type emitting element is substantially perpendicular to the main surface of said first rim.

Advantageously, the total field of the screen (represented by the lens-type optical unit) makes it possible to cover multiple positions of the pupil.

The image provided by the visual information emitting module may be monochromatic or polychromatic.

In one embodiment that can be combined with all of the other embodiments and alternatives, the spectacles include an electronic system for detecting the ambient brightness,

5

configured to control the brightness of the display in real time according to the ambient brightness of the environment.

In another embodiment that can be combined with all of the other embodiments and alternatives, the geometric reflection element is mounted on an adjustable support by means of a control member making it possible to move the mirror in translation by several micrometers while preferably maintaining a constant angle between the display and the surface of the lens-type optical unit.

As an alternative to the above embodiment (or less preferably, as a complement to the above embodiment), it is the display (preferably with its element for optical transformation of visual information) that is mounted on an adjustable support by means of a control member making it possible to move the display in translation (preferably with its element for optical transformation of visual information) so as to be capable of adjusting the focal point and the diopter; this makes it possible to at least partially compensate for certain visual defects of the user, such as myopia or hyperopia.

In general, in the context of the present invention:

said element for optical transformation of visual information advantageously includes at least one lens, preferably aspherical, thereby reducing the aberration;

said geometric reflection element advantageously includes at least one mirror, which may in particular be a flat or convex mirror, and which may have a circular, oval, oblong, rectangular or square shape (preferably with rounded edges), with the understanding that shapes without corners are preferred because they are less bulky and easier to integrate with the support;

said visual information emitting module is preferably an OLED-type display, which may be a monochromatic or color display. It is possible to use in particular a micro-display as sold by the Microoled™ company in Grenoble;

said emitting module with its geometric reflection element may be placed identically on the left- or right-handed portion of the spectacles, according to the dominant eye of the user.

It should be specified that, in the context of the present invention, the term “lens” in the expression “lens-type optical unit” must be understood as an “spectacle lens” and not as an indication of a specific material: in fact, said “lens” may be made of any suitable material, such as so-called organic glass, for example a polycarbonate such as allyl diglycol carbonate (a resin known by the abbreviation “CR-39”), a plastic film, a mineral glass, and may or may not allow for optical correction, and/or may or may not absorb at least a portion of the visible light spectrum (sunglasses), and/or may or may not be colored, with the understanding that said functionalities (and others, such as scratch-resistant, anti-fog, polarizing and semi-reflective surface functions may be intrinsic to the “lens” materials used and/or may be obtained owing to one or more suitable surface coatings. In fact, the lens-type optical unit used in the context of the present invention may be a known type of unit in the eyewear field.

The word “spectacles” is used here in the plural to designate a singular object (as shown in the figures) or an object in the plural, as said word “spectacles” is derived from the expression “a pair of spectacles”.

#### DESCRIPTION OF THE FIGURES

The invention will be described below in reference to FIGS. 1 to 15, provided solely as non-limiting examples, wherein:

6

FIG. 1 shows a front view of an embodiment of the spectacles according to the invention, integrated in a bicycle-type helmet.

FIG. 2 shows another embodiment of the spectacles according to the invention, seen from the interior (FIG. 2a), the front (FIGS. 2b and 2c), and in perspective from the interior (FIG. 2d).

FIG. 3 shows a simplified diagram of the 2D geometric optics of the display system of the spectacles according to the invention, for two different inclinations of the mirror.

FIG. 4 shows two different views (FIGS. 4a and 4b) of a simplified diagram of the 3D geometric optics of the display system of the spectacles according to the invention.

FIG. 5 shows two different (FIGS. 5a and 5b) simplified schematic views of an embodiment with two lenses.

FIG. 6 shows the spectacles of FIG. 2, with three different target areas, moved vertically (FIG. 6a) or laterally (FIG. 6b).

FIG. 7 shows a schematic view of another embodiment of the invention, seen from the interior.

