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20 **MULTIFUNCTIONAL OPTICAL AIMING DEVICE**

FIELD OF THE INVENTION

The invention relates to optical aiming devices, such as are employed in connection
25 with weapons, and in particular to an aiming device with a multifunctional laser.

BACKGROUND OF THE INVENTION

30 Weapons are mainly used in military or military-like employment. In the civilian sphere, weapons are mainly used for hunting or sport. Increasingly there are realistic simulation games, which make it possible for several players to experience combat-like situations.

Today, weapons are often equipped with optical aiming devices which make the exact sighting of the target possible in order to increase the accuracy of hits in this way. A new
35 type of optical aiming device makes use of a laser, which emits a light beam. This light beam can be recognized as a light spot on the target. Depending on the wavelength of the laser light, the "marksman" must wear suitable goggles, for example night vision goggles.

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In order to make possible a differentiation between the various participants in simulations, during battle or in simulated games, an aiming device can be expanded by an identification unit. A typical laser identification/simulation system is described in the European Patent Application EP 97 120818.6 (publication number EP 0 859 243 A1) of
5 present Applicant. With such a laser identification/simulation system, the participants preferably wear harness devices on their bodies and have weapons with a system device which emits a modulated laser beam. These harness systems are preferably those described in the following European Patent Applications: EP 0 859 243 A1, EP 0 836 068 A1 and EP 0 836 069 A1. The modulated and/or coded laser beam transmits a message
10 from the weapon of the marksman to the harness device of the sighted participant. This message requests the harness device of the sighted participant to identify itself, or respectively the wearer of the harness device. The sighted participant can return a confirmation code to the marksman for this purpose. Depending on the design, such a laser identification/simulation system makes possible the identification of friendly
15 participants and the detection of enemy participants. This system can be used for the so-called identification friend or foe (IFF).

There is also the option of realizing an individual identification of the marksman in that, for example, the light spot is differently designed (for example as a triangle or as two dots).

A laser-based combat simulation system is described in US Patent 5,788,500 of
20 present Applicant. This system makes use of a special laser, which emits a continuous light beam. This type of laser is called continuous wave (CW) laser.

Depending on the situation, it would also be useful for the participants to be able to use a flashlight in order to improve visibility under adverse conditions or for illuminating defined targets. Particularly in situations where the various participants can hardly be
25 distinguished by their clothing or equipment, a flashlight is often a useful object. A flashlight is required in night deployments in particular in order to make it possible for a soldier wearing night vision goggles to illuminate his vicinity, or to shine a light on special locations in his vicinity. However, just like any other piece of equipment, such a flashlight entails disadvantages. Among other things, weight and size play essential roles in mobile
30 deployment. In some cases the weight of the equipment already has negative effects on the mobility and speed of a soldier. Also, the possibility of using a further piece of equipment is partially limited if, for example, it is necessary to hold an aimed weapon with both hands.

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Battlefield activities become more and more complex and develop with increasing speed. Decisions must be made in fractions of a second. Wrong decisions here could be fatal. Often little time remains to process the flood of information. This requires the full attention of the participant. Manipulation of additional pieces of equipment, such as the
5 already mentioned flashlight, is only possible in exceptional cases.
Also, such a flashlight would have to be extremely rugged to be approved for military use.

OBJECT AND SUMMARY OF THE INVENTION

10 It is an object of the invention to make available a novel illuminating unit. It is a particular object to make available an illuminating unit which is particularly suitable for military and/or simulation use.

These objects are attained by an aiming device in accordance with claim 1. The advantages of this aiming device will be disclosed in the following description.

