Aiming scope with illuminated sights and thermal imaging camera

The field of the invention is that of aiming scopes comprising a thermal imaging camera and an illuminated sight.

To carry out his or her various missions with his or her weapon, the infantry soldier needs the following:

- daytime and nighttime firing capability, requiring an accurate sighting making it possible to best make use of his or her weapon, ideally for effective firing beyond 300 meters;
- rapid sighting in dynamic combat situations;
- conservation of a good situation awareness to respond to any threat that might occur on the battlefield, daytime and nighttime. This situation awareness notably entails conserving a wide field of vision encompassing the surrounding space;
- capacity to "decamouflage" or perceive threats, both daytime, and nighttime;
- discretion, which is reflected, notably at night, through the absence of light emission from the sighting members;
- absence of boresighting setting operation to switch from day sighting to night sighting and vice versa, so as to save time and ensure the reliability of the sighting;
- mobility and endurance, which necessitates equipment that is as lightweight and compact as possible.

These needs are reflected by strong demands on the sighting members that equip the assault rifle with which the infantry soldier is provided. In practice, these requirements are satisfied only partially and are not at all with a single piece of equipment that is compact and lightweight.

The routine solutions for ensuring the sighting on an assault rifle are as follows. For daytime sighting, the weapon basically comprises an eyepiece – front sight assembly. This assembly is simple, robust and inexpensive, but offers little accuracy.

The weapon can also comprise, for daytime sighting:

- an illuminated sight, that is to say an optical assembly that makes it possible to superpose a luminous symbol or dot on the outside in the sighting axis. This illuminated sight can possibly be associated with a switchable magnifying optic. As an example, the magnification is 3;
- a laser pointer;
- a daytime magnifying scope;

for nighttime sighting, the weapon can comprise:

- a laser pointer;
- an aiming scope with a light-intensifying aiming scope called "IL" scope;
- an infrared aiming scope, called "IR" scope;
- a light-intensifying or infrared adapter or "clip-on" positioned upstream of a daytime aiming scope;
- a sighting device comprising night glasses associated with an illuminated sight secured to the weapon.

These known solutions each have advantages and drawbacks, but none completely addresses the overall need identified above.

The illuminated sight solution is particularly well thought of because it offers good accuracy, while preserving a good perception of the overall situation inasmuch as it allows the sighting and the firing with both eyes open and allows a position of the eye that is relatively far from the illuminated sight optic, the eye not having to be close to an eyepiece. The shooter can keep both eyes open, the illuminated sight transmitting the landscape without magnification.

The sighting by means of a laser pointer, widely used, notably at night, is very advantageous because it allows for rapid firing in dynamic combat, without the eye having to be aligned behind a sight, or even having to shoulder the weapon in an extreme situation. On the other hand, the laser pointer remains indiscrete, notably at night. Even when it is a pointer emitting in the near infrared, it is easily detectable with night vision glasses or even with certain equipment using a camera that is sensitive in the near infrared.

The aiming scopes in general, whether they be daytime scopes or nighttime scopes, with thermal light intensifying or thermal infrared, offer the

advantage of their accuracy, by virtue in particular of their magnification. They present the drawback of requiring the eye used for the sighting to be positioned close to an eyepiece; moreover, the user cannot use the other eye for an overview. This operation takes a certain time, which constitutes a loss of efficiency in dynamic combat. Furthermore, the shooter is momentarily cut off from his or her environment and may then be unaware of new threats. Finally, at night, if equipped with night vision glasses, the combatant has to take those night vision glasses off in order to be able to correctly position the free eye behind the aiming scope. There again, that represents an additional delay in the action and a break with respect to the environment of the combatant.

The infrared or thermal imaging aiming scopes present the same drawbacks but offer a few significant advantages: night vision, including in total darkness, enhanced vision in the fog and smoke of the battlefield and above all the capacity to “decamouflage” any hot target.

To try to provide an appropriate response, it is possible to juxtapose several systems within a single piece of equipment. For example, as can be seen in figure 1, some sighting equipment items combine an IL or IR aiming scope topped by an illuminated sight. In this case, the scope comprises a thermal imaging camera and a viewing device. The thermal imaging camera comprises a focusing lens 1 and a photosensitive receiver 2. The viewing device comprises a microdisplay 3 and an eyepiece 4. The illuminated sight comprises a luminous symbol 5 and an optic 6 for collimation and superpositioning with the direct vision 7.