FIG. 8 shows the projection of a quadratic grid on the pupil, obtained with spectacles according to an embodiment of the invention.

FIG. 9 shows an example of an information display for spectacles obtained with a display system according to the invention provided with an OLED-type display having dimensions of 300×356 pixels (active surface: 3.1 mm×3.6 mm).

FIG. 10 shows an example of a spectacle lens-type optical unit according to a particular embodiment of the invention.

FIG. 11 shows the mirror and (in the cross-section according to a longitudinal axis) the housing that contains the display and the lens, attached to said spectacle lens-type optical unit, according to another particular embodiment of the invention.

FIG. 12 shows two views of an optical module according to the invention: FIG. 12(a) shows a longitudinal cross-section view, and FIG. 12(b) shows a perspective view of the cap.

FIG. 13 shows a perspective view of another embodiment in which a bridge module integrates the optical block.

FIG. 14 shows two views of a bridge module integrating an optical module: FIG. 14(a) shows the module with a removable nose support on the bridge connector, and FIG. 14(b) shows the module without the nose support.

FIG. 15 shows the bridge module of FIG. 14(b) with a connected cable connector.

The following numeric references are used in the present description:

1	Spectacles
2	Display
3	Mirror
4	Lens-type optical unit
5	Lens
6	Target area
7	Eye
8	Electronic housing
9	Attachment of the mirror 3
10	Face of the spectacles
11	Means for attaching the spectacles 1
12	Lateral edge of the face 10
13	Passage for the nose
14	Internal edge of the face 10
15	Rim
16	Bridge
17	Internal edge of the rim 15
18	Lateral edge of the rim 15

-continued

19	Helmet
20	Display attachment 2
22	Optical block
22	Cap of the optical block 21
23	Spacers
24	Positioning and protection elements
25	Nose support
30, 31, 32	Mechanical positioning elements
40	Bridge module
41	Removable nose support
42	Socket
43	Connector
44	Electronic housing

## DETAILED DESCRIPTION

We will describe the embodiments of the invention in greater detail below, in particular in relation to the figures.

FIG. 1 shows a front view of an embodiment of the spectacles 1 according to the invention, integrated in a helmet 19 of the bicycle helmet type. The spectacle lens-type optical unit 4 has a passage 13 for the nose; therefore, it is closer to the face than the visor in motorcycle helmet-type visored helmets. It is this proximity of the optical unit 4 with respect to the eye 7 that creates the need for a compact display system that is not bulky or obstructive. In this embodiment, the geometric reflection element 3 is a mirror, attached by means of an attachment point 9 to the optical unit 4 at the top portion of the optical unit 4, near the eyebrow and the nose of the wearer. The emitting module 2 is attached by means of an attachment point 20 to the optical unit 4, at the bottom portion of the optical unit 4 near the nose. An optical transformation element 5 is located in the optical path that leads from the emitting module 2 to the geometric reflection element 3. The image is projected onto the interior dioptr of the optical unit 4 and reflected into the eye of the user.

In this embodiment, the optical unit 4 is attached directly to the helmet 19. The attachment means may be a groove provided in the lower portion of the helmet, into which the upper edge of the optical unit is inserted over the entire length thereof, or (as in the helmet shown in community design model no. 000 175 955-0001) a hinge on each side that pivotably connects the optical unit 4 to the helmet 19 so that it can be opened by pivoting upward.

FIGS. 2a, 2b, 2c and 2d show another embodiment that is based on a pair of common spectacles. FIG. 2a is a view from behind (i.e. the user's perspective), FIG. 2b is a front view, FIG. 2d is a perspective view from behind, and FIG. 2c is similar to FIG. 2a, but with arrows representing the optical path of the image showing the emitted visual information, and a gray area representing the target area 6 onto which said visual information is projected on the interior of the optical unit 4a represented by the lens.