15 The invention will be described in what follows by means of different exemplary embodiments in connection with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

20 **Fig. 1** represents an aiming device in accordance with the invention mounted on a weapon,

Fig. 2 shows the rear of an aiming device in accordance with the invention,

25 **Fig. 3A** shows an aiming device in accordance with the invention with a diffraction grating in the operating mode **M1**,

Fig. 3B shows an aiming device in accordance with the invention with a diffraction grating in the operating mode **M2**,

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Fig. 4A represents a pivotable diffraction grating in accordance with the invention,

Fig. 4B represents a displaceable diffraction grating in accordance with the invention,

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Fig. 4C represents a rotatable disk with different diffraction gratings in accordance with the invention,

Fig. 5 is a schematic representation of an aiming device with a diffraction grating in accordance with the invention, and

Fig. 6 is a schematic block diagram for controlling a VCSEL in accordance with the invention.

10 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows how an aiming device **1** in accordance with the invention is mounted on a weapon **2** in such a way that the center of gravity line **21** of the weapon **2** equipped with the aiming device **1** intersects the aiming device **1** itself. The aiming device **1** comprises a semiconductor laser (not represented in **Fig. 1**) and a housing **3**. The so-called semiconductor laser, as well as all other components (controls, battery, etc.), are placed into this housing **3**. The housing **3** has a mounting rail **4**, which makes it possible to mount the aiming device **1** on the weapon **2**, or respectively to separate it from the weapon **2**. In the present embodiment the housing **3** is cylindrical in order to allow the marksman to aim along the aiming line **22**. The rear **5** of the housing **3**, see **Fig. 2**, facing the marksman, has three indicator elements **6, 7, 8** in the present embodiment, which make it possible for the marksman to determine which operating mode the aiming device **1** is in. A rotary switch **15** is provided, by means of which one of the operating modes **M1, M2** or **M3**, which will be described in what follows, can be set. Further details of this will be explained in the following text.

The aiming device in accordance with the invention can be operated in at least one first, **M1**, second, **M2**, or third operating mode **M3**. A separate indicator **6, 7, 8** with the appropriate designation **M1, M2, M3** can be provided for each one of these modes on the rear **5**. It is obvious that various other arrangements and embodiments are possible. For example, the indicator can be represented in a viewfinder, or it can inform the marksman regarding the mode via an acoustic signal.

In the first operating mode **M1**, a bundled laser beam **11** leaves the aiming device **1**. This laser beam **11** has a beam divergence, which is suitable for sighting a target. Typically, the beam divergence in mode **M1** lies between 1 mrad and 5 mrad, and preferably between 2 mrad and 3 mrad. With this, the source point at the target is clearly visible to the marksman. There is a slightly scattered field around this source point at the target. In this first operating mode **M1** the aiming device is used as the target source.



A laser identification/simulation system for identifying a target is known from European Patent Application EP 97 120818.6 (EP 0 859 243 A1) mentioned at the outset. This laser identification/simulation system is designed in such a way, that coded laser radiation is transmitted. The target (for example a participant in the simulation, or a soldier) wears
5 sensor means in the form of a harness device for detecting this laser radiation and for converting it into electrical signals. The electrical signals are fed to a discriminator. Such a harness device furthermore has transmitting means which, in accordance with decisions made in the discriminator, return reports to receiver means located within or outside of the laser identification/simulation system.

10 Such a system is mounted on weapons which are normally operated by soldiers, wherein all participants in an exercise, both persons and objects, are equipped with sensors, which register a possible weapons effect on a participant. The functioning of such known systems, for example the so-called SIMLAS, represents the technical basis of an IFF (identification friend or foe) system, which can also be employed with the present
15 invention.

In the second operating mode **M2**, the laser beam **11** now has a beam divergence which is greater than 5 mrad and less than 30 mrad in order to make possible a simple interrogation of such a harness device regarding identification information. In this mode **M2**, the beam divergence preferably lies between 10 mrad and 20 mrad. If the laser beam
20 is bundled too tightly, the target must be sighted very accurately (similar to firing a round). It is advantageous if it is not necessary to aim in such an exact manner for addressing a detector of the harness device. Thus, in this second mode **M2** the aiming device **1** is used as an identification source. But it can also be very important that the diameter of the beam is not too large in order to prevent the interrogation/identification of objects located behind
25 the target, while the actual target has not been acquired.