These solutions result in relatively bulky equipment offering a juxtaposition of functions but without them being combined. At a given instant, the user must choose to use either the illuminated sight, or the scope and therefore never benefits from the cumulative advantages of both systems. In the case of a system associating a thermal infrared scope and an illuminated sight, the user must choose between benefiting from the rapid sighting and the situation awareness offered by the illuminated sight, or benefiting from the decamouflaging and night vision offered by the thermal imaging scope.

To sum up, the existing solutions based on a single principle of illuminated sight, pointer or scope type do not meet all of the needs of the infantry soldier for firing in any situation. The solutions which juxtapose two principles in the same equipment such as, for example, an illuminated sight and a thermal imaging scope make it possible to bring together certain advantages without it being possible to benefit from them all simultaneously. Moreover, these systems are bulky and heavy. They do not meet all of the needs identified above.

The scope according to the invention does not have the above drawbacks. Indeed, several images from different sources are perceived by a single eyepiece of illuminated sight type. Several of the requirements of this type of equipment are thus assured while retaining a reduced bulk. More specifically, the subject of the invention is a sighting or spotting scope comprising, in a single mechanical structure, a camera and a video microdisplay associated with an eyepiece, characterized in that the eyepiece uses an optical combiner arranged so as to superpose the image of the video microdisplay on the outside landscape.

Advantageously, the scope comprises a luminous symbol or dot and an optical device arranged to superpose the image of said luminous symbol or dot on said image of the video microdisplay and on the outside landscape.

Advantageously, the optical chain composed of the camera, of the microdisplay and of the eyepiece has a magnification of one, the image of the microdisplay conforming to that of the outside landscape.

Advantageously, the optical combiner comprises a flat semireflecting surface inclined at approximately 45 degrees to a sighting or spotting axis.

Advantageously, the semireflecting surface is incorporated in a splitter plate comprising two flat and parallel faces.

Advantageously, the semireflecting plate is incorporated in a splitter cube comprising two flat and parallel faces. The normal to said faces can be parallel to the sighting or spotting axis.

Advantageously, the splitter prism comprises a reflecting concave mirror, the optical axis of which is at right angles to the sighting or spotting

axis, the light rays from the video microdisplay being transmitted by the semireflecting plate, reflected by the concave mirror then by the semireflecting plate.

Advantageously, the splitter prism comprises a convex input face, the optical axis of which is at right angles to the sighting or spotting axis and opposite to the concave mirror.

Advantageously, the optical combiner comprises a concave semireflecting surface of "freeform" or diffractive type inclined to the sighting or spotting axis and the eyepiece comprises a convex mirror associated with the concave semireflecting surface.

Advantageously, the optical device comprises a splitter plate or a splitter cube disposed in front of the video microdisplay so that the image of the luminous symbol or dot is, by reflection or transmission by the splitter plate or by the splitter cube, merged with the video microdisplay.

Advantageously, the camera is a thermal infrared or low light level camera.

The invention will be better understood and other advantages will become apparent on reading the following description given in a nonlimiting manner and from the attached figures in which:

figure 1, already commented on, represents a sighting scope-illuminated sight combination according to the prior art;

figure 2 represents a perspective view of a sighting or spotting scope according to the invention;

figure 3 represents a production scheme for a sighting or spotting scope according to the invention;

figure 4 represents a first embodiment of an eyepiece according to the invention;

figure 5 represents a second embodiment of an eyepiece according to the invention;

figure 6 represents a third embodiment of an eyepiece according to the invention;

figure 7 represents a variant embodiment of a sighting or spotting scope according to the invention comprising the generation of a collimated luminous dot;

figure 8 represents a fourth embodiment of an eyepiece according to the invention.

Figure 2 represents a perspective view of a sighting and spotting scope according to the invention. It comprises, essentially, two main subassemblies which are a camera 10 and a viewing device 15 comprising a microdisplay and an eyepiece with optical combiner. The optical combiner is mounted on top of the camera. The assembly of the optical and electronic components is incorporated in a sealed structure 80 which protects them from the outside environment and from impacts.

This structure comprises a mechanical fixing interface 85 that makes it possible to fix it onto a weapon equipped with a standard interface. This interface is, for example, a "Picatinny" rail or the equivalent thereof.

The structure also comprises a set 87 of buttons and control members allowing in particular the On/Off controls of the different functions of the equipment, the video microdisplay brightness settings, the electronic and mechanical boresighting settings, the electronic settings for superpositioning of the different images generated on the outside landscape. It can be disposed on one of the two lateral flanks of the scope. As an example, in figure 2, the set comprises three buttons disposed on the left lateral flank of the scope, other buttons being disposed on the left flank of the scope.