As shown in FIG. 2b, the spectacles include two rims 15a,b connected by a bridge 16, providing a passage 13 for the nose of the wearer. Each rim 15a,b is equipped with means for attachment 11a,b of the spectacles 1 to the wearer's head, in this case a spectacle stem.

More specifically, each rim 15a,b includes a lateral edge 18a,b and an internal edge 17a,b, a stem 11a,b being mounted on said first and second lateral edges 18a,b of the rim 15a,b. Each rim 15a,b includes a lens-type optical unit 4a,b. The rims 15a,b and the lens-type optical unit 4a,b together form the face 10 of the spectacles 1.

According to the invention, the spectacles 1 include an emitting module 2 and an element for geometric reflection of the visual information 3, which may be a mirror. The visual information (which will hereinafter also be referred to as “the image”) emitted by the emitting module 2 undergoes an optical transformation by means of an optical transformation element 5, in this particular case a lens that it passes through before arriving at said geometric reflection element 3. The image is projected onto the internal face of the spectacle-type optical unit 4a, from where it is reflected into the eye 7 of the spectacle wearer. Said optical transformation element 5 makes it possible, on the one hand, to enlarge the image and, on the other hand, to correct the optical aberrations after reflection on the internal face of the spectacle lens 4a. Said optical transformation element 5 may be a lens (or multiple lenses positioned between the emitting module 2 and the geometric reflection element 3), or it may be integrated in said geometric reflection element 3, which may be an aspherical mirror.

The geometric reflection element 3 may be attached to the optical unit 4a by means of an attachment point 9.

The emitting module 2 and the optical transformation element 5 may be integrated in the same housing or block, which will hereinafter be referred to as the “optical block”; it is designated by reference 21 in FIG. 2c. FIG. 12 shows two views of said optical block: longitudinal cross-section (FIG. 12(a)) and perspective (FIG. 12(b)), with the cap 22 in place. In this embodiment, the optical block 21 includes the display 2, two optical lenses 5 separated by mechanical spacers 23, and a mirror 3 connected to a mechanical positioning and protection element 24.

In the embodiment of FIG. 2, the emitting module 2 is mounted at the bottom portion of a first internal edge 14a of the face 10, while the geometric reflection element 3 is mounted at the top portion of said first internal edge 14a.

If the spectacles have a frame with a rim, the internal edges 17a,b of the rim may coincide with the internal edges 14a,b of the face, and the lateral edges 18a,b of the rim may coincide with the lateral edges 12a,b of the face. The stems 11a,b may be mounted on the first and second lateral edges 12a,b of the face or one the first or second lateral edges 18a,b of the rim, or may be attached to another place on the face 10, in particular to the rim 15a,b or directly to the lens-type optical unit 4.

The electronic components and cards for controlling the visual information emitting module 2 and/or the electrical energy storage elements (typically one or more batteries, not shown in the figures) that supply the electronics for controlling the emitting module 2 and/or said emitting module may be housed in an electronic housing 8 and/or in one and/or the other of the spectacle stems 11a,b and connected by a flexible cable (commonly called a “flex”), not shown in the figures.

In an embodiment that may be combined with all of the other embodiments described herein, said face 10 and/or said lens-type optical unit 4 includes a semitransparent photovoltaic cell that supplies, directly or by means of batteries, the control electronics and/or said visual information emitting module 2. Such semitransparent photovoltaic cells are known in the prior art.

FIG. 3 shows, in a simplified and schematic manner, the 2D geometric optics of the display system of the spectacles according to the invention, for different adjustments of the emitting module 1 (with its optical transformation element 5) and the geometric reflection element 3 (FIGS. 3a and 3b). In these adjustments, the distance d between the point of impact P1 on the geometric reflection element 3 of the

incident optical beam coming from the visual information emitting element 2, on the one hand, and the starting point P2 of the optical beam reflected by the optical unit 4 advantageously remains constant, and the angle of reflection on the optical unit 4 advantageously remains constant. This figure shows the possibility of modifying the positioning of the emitting module 2 when designing spectacles or in the fine-tuning of the position of the point P2 on the optical unit 4. Advantageously, during these adjustments, the length d1 does not change significantly, so as not to modify the focusing of the image coming from the module 2.