As mentioned in the preface, it is necessary for a marksman, and in particular for a soldier, to shine a light on his surroundings or to illuminate a potential target. This is indicated in particular in case of poor visibility at night, in fog, or in a case where the marksman wears special goggles (for example a night vision device). In accordance with
30 the present invention the aiming device now can assume a third operating mode, wherein the laser beam **11** is widened to such an extent, that the aiming device **1** can be employed as an illuminating device. To this end, the beam divergence should be greater than in the second operating mode. The beam divergence in the third operating mode preferably lies between 50 mrad and 100 mrad.

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Such a widening of a laser beam could be achieved by means of a lens. However, it has been found that the use of a lens has a grave disadvantage. The optical axis of such a lens must lie exactly in the source beam of the laser beam 11. Otherwise a lateral offset of the laser beam 11 will occur after it has passed through this lens. Because of this
5 exact, sighting would be required also for the case of an illumination. This requires time, which possibly may not be available. In a lab setup, exact positioning of the lens in the beam path poses no problem. In actuality, for example in military employment, such exact positioning of the lens in the laser beam 11 is hardly possible. Moreover, if it is considered that the lens must be movably seated, so that it can move the laser beam 11, when
10 required, it has been shown that such seating is mechanically very demanding and delicate. A blow against the aiming device 1, or slight soiling of this device 1, would make the exact placement of the lens in the laser beam 11 impossible.

It has been found that these problems can be circumvented if a diffraction grating is used in place of the lens. Such a diffraction grating has the great advantage over the
15 mentioned lens that the position of the diffraction grating in the laser beam is not critical. The diffraction grating does not absolutely have to lie in the source beam of the laser. The diffraction grating does not absolutely have to lie in the optical axis of the laser beam.

A diffraction grating which is suitable for use in connection with the present invention can be produced, for example, on a glass plate or a plastic support. Various plastic foils
20 are also suitable for producing the diffraction grating. Such a plastic foil can either be applied to a substrate (for example a glass plate), or it can be stretched over a suitable frame.

A holographic diffraction grating is well suited for the employment for the controlled widening of the laser beam 11 described here.

25 The system on which the invention is based is schematically represented in Figs. 3A and 3B. The aiming device 1 is shown in these drawing figures. It emits a laser beam 11 having a defined beam divergence. It is assumed for the sake of simplicity that in Fig. 3 the aiming device 1 is shown in mode M1, wherein the laser beam has a divergence between 1 mrad and 5 mrad. By means of this a light spot 13, which is greatly limited in
30 size, is created on the target 14. The aiming device 1 has a diffraction grating 9, which is pivotably seated by means of an arm 10.

The operating mode M3 is represented in Fig. 3B. In this mode M3 the diffraction grating 9 has now been pivoted into the laser beam 11. The desired beam widening results from the scattering effect of the diffraction grating. Now the laser beam 11 has a
35 beam divergence between 30 mrad and 100 mrad. A large light spot 12 is generated on the target 14. It is therefore possible to employ the laser beam 11 for illuminating purposes in this operating mode M3. Because of the diffraction grating it is now also possible to picture a small portion of the originally bundled laser light in the center of the



light spot. In this way simultaneous lighting (**M3**) and aiming (**M1**) is possible. The marksman can light a target, for example by simply holding the weapon up, or light his surroundings by pivoting the weapon, without exactly sighting the target.