Figure 3 represents a first embodiment of a sighting or spotting scope according to the invention. For this figure and the subsequent figures, the following conventions have been adopted. The optical or mechanical elements are represented in bold lines, the light rays are represented by thin lines and the optical axes are represented by dotted lines. For the purposes of clarity, only the light rays on the optical axis are represented.

The camera is preferentially a thermal imaging camera, composed of an infrared lens 20 operating in the spectral band situated between 8 µm and 12 µm and an infrared sensor 25 with microbolometers sensitive in the same spectral band.

The camera can also be a low light level camera, implementing a low-noise "CMOS" sensor, "CMOS" being the acronym for "Complementary

Metal Oxide Semi-conductor" or an "EB-CMOS" sensor, "EB-CMOS" being the acronym for "Electro-Bombarded CMOS". The camera can also be an "SWIR" camera, "SWIR" being the acronym for "Short Wave InfraRed", operating in the spectral band between 1 µm and 2 µm, sensing the night light from the night glow and also offering decamouflaging capabilities.

This camera comprises a power supply, sensor driving and image processing electronics 30 as well as a power supply unit 40 receiving several battery cells or a block of rechargeable batteries so as to ensure the autonomy thereof, which can be disposed behind the scope, on the observer eye side.

The viewing device comprises a microdisplay 50, an eyepiece 60 with optical combiner 70 and the electronics necessary for powering and driving the microdisplay.

This microdisplay 50 displays a video sighting reticle, possibly enriched with rear sight correction elements or optical distance measuring symbols or graduations. It also displays the thermal infrared image of the scene from the thermal imaging camera.

This microdisplay can be, for example, an "OLED" display, "OLED" being the acronym for "Organic Light Emitting Diode", an "LCD", "LCD" being the acronym for "Liquid Crystal Display", an "LCOS" display, "LCOS" being the acronym for "Liquid Crystal On Silicon".

The optical chain composed of the camera, the microdisplay and the eyepiece has a magnification of one, the image of the microdisplay conforming to that of the outside landscape. The optical combiner ensures the perfect positioning of the image of the microdisplay on the outside landscape.

The eyepiece with optical combiner has different possible embodiments.

In a first embodiment illustrated in figures 4, 5 and 8 which represent different optical eyepiece combinations, the optical combiner comprises a flat semireflecting surface inclined at 45 degrees to a sighting or spotting axis. This surface does not have optical power.

This surface can belong to a semireflecting plate with flat and parallel faces of small thickness as seen in figure 8.

As illustrated in figures 4 and 5, this plate can advantageously be incorporated in a splitter cube comprising two flat and parallel faces so as not to introduce distortion on the outside landscape. The normal to these faces can be parallel to the sighting or spotting axis.

Figure 4 represents a first eyepiece 61 comprising a focusing optic and an optical combiner 71 with splitter cube. The focusing optic forms from the microdisplay 50 an image to infinity which is superposed on the outside landscape by means of the optical combiner 71. The optical combiner 71 comprises an inclined flat semireflecting plate 711 and two flat and parallel faces 712 and 713. As in the example, the focusing optic of figure 4 comprises three lenses 610, 611 and 612 and a flat return mirror 613 situated between the second and third lenses. This mirror 613 makes it possible to reduce the bulk of the focusing optic. In a variant embodiment, the mirror can be replaced by a totally reflecting prism. In this configuration represented in figure 4, the optical combiner 71 directly reflects the image from the display to the eye Y of the observer.

Figure 5 represents a second eyepiece 62 comprising a focusing optic and an optical combiner 72 with splitter cube. In this configuration, the optical combiner has optical power on the path of the microdisplay. The optical combiner has no optical power on the direct transmission path. Thus, the number and the size of the lenses necessary to the collimation are reduced. The eyepiece is simpler and less bulky.

The splitter cube 72 then comprises a reflecting concave mirror 722, the optical axis of which is at right angles to the sighting axis. The collimation of the light rays from the display 50 is ensured by a group of three lenses 620, 621 and 622 and by the combiner 72. The light rays from the video microdisplay 50 pass through the group of lenses, are transmitted by the semireflecting plate 721, reflected by the concave mirror 722 then a second time by the semireflecting plate 721 toward the eye of the observer.

In this optical combination, as in the preceding one, a flat return mirror 623 makes it possible to reduce the optical bulk of the eyepiece. In a variant embodiment, the splitter cube comprises a convex input face 723, the optical axis of which is at right angles to the sighting or spotting axis and

opposite to the concave mirror 722. The function of this convex face 723 is to avoid the total reflections seen by the eye which originate from the scene and are reflected by total reflection on this face of the prism. This convex face makes it possible to defocus these spurious images and push them back into a zone that is not visible to the eye in firing position.