FIG. 4 shows, in a simplified and schematic manner, the 3D geometric optics of the display system of the spectacles according to the invention, with two different views (FIGS. 4a and 4b). It shows the role of the optical transformation element 5, which is in this case a lens, but which may, in an alternative (shown in FIG. 5), include two lenses.

FIG. 5 shows a partial view of the spectacles according to the invention (the stems and the rim have been omitted so as not to encumber the figure) in which the element for optical transformation of the visual information generated by the emitting module 2 includes two lenses 5a,b. FIG. 5b is rotated 45° with respect to FIG. 5a.

FIG. 6 shows the spectacles of FIG. 2 in which the target area 6 is offset. In FIG. 6a, the target area 6 is offset upward (target area 6') or downward (target area 6''), in FIG. 6b it is moved laterally outwardly (target area 6''') or inwardly target area 6'''. It is also possible to envisage a movement that combines these two types of movement. The choice of the positioning of the target area 6 on the surface of the optical unit 4 is made according to the intended use of the spectacles. The adjustment of this position may be performed in the factory or by the optician, or by the user him or herself. In one particular embodiment, the geometric reflection element 3 is mounted on an adjustable support (not shown in the figures) by means of a control member (not shown in the figures) making it possible to move said geometric reflection element 3 in translation by several micrometers while preferably maintaining a constant angle between the display 2 and the surface of the lens-type optical unit 4.

FIG. 7 shows the spectacles according to the invention in which the configuration of the display 2 and of the mirror 3 is inverted with respect to the embodiment of FIG. 2: the display 2 is located at the top portion (near the eyebrow) and the mirror 3 is located at the bottom portion.

The spectacles according to the invention may be made with or without a rim, or with a partial rim (for example, only at the top or only at the bottom). If the spectacles do not have a rim, the face 10 is formed by the lens-type optical unit 4a,b, as in FIG. 1. The bridge 16 may or may not be present, and the optical unit 4 may consist of a single part that provides a passage 13 for the nose, as in the embodiment shown in FIG. 1. Similarly, the frame may have pads (not shown in the figures) close to the passage 13 for the nose, in order to stabilize the spectacles on the wearer's nose; these pads then form part of the face 10. All of these types of spectacles and frames are known as such, and it is a feature (and an advantage) of the present invention that it can be carried out with common frames, or at least with frames that are aesthetically similar to common frames. The main constraints are as follows: the frame or the face must actually make it possible to have the emitting module and the geometric reflection element at the top or bottom portion of an internal edge of the face, and the spectacles must be adapted so as to receive, on the one hand, an electrical energy storage element and, on the other hand, the electronics for control of the emitting module. To achieve these

objectives it may for example be necessary to choose stems 11 having a particular shape and/or size, making it possible to provide a housing for receiving said energy storage element and/or said control electronics, and/or to provide an electronic housing 8.

Numerous alternatives are possible in the realization of the invention; these alternatives may be combined with all of the embodiments described herein, and may be combined with one another.

For example, optical layers deposited at the surfaces of the geometric reflection element 3 and/or the spectacle lens (dichroic or antireflective) may improve the reflection rate as a function of the emitting wavelengths of the display and reduce parasitic reflections.

To increase the contrast of the system, the optical layers on the interior surface of the lens may be complemented by a reflective layer with a complementary color on the external face of the lens, and/or by a layer absorbing the complementary color, and/or by the choice of a lens absorbing the complementary color. This makes it possible to reduce the parasitic reflections in the lens, and to increase the contrast. Similarly, it is possible to tint the lens with the complementary color in order to obtain the same effect, and/or to add a sunglasses function.