The installation of the diffraction grating can take place by means of various mechanical devices. Three examples are schematically represented in Figs. **4A**, **4B** and **4C**. A pivoting device, which is fastened on or in the aiming device **1**, can have a joint **16** which makes it possible for the marksman to flip the diffraction grating **9** into the beam path of the laser beam, as indicated by the two-headed arrow on the left side. This embodiment is represented in Fig. **4A** and in Figs. **3A** and **3B**. It is also possible to guide the diffraction grating **9** on rails **17**, wherein it can be pushed into the beam path by a lateral displacement (see the two-headed arrow), as represented in Fig. **4B**. Fig. **4C** shows a circular disk **21** with three diffraction gratings **18**, **19**, **20**. This disk is seated in the laser beam and can be rotated, as indicated by the two-headed arrow. If the diffraction grating **18** is in front of the laser beam, the latter has a beam divergence as desired for the operating mode **M1**. If the disk **21** is rotated to bring the diffraction grating **19** into the beam, a beam divergence corresponding to the operating mode **M2** is created. The third diffraction grating **20** creates the beam divergence desired for the mode **M3**.

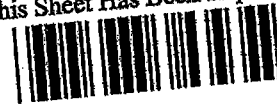
It is also possible to provide several such disks **21** with diffraction gratings, which are seated in the beam path, each rotatable in respect to the others.

The installation of the diffraction grating can also be automated. For example, the diffraction grating can be brought into the desired position by spring force or by a motor. The displacement by a spring force is suitable for suddenly switching from the illuminating mode **M3** or the identification mode **M2** into the aiming mode **M1**. In this case a pretensed spring can move the diffraction grating **9**.

If a semiconductor laser is used, which emits a laser beam **11** in the non-visible wavelength range, an illuminating device is obtained, whose deployment is not visible to the human eye. An illuminated target is only visible if suitable goggles (for example night vision goggles) are worn. This can be advantageous during a firefight, since a marksman would disclose his position if he were to use an illuminating device emitting visible light. The person who is being illuminated can also see that he is in the cone of light. This is possibly not desirable and can be avoided by using a semiconductor laser emitting non-visible light.

The aiming device in accordance with the invention transmits a laser beam **11** which can be used for various purposes by affecting the beam divergence.

Three different operating modes have been described up to now. Additional operating modes can be provided for making communications, or respectively the compatibility, with harness systems of different types and structures possible. For example, it would be conceivable for the aiming device to have a switch, which switches the beam divergence



from a mode **A1** into a mode **A2**, wherein the beam divergence is different in each case. In the mode **A1** this aiming device can contact relatively insensitive sensors of older types, wherein in mode **A2** only highly sensitive sensors of newer types are excited. Switching from **A1** to **A2** and vice versa again takes place by the insertion of a suitable diffraction
5 grating, or respectively by the movement of such a diffraction grating from a first into a second position.

Semiconductor lasers are particularly suited as laser sources. A differentiation between two types of semiconductor lasers is made here. The so-called edge emitting lasers have a layer structure, which is bordered by vertical facets at both ends. This
10 means that these lasers have a rectangular shape. The facets have either been etched or cleaved. In the active zone of the laser, lightwaves are passed back and forth in parallel from facet to facet and undergo an amplification, if a suitable voltage has been applied. The laser light exits through one of the facets.

The second type of semiconductor lasers are so-called vertical cavity surface-emitting
15 lasers (VCSEL). As the name implies, this type of lasers emits vertically in respect to the layer structure, and therefore also vertically in respect to the surface of the laser. Typical VCSELs have a cylindrical shape. The advantages of such a structure lie in a relatively small active volume, a radially symmetrical distribution of the near field, and in the possibility of two-dimensional integration. The active layer(s) customarily has/have a
20 thickness of only a few atoms. The laser light is amplified in the active layer(s), wherein electrons can assume discrete energy levels. These energy levels are separated by a blocking zone (semiconductor gap). If the electrons are forced to jump the semiconductor gap, photons of corresponding energy are emitted. A VCSEL basically consists of two Bragg reflectors (DBRs). A DBR is an alternating layer sequence of two semiconductor
25 materials of different diffraction indices, each of a thickness of half a wavelength of the laser light. In the range of this wavelength, the DBR reflects light almost completely, therefore two DBRs constitute a high-quality resonator. A portion of the light is coupled out of the upper Bragg mirror.