In a second embodiment illustrated in figure 6, the optical combiner 73 comprises a concave semireflecting surface of "freeform" or diffractive type inclined to the sighting or spotting axis. "Freeform" surface is understood to mean a surface which does not have symmetry of revolution. It can be defined in different ways.

In this configuration, the semireflecting surface is inclined to the optical axis by a significant angle which can be around 40 degrees. In this case, the eyepiece 63 comprises a convex mirror 632 that is also inclined to the optical axis associated with the concave semireflecting surface 73 as can be seen in figure 5. This mirror can also be a surface of "freeform" or diffractive type. Finally, the eyepiece 63 comprises a group of two lenses 630 and 631 forming a pair, the convex mirror 632 and the concave semireflecting surface 73. If the group of lenses has a significant focal length, it is possible to interpose between the display 50 and this group of lenses an optical beam-folding device which can be mirror-based or prism-based so as to reduce the bulk of the eyepiece.

In an important variant embodiment of the sighting and spotting scope according to the invention, the scope comprises a luminous symbol or dot and an optical device arranged to superpose the image of this luminous symbol or dot on the image of the video microdisplay and on the outside landscape. The optical device then comprises a splitter plate or a splitter cube disposed in front of the video microdisplay so that the image of the luminous symbol or dot is, by reflection or transmission by the splitter plate or by the splitter cube, merged with the video microdisplay.

In its basic version, the luminous dot is produced by means of a light-emitting diode placed in front of a feed hole, the latter being positioned in the focal plane of the eyepiece so as to be superposed on the image of the microdisplay. This dot is generally red. The luminous dot is fixed onto a

translation adjustment mechanism in the focal plane so as to allow the user to perform boresighting adjustments of the sighting axis embodied by the luminous dot relative to the firing axis of the weapon. The reticle of the display and the red dot constitute two alternative solutions for showing the sighting axis of the weapon, the red dot being a simple solution with very low consumption. The video reticle makes it possible to generate patterns of various and sophisticated forms comprising, for example, optical distance measuring symbols of people or of vehicles ensuring an approximate range finding.

The "red" dot therefore constitutes an optional complement to the video microdisplay. It also allows for a low-consumption degraded mode when the microdisplay and the thermal image are not operating, for example to save on the electrical energy of the scope.

A first example of execution of this variant embodiment is represented in figure 7. A splitter cube 90 comprising a flat semireflecting plate 91 is disposed between the microdisplay 50 and the first lens of the eyepiece. The latter has the configuration of the eyepiece 60 of figure 3. The red dot 95 is disposed so that its image, by reflection on the semireflecting plate 91, is merged with the microdisplay.

A second exemplary embodiment is represented in figure 8. In this example, the eyepiece 64 comprises an optic 640 disposed between the microdisplay 50 and the splitter cube 900. An identical optic 640bis is also disposed between the red dot 95 and the splitter cube 900. The splitter cube is an assembly of two prisms 901 and 902, the common face 910 of which comprises the semireflecting treatment. In the case of figure 7, the prism 902 operates by total reflection. The eyepiece part therefore comprises, in this order, the optics 640 and 640 bis, the splitter prism 900, a totally reflecting prism 641 which ensures the folding of the beams and the semireflecting plate 73 and the pair 642.

It should be noted that it is easily possible to adapt the eyepiece with freeform plate of figure 6 so as to introduce the generation of the red dot. To this end, it is sufficient to dispose a splitter cube or any other prism assembly between the microdisplay and the lens.

The sighting scope according to the invention can comprise complementary modular optical systems that make it possible to modify the perception of the outside landscape. Thus, it is possible to dispose, downstream of the optical combiner, a magnifying afocal optic with a magnification of 3 for example. Likewise, it is possible to dispose, upstream of the combiner, an optical module that is unchanging in terms of magnification and of light-intensifying axis deflection. The user thus perceives both an intensified image and a thermal image of the outside landscape.