The curves of the internal and external surface of the lens may be adjusted so as to provide an ophthalmic correction for the spectacle wearer. The internal surface makes it possible to correct the vision of the virtual image projected by the display device, and the combination of the internal and external surface makes it possible to correct the natural vision of the spectacle wearer.

The mirror may have any shape, but shapes without corners, in particular circular or oval shapes, are preferred, leaving a free field sufficient for the reflection of the image in order to reduce its bulk and be better integrated with the support.

It is possible to provide means for adjusting the focal point between the mirror and the display with a mechanical support of the mirror, adjustably attached to the support of the frame. Thus, by screwing or unscrewing the mirror, the mirror can be moved in translation by several micrometers while maintaining an identical angle between the display and the spectacle lens.

It is also possible (alternatively or as a complement to the above embodiment) to provide means for adjusting the focal point and the diopter with a mechanical support of the display, adjustably attached to the support of the frame. Thus, by screwing or unscrewing the display (and preferably simultaneously the lens 5 or lenses, mounted on the same optical block 21 as the display 2), the display 2 (and its lens(es)) can be moved in translation by several micrometers, so as to make it possible to adjust the focal point and the diopter; this makes it possible to at least partially compensate for certain visual defects of the user, such as myopia or hyperopia.

It is possible to provide a system enabling the brightness of the display 2 to be adjusted. This system may be associated with an electronic system for capturing the ambient brightness, configured to adjust the brightness of the display in real time according to the external environment.

In an example embodiment, a base 8 sports glasses frame was used, as shown in FIG. 2. The emitting module (a bright monochromatic OLED micro-display with a spectrum centered at 530 nm) was mounted at the bottom portion of the first internal edge, the mirror at the top portion of said first internal edge. The image of the display 2 passes through the correction lens 5, then is reflected by the flat mirror to the

## 11

spectacle lens 4, which reflects up to 20% of the incident light according to the surface deposit applied. The bright (up to 20,000 Cd/m<sup>2</sup>) and high-contrast (1:970,000) micro-display make it possible to keep a display bright enough to be visible by the user even in an outdoor environment. The high contrast makes it possible to maintain a very dark background (0.003 Cd/m<sup>2</sup>) outside of the elements displayed on the spectacle lens.

It is also possible to use other spectacle curves, for example base 6, base 7, base 9 and base 13 or other curves and shapes.

It is also possible to use a color OLED display. In one embodiment, a color OLED display with a 3.1 mm×3.6 mm surface with 256×300 pixels and a circular mirror with a diameter of 10 mm was used with sports glasses of the type shown in FIGS. 2 and 6. As the optical transformation element 5, two aspherical optical polyester resin lenses OKP4 (optical index  $n=1.607$  at a wavelength of 546.1 nm) were used. FIG. 8 shows the projection of a quadratic grid with a total field of 10° displayed by the display at the nominal point of the pupil (FIG. 8b), at a lateral distance of -2 mm (FIG. 8a) and at a lateral distance of +2 mm (FIG. 8c). It is noted that the image shows very low distortion in the nominal position, and hardly deteriorates when the position is moved by 2±mm. Such a display system is of a very satisfactory quality for displaying alphanumeric signs (text, sequences of digits representing the time, etc.) and images. In this embodiment, the position of the display center is around 160 of horizontal convergence and around 6° of elevation above the horizon. In this position, the user has good direct visibility of the environment without the vision being obstructed by the display, and may also easily recognize the alphanumeric sequences and pictograms that provide information on speed, altitude change, GPS coordinates and so on (see FIG. 9 for an example of a display, reproduced in black and white).

The applicant realized that in the spectacles according to the invention, the image rendering quality of the optical system is rather highly dependent upon the precision of the positioning of the optical lenses 5, the display 2, the mirror 3 and the spectacle lens 4 on which the image is projected. A pivot, an off-centering or stresses and deformations of a few dozen micrometers on the optical block may produce optical aberrations affecting primarily the clearness of the image: these aberrations cause a deflection of the beams and therefore of the focal points in the pupil.