In the course of the past years the most diverse VCSEL structures have been
30 developed which, depending on their application, are of different complexity. VCSELs are commercially available as components in various shapes and designs. There are also some VCSELs with an integrated monitor diode. This allows the construction of a control circuit, for example for limiting the maximally emitted light output in order to be able to maintain safety standards. Similar to an LED, a VCSEL is customarily integrated in a
35 plastic housing, wherein an optical component (for example a lens) is normally located in the beam path. Typical dimensions of a VCSEL lie between 2 mm x 5 mm (width x height) and 10 mm x 20 mm.



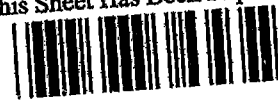
VCSELs can be produced more simply than the edge emitting lasers, since a large number of VCSELs can be produced on the same substrate material. Moreover, these VCSELs are normally smaller. A further advantage of the VCSELs is that they can be tested in batches. Other laser diodes normally require individual testing. A further
5 advantage of VCSELs lies in that they emit light in a very narrow band.

VCSELs of wavelengths in the infrared range are already widely used. Red VCSELs emit at a wavelength around 670 nm. For this purpose, structures with laser-active layers of GaInP/AlGaInP and with Bragg mirrors of AlAs/AlGaAs are produced by MOVPE (Metal Organic Vapor Deposition) processes. To obtain a high current density and a narrow
10 laser beam, small columns can be etched out of the upper p-doped DBR (for example by ion beam etching), which are supplied with metal contacts at the top. VCSELs are available at wavelengths between 600 nm and 2000 nm. There are numerous producers of VCSELs, who issue detailed data sheets in connection with the VCSELs they sell in order to make possible an appropriate circuit dimensioning.

The laser beam emitted by a VCSEL has little divergence. A commercial VCSEL has a beam divergence between 1 mrad and 10 mrad, and preferably between 3 mrad and 5 mrad. This is an advantage over other lasers, whose beam must first be widened for all applications. Furthermore, VCSELs typically emit through relatively large symmetrical apertures, so that the laser beam is rounder and has less divergence than with
20 conventional edge emitting laser diode structures.

Fig. 5 is a schematic representation of a further embodiment of the present invention. A semiconductor laser **30** has been integrated into an aiming device **31**. The laser **30** emits a laser beam **32**, which is conducted through a lens **33**. From this results a laser beam **34** which is free or almost free of divergence. A light spot **35** of a small, accurately
25 defined circumference results at the target. The mode represented can be, for example, the first operating mode M1. If now a diffraction grating **36** is inserted into the laser beam **34**, the latter is widened to a laser beam **37**. A larger light spot **38** results on the target. The diffraction grating **36** is shown to the left of the aiming device in order to show where the laser beam **34** passes through the diffraction grating **36**.

There are numerous possibilities for controlling a VCSEL. A usable arrangement is schematically represented in Fig. 6. As represented, the VCSEL **40** is controlled via a driving transistor **42** (for example a bipolar transistor) and a multiplier resistor **41**. This is a common collector, since the VCSEL **40** is located in the collector circuit of the transistor **42**. The base electrode **47** of the transistor **42** is connected with a microprocessor **43**.
30 Such a collector circuit is used as a constant current source. The transistor **42**, and therefore also the VCSEL **40**, are controlled by this microprocessor **43**. If an operating voltage V is applied between the positive pole **45** and ground **46**, a current can flow through the VCSEL **40** by means of the application of a signal to the base electrode **47** of



the transistor **42**. If such a current flows, the VCSEL **40** emits a laser beam **44**. If the microprocessor **43** modulates the signal at the base electrode **47** of the transistor **42**, a pulsed laser beam **44** results, as schematically represented above this laser beam. Instead of controlling the VCSEL **40** by means of a microprocessor **43**, a suitable gate

5 circuit can also be used for control.