The first advantage of the scope according to the invention is, for daytime sighting, to add a decamouflaging capability to an illuminated sight, while retaining the ergonomic qualities of the illuminated sight which offers a large eye print, does not occult the peripheral field of view and makes it possible to engage a target while keeping both eyes open. The user has, in the window of the sight, the direction image of the scene on which are superposed on the one hand, the light reticle embodying the firing axis of his or her weapon, and on the other hand, the video image of the hot targets present in the scene and likely to constitute threats. The display solely of the hot targets, at human body temperature, by deleting the background of the scene is ensured by conventional algorithms used in thermal imaging, notably in the IL/IR fusion systems. These algorithms are known to the person skilled in the art. The combatant benefits therefore from a merged vision between the direct vision of the scene and the thermal infrared vision of the target, on which appears the light reticle showing the firing axis of the weapon when the combatant aims at this target.

The second advantage of this scope is to allow, at night, an infrared sighting, in the manner of what can be done with a conventional thermal imaging aiming scope, but with the ergonomics of an illuminated sight: magnification of 1, large eye print, sighting with both eyes open.

The third advantage is to allow, at night, the combatant to watch in the illuminated sight by using the light-intensifying night vision glasses with which he or she may be provided, the latter being fixed onto his or her head or his or her headset and thus held in front of his or her eye. The combatant then benefits from the perception of the night scene over a wide field, that of the night vision glasses. This field is typically 40°. Moreover, the combatant

benefits from the infrared vision of the scene around the reticle which defines its sighting axis. He or she then benefits both from the situation awareness through the night vision glasses offering a wide field that he or she can use with both eyes open, and from the image of the target decamouflaged in thermal infrared.

The combatant therefore has at his or her disposal a dual image merging system: direct and thermal infrared vision in daytime, light intensification and thermal infrared at night. This is effective without adding specific night vision glasses but simply by using the night vision glasses already available in the armed forces. This dual benefit, obtained from a single, lightweight and compact module, is added to the advantage of having, in daytime as at nighttime, ergonomy of illuminated sight type which allows for rapid sighting, both eyes open, while retaining, at each instant, a good perception of the environment, which is profitable for responsiveness in a dynamic combat situation and that makes it possible to obtain superiority in a duel situation.

CLAIMS

1. A sighting or spotting scope comprising, in a single mechanical structure (80), a camera (10) and a video microdisplay (50) associated with an eyepiece (60), characterized in that the eyepiece comprises, in this order, at least one group of lenses, a return mirror and an optical combiner (70) arranged so as to superpose the image of the video microdisplay on the outside landscape.

2. The sighting or spotting scope as claimed in claim 1, characterized in that the scope comprises a luminous symbol or dot (95) and an optical device (90) arranged to superpose the image of said luminous symbol or dot on said image of the video microdisplay and on the outside landscape.

3. The sighting or spotting scope as claimed in one of the preceding claims, characterized in that the optical chain composed of the camera, of the microdisplay and of the eyepiece has a magnification of one, the image of the microdisplay conforming to that of the outside landscape.

4. The sighting or spotting scope as claimed in one of the preceding claims, characterized in that the optical combiner comprises a flat semireflecting surface (711, 721) inclined at approximately 45 degrees to a sighting or spotting axis.

5. The sighting or spotting scope as claimed in claim 4, characterized in that the semireflecting surface is incorporated in a splitter plate (73) comprising two flat and parallel faces.

6. The sighting or spotting scope as claimed in claim 4, characterized in that the semireflecting surface is incorporated in a splitter cube (71, 72) comprising two flat and parallel faces.

7. The sighting or spotting scope as claimed in claim 6, characterized in that the splitter cube comprises a reflecting concave mirror (722), the optical axis of which is at right angles to the sighting or spotting axis, the light rays from the video microdisplay being transmitted by the semireflecting plate, reflected by the concave mirror then by the semireflecting plate.

8. The sighting or spotting scope as claimed in claim 7, characterized in that the splitter cube comprises a convex input face (723), the optical axis of which is at right angles to the sighting or spotting axis and opposite to the concave mirror.

9. The sighting or spotting scope as claimed in one of claims 1 to 3, characterized in that the optical combiner comprises a concave semireflecting surface (73) of "freeform" or diffractive type inclined to the sighting or spotting axis and in that the eyepiece comprises a convex mirror (632) associated with the concave semireflecting surface.

10. The sighting or spotting scope as claimed in one of claims 2 to 9, characterized in that the optical device comprises a splitter plate or a splitter cube (90) disposed in front of the video microdisplay so that the image of the luminous symbol or dot is, by reflection or transmission by the splitter plate or by the splitter cube, merged with the video microdisplay.

11. The sighting or spotting scope as claimed in one of the preceding claims, characterized in that the camera is a thermal infrared camera.

12. The sighting or spotting scope as claimed in one of claims 1 to 10, characterized in that the camera is a low light level camera.