To overcome this problem, three particular embodiments have been proposed, which provide means for positioning the optical block 21 with respect to the lens without external stresses that might alter the image rendering quality. A mechanical function has thus been added to the spectacle lens in order to reduce the assembly tolerance.

In a first embodiment, shown in FIG. 10, the aforementioned positioning means include a: least one mechanical positioning element 30, 31, 32 (such as a stop or a rib) formed directly on the spectacle lens 4, thereby facilitating the positioning and the adjustment of the optical block 21 (and optionally also the mirror 3) against the lens 4 in the optimal position.

These positioning elements 30, 31 may be integrated, in particular integrally molded, with the spectacle lens 4, for example in the form of hyperstatic stops molded on the lens to keep the optical block 21 in the nominal position. In this case, the optical block 21 has "female"-type extrusions capable of cooperating with these positioning elements. The cooperation of these positioning elements and these female extrusions may in particular be of the mortise and tenon

## 12

type, or of the resilient snap-lock type. This cooperation makes it possible to hold the entire optical block 21 with sufficient precision with respect to the lens 4. Similarly, it is possible to provide a mechanical positioning element 32 formed directly on the spectacle lens in order to keep the mirror 3 in the nominal position.

In a second embodiment, not shown in the figures, at least one base is integrated in the spectacle lens-type optical unit (typically by molding), on which the optical block (and possibly also the mirror) can be precisely attached (for example by snap-locking).

In a third embodiment, shown in FIG. 11, the optical block 21 is directly integrated with the lens-type optical unit 4. This may be performed by molding. In an alternative, it is possible to integrate the attachment 9 of the mirror in the lens-type optical unit 4. This may be performed by molding.

In particular, it is possible to produce an optical block 21 into which the display 2 and the optical transformation element 5 (including, for example, one or more lenses) are then inserted. This optical block 21 may include a base (not shown in the figure) for attaching the geometric reflection element 3. This optical block advantageously includes holding means, in particular removable, that make it possible to hold the optical lenses 5 and/or the display 2 and/or the mirror 3 with respect to the walls of this block. These holding means may be of any suitable type, in particular mortise and tenon, or resilient snap-locking.

These three embodiments described immediately above make it possible to overcome the constraints on adjustment and holding of the mechanical parts because the positioning of the optical elements (display, lenses and mirror) is performed directly on the spectacle lens. In this way, the precision of the positioning of the elements is ensured and the image rendering quality is optimal.

Another embodiment is shown, with a number of alternatives, in FIGS. 13 to 15. In this embodiment, the bridge of the spectacles integrates the optical block 21; this assembly is referred to here as the bridge module 40. It includes the electronic housing 8. FIG. 13 shows the mirror 3, which is in the top position; in an alternative (not shown in the figures) the optical block is inverted so that the mirror is at the bottom and the display is at the top. FIG. 14 shows two bottom views of the bridge module 40; the lower portion of the cap of the optical block 21 is not shown so that the position of the OLED display 2 can be shown.

In a very advantageous alternative, the bridge module includes an electrical connection socket 42; it is visible in FIG. 14(b). It may be protected by a removable nose support 41, visible in FIG. 14(a). As is shown in FIG. 15, said connection socket 42 may receive a connector 43 in order to transfer data to the display and/or in order to recharge the battery. It may communicate with an electronic module that may be located in a housing 44 on the bridge and/or in the lateral electronic housing 8 (FIG. 13 shows both simultaneously).

Said electronic module may include at least one micro-processor configured to satisfy at least one of the following functions: management of the electrical power supply and/or of battery recharging, or a wireless communication module function (such as Bluetooth). The electronic module may include a proximity and/or ambient light sensor (and can then be configured to automatically adapt the brightness of the micro-display to the level of ambient light), one or more control elements (such as a pushbutton), one or more signaling elements (such as a light-emitting diode), and a lighting element. The pushbutton or the proximity sensor



13

may be configured to actuate the start/stop function of the micro-display, or another function thereof.