In one embodiment the aiming device **1** in accordance with the invention consists of an aiming unit having a semiconductor laser for sighting a target. The aiming device **1** furthermore contains an identification unit, which interrogates the target for identification information by means of the same laser beam **11**. An illuminating unit is furthermore

10 integrated into the aiming device **1**, which makes it possible to illuminate a target by means of the laser beam **11**. The components of the aiming unit, the identification unit and the illuminating unit can either be separately executed, or all, or respectively a part, of the components can be used by all three units. In every case, however, is the semiconductor laser used by all units, wherein the beam divergence is changed as a

15 function of the purpose for which it is used. One or several diffraction gratings are brought into the laser beam for this purpose. In addition to the adaptation of the beam divergence it is of course also possible to switch the control of the semiconductor laser accordingly.

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**WHAT IS CLAIMED IS:**

1. An aiming device for a weapon, consisting of an aiming unit containing a laser for
5 sighting a target by means of a laser beam (11) emitted by the laser, and of an
identification unit which, by means of the laser beam (11), interrogates the target in
respect to identification information, characterized in that the aiming device (1) contains an
illuminating unit, which makes it possible to illuminate the target by means of the laser
beam (11), wherein the laser is a semiconductor laser, which can be used for the aiming
10 unit, the identification unit, as well as for the illuminating unit.
2. The aiming device in accordance with claim 1, characterized in that the
semiconductor laser is constructed of several semiconductor layers, wherein the laser
beam is emitted vertically in respect to the semiconductor layers.
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3. The aiming device in accordance with claim 2, characterized in that the
semiconductor laser is a vertical cavity surface-emitting laser (VCSEL).
4. The aiming device in accordance with claim 2 or 3, characterized in that the
20 semiconductor laser contains at least one optical component which is integrated into the
semiconductor laser.
5. The aiming device in accordance with claim 4, characterized in that the optical
component is an optical lens which is located in the beam path of the laser beam (11).
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6. The aiming device in accordance with claim 1, characterized in that the laser beam (11)
has a beam divergence which can assume at least a first mode (M1) and a second mode
(M2), wherein the laser beam (11) in the first mode (M1) has a beam divergence between
1 mrad and 5 mrad in order to allow exact sighting of the target, and in the second mode
30 (M2) has a beam divergence which is greater than 5 mrad in order to allow a simple
interrogation of the target in regard to identification information.
7. The aiming device in accordance with claim 6, characterized in that the beam
divergence can assume a third mode (M3), wherein the beam divergence is greater than
35 the beam divergence in the second mode (M2).





8. The aiming device in accordance with claim 6, characterized in that a diffraction grating (9) is fastened pivotably on or in the aiming device (1) in such a way that it can be moved into the beam path by means of a pivot movement, wherein the beam divergence takes up one of the said modes (M1, M2, M3) because of this.

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9. The aiming device in accordance with claim 6, characterized in that at least two diffraction gratings (9) are pivotably fastened on or in the aiming device (1) in such a way that they can be moved individually or together into the laser beam (11) by means of a pivot movement, wherein the beam divergence respectively assumes one of the said modes (M1, M2, M3).

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10. The aiming device in accordance with claim 6, characterized in that a diffraction grating (9) is fastened on or in the aiming device (1) in such a way that it can be moved into the laser beam (11) by means of a pivot movement, that it assumes a first position or a second position there, wherein in the first position the beam divergence assumes one (M1) of the said three modes, and in the second position another (M2, M3) of the three modes.

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11. The aiming device in accordance with claim 10, characterized in that the diffraction grating (9) has a first area so that a predetermined beam divergence can be created when the diffraction grating (9) is in the first position, and that it has a second area so that a predetermined different beam divergence can be created when the diffraction grating (9) is in the second position.

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12. The aiming device in accordance with claim 1, characterized in that the aiming device has a device (15), preferably a key, by whose actuation the illuminating unit is activated for illuminating the target by means of the laser beam (11).

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13. The aiming device in accordance with claim 1, characterized in that several diffraction gratings can be switched in series into the laser beam.

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14. The aiming device in accordance with claim 1, characterized in that zooming can be achieved by the series switching.