In all of the embodiments described, the support **25** for the nose may be removable so that a support fitting the user's shape can be selected. In an alternative (not shown in the figures), the removable nose support **41** is part of the bridge support **40**.

The spectacles according to the invention have numerous applications and uses, in particular in the professional domain, the sports domain, and city and daily life. These various applications may require an adaptation of the spectacle frame, the shape of the lenses, the precise location of the emitting module **2** and the geometric reflection element **3** (in the top or bottom position with respect to the internal edge in particular), the location of the target area **6**, and the optical adjustment (apparent distance of the projection). They may also require interfacing of the spectacles with an external microprocessor, for example by wireless communication (for example according to the Bluetooth™ standard).

In the professional domain, the spectacles **1** according to the invention may be used by people performing various tasks in a production facility, in a packaging plant, in a warehouse, in a logistics environment: in this case, it involves emitting information to the user and/or guiding the user in the execution of his or her tasks with both hands free. For example, when the user moves in a warehouse with a cart in order to collect packages at different storage stations, the spectacles according to the invention may display the code of the package, and/or the location of the next station. For a production operator, the spectacles may display for the wearer a procedure to be followed in order to carry out operations, or instructions or alert messages to be taken into account.

The spectacles **1** according to the invention may be used by medical or paramedical personnel in a health establishment in order to display useful information for the wearer (product lists, patient information, analysis results, physical, chemical or physicochemical parameters, instructions) without the personnel needing to use their hands in order to handle paper documents or display screens.

The spectacles **1** according to the invention may be used by aviation personnel in order to display important information for controlling the aircraft. As an example, this information may come from the traffic alert and collision avoidance system (TCAS). It may also be used by emergency intervention personnel (firefighters, police officers, technical support) in order to visually notify them of information.

The spectacles **1** according to the invention may be worn by athletes (for example, while running, bicycling, skiing or snowboarding) in order to display useful information for the wearer during the activity, for example, heart rate, speed, distance covered or remaining distance, timekeeping, elevation, geographic, topographic information, etc., including direction indications and GPS data, as well as tourist information (for example, concerning the ski station: closing time of a lift, waiting time, etc.). For diving masks, aside from heart rate information and timekeeping information, the diving depth and information relating to the decompression stops may advantageously be displayed.

Another use of the spectacles **1** according to the invention in an athletic context is the use by referees, for example between the central referee and the assistant referee.

In city or daily life, the spectacles **1** according to the invention may in particular be used to display timekeeping and geographic information, GPS information, meteorologi-

14

cal information, information on air pollution (pollution index), on tourist attractions (monuments, water points, bathroom availability). The spectacles according to the invention may also be used in the context of games, in particular in augmented reality (Pokemon™ GO-type, for example), and to display information on social networks (such as: Twitter™, Facebook™, Instagram™, Snapchat™, WeChat™, WhatsApp™, Line™) or notification or content of email and SMS-type messages).

What is claimed is:

**1.** Spectacles, comprising:

an optical unit comprising:

a lens having an exterior surface and an opposite side interior surface facing a wearer;

an optical block attached to the interior surface of the optical unit lens and comprising:

an emitting module;

a transformation element comprising at least one lens, wherein the emitting module and the transformation element are disposed within a housing positioned in a lower portion of the optical unit lens; and

a geometric reflection element, which is external to and separated from the housing;

wherein the emitting module is configured to project an image through a lens of the transformation element to the geometric reflection element which reflects the image onto a target area of the interior surface of the optical unit lens which is configured to receive and display the image to the wearer, and

a frame with a first rim and a second rim connected by a bridge, the first rim having a first internal edge opposing a second internal edge of the second rim, the first internal edge and the second internal edge extending from a radiused portion, the radiused portion to border the bridge, wherein one side of the optical block extends along and conforms to a bottom portion of the first internal edge of a side of an interior contour of the frame, said interior contour being formed by a top, bottom and the side of the frame proximate the wearer's nose.

**2.** The spectacles according to claim **1**, wherein a main surface of the emitting element is substantially perpendicular to the main surface of the optical unit lens.

**3.** The spectacles according to claim **1**, wherein said geometric reflection element is a mirror.

**4.** The spectacles according to claim **1**, further comprising an electronic system for detecting an ambient brightness, and configured to control a brightness setting of the emitting module in real time according the ambient brightness of an environment.

**5.** The spectacles according to claim **1**, wherein the optical block fits snugly against the interior contour of the frame.

**6.** The spectacles according to claim **1**, wherein the optical block has a first end and a second end, wherein the first end of the optical block is attached to a lower portion of the interior surface of the optical unit lens, proximate a base of a wearer's nose and the second end of the optical block is attached to an upper portion of the interior surface of the optical unit lens proximate a wearer's eyebrow.

**7.** The spectacles according to claim **1**, wherein the transformation unit comprises a plurality of lenses through which the image is transmitted.

**8.** The spectacles according to claim **1**, wherein the optical unit includes a semitransparent photovoltaic cell that supplies power to the emitting module.

## 15

9. The spectacles according to claim 1, wherein the geometric reflection element is mounted on an adjustable support.

10. The spectacles according to claim 1, wherein the emitting module is an OLED (organic light-emitting diode) display. 5

11. The spectacles according to claim 1, wherein the spectacles are integrated into a helmet.

12. The spectacles according to claim 1, wherein the optical block consists of 10

an emitting module; a transformation element comprising at least one lens; and a geometric reflection element.

13. A method of displaying an image in spectacles, the method comprising:

generating an image for display in the spectacles, wherein the spectacles comprise: 15

an optical unit comprising of:

a frame;

a lens configured to display the image;

a geometric reflection element and 20

an optical block attached to an interior surface of the optical unit lens and comprising:

an emitting module; and

a transformation element comprising at least one lens, wherein the emitting module and the transformation element are disposed within a housing positioned in a lower portion of the optical unit lens, wherein the geometric reflection element is external to and separated from the housing; 25

projecting the image from the emitting module, through one or more lenses of said transformation element, to a geometric reflection element, wherein the geometric reflection element directly reflects the image onto a target area on an interior surface of the optical unit which is configured to receive and display the image to the wearer, 30 35

wherein the emitting module and the transformation element are integrated into an optical block,

## 16

wherein one side of the optical block extends along and conforms to an interior contour of the frame, said contour being formed by a top, bottom and side of the frame proximate a wearer's nose,

wherein said geometric reflection element is a mirror.

14. Spectacles, comprising:

an optical unit comprising a lens;

a frame; and

an emitting module, a transformation element comprising

at least one lens, and a geometric reflection element, in series, wherein the emitting module and the transformation element are disposed within a housing positioned in a lower portion of the optical unit lens, wherein the geometric reflection element is external to and separated from the housing, wherein an image is projected from the emitting module through the transformation element to the geometric reflection element which directly reflects the image onto an interior surface of the optical unit lens for display to a wearer, 20

wherein the emitting module, transformation element, and geometric reflection element are each attached exclusively to the optical unit lens.

15. The spectacles according to claim 14, wherein the transformation unit comprises a plurality of lenses through which the image is transmitted.

16. The spectacles according to claim 14, wherein the optical unit includes a semitransparent photovoltaic cell that supplies power to the emitting module.

17. The spectacles according to claim 14, wherein the geometric reflection element is mounted on an adjustable support.

18. The spectacles according to claim 14, wherein the emitting module is an OLED (organic light-emitting diode) display.

19. The spectacles according to claim 14, wherein the spectacles are integrated into a helmet.

\* \* \* \* \*