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SIGHTING DEVICE HAVING AN IMAGE

INTENSIFIER.

This invention relates generally to sighting devices, and is particularly applicable to firearms and the like, especially sighting devices for night-time use to guide the eye in aiming.

Sighting devices of the type in which an image of a viewed scene is observed frequently use aiming reticles which appear in the field of view. Such reticle can be of either the silhouette or the illuminated type.

In the silhouette type, an opaque marking appears against the viewed scene as the background. The problem with this type of sighting device is that, unless the scene is in bright light or the mark is so large that it obscures a significant part of the viewed scene, the mark can be very difficult to see.

Marks which are illuminated by an internal light source have been suggested for optical equipment. Thus, U.S. Patent No. 3,960,453 discloses a conventional daylight telescope having a row of light-emitting diodes (LED's) whose images are projected into the field of view of the telescope to provide a moving light spot, the speed of which is adjusted to follow a moving object. Once velocity is determined, all but one of the diodes is turned off so as to provide a single lighted diode which serves as an aiming mark having the correct lead, once the distance to the

1 target is set. While suitable for the purpose of pro-
viding a moving reference, the emitting area of each
diode is too large to provide a good aiming mark.
Therefore, these and other known designs are unsuitable
5 for sighting devices intended for firearms, when used
under conditions of poor illumination of the field of
view and of the target.

U.K. Specifications 1494237 and 1411718 disclose the
use of illuminated aiming reticles at the objective or
10 input side of an image intensifier or transformer. Both
the target image and the reticle image are processed by
the intensifier or transformer. Accordingly, a contrast,
especially colour contrast, cannot be reliably achieved
between reticle and target. Moreover, there will be
15 conditions of target illumination for which it could
be difficult for an observer to distinguish the reticle

In accordance with a broad aspect of the invention,
there is provided a sighting device comprising an image
intensifier device, capable of rendering a target visible
20 at an output surface of the device under conditions of
poor illumination, and means for imaging an illuminated
aiming mark substantially at the output surface of the
image intensifier device, said imaging means comprising
an eyepiece lens through which a viewer can observe the
25 output surface of the image intensifier device, a light
source for providing the illumination for the aiming
mark, and beam combiner means for directing the light
from the light source through the eyepiece lens, so that
the viewer will observe a virtual image of the aiming
30 mark superimposed on the image on the output surface of
the image intensifier device.

Such a device can be designed so that the aiming
mark is easily discernable against a background of target
images having wide ranges of brightness.

35 The aiming mark may consist of the output end of an
optical fibre through which light is directed from the
light source to the beam combiner means. Alternatively,

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1 an aperture through which light is directed from the light source to the beam combiner means may be used. Generally, the beam combiner means comprise a partially reflective mirror.

5 As a feature pertaining to a particularly useful embodiment, the image intensifier tube produces upon

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1 its output surface an image of one colour and the
 aiming mark is of a contrasting colour. The partially
 reflective mirror is suitably a dichroic mirror which
 favours reflection of the light of the colour of the
 5 aiming mark and which favours transmission of the
 light of the colour of the image produced upon the
 output surface of the image intensifier tube. In one
 such practical embodiment, the light source is a light-
 emitting diode which preferably emits red light, while
 10 the output surface of the image intensifier tube gener-
 ates images in a contrasting colour, such as yellowish-
 green.

Moreover, a sighting device according to the
 invention is preferably equipped with means for dis-
 15 placing the position of the aiming mark projected up-
 on the output surface of the image intensifier tube,
 e.g. in mutually orthogonal directions oriented sub-
 stantially parallel to the output surface of the image
 intensifier tube.

20 For a better understanding of the invention and
 to show how the same may be carried into effect, refer-
 ence will now be made, by way of example, to the ac-
 companying drawings, wherein:

Figure 1 is a side view of a sighting device,
 25 with portions shown in cross-section;

Figure 2 is a detailed, partly schematic
 cross-sectional side view of portions of the device
 of Figure 1;

Figure 3 is a similar cross-sectional view
 30 taken along line 3-3 of Figure 1;

Figure 4 is a similar cross-sectional view
 taken along line 4-4 of Figure 1; and

Figure 5 is a cross-sectional view illustrating
 a modification of the light source assembly.

35 Referring with particularity to Figure 1, a
 housing 10 holds an objective lens 12 of high light-
 gathering power and an image intensifier tube 14. An

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1 image of the scene 16 in front of the lens 12 is
formed on the front surface, which is the image in-
put surface 18, of input fibreoptic plate 20 forming
part of the known image intensifier tube 14. Light
5 rays 22 and 24 show how light from the viewed scene
is focussed by lens 12 onto the input surface 18 of
the image intensifier tube 14. The fibreoptic plate
20 is comprised of a bundle of thin optical fibres
whose ends form the front and rear bonding surfaces
10 of the plate. Each of the optical fibres passes one
very small elemental area of the image formed on the
input surface 18 to a photocathode 26 mounted on the
rear surface of the fibreoptic plate 20. The result-
ing image formed on photocathode 26 is therefore a
15 mosaic of such elemental areas. Each of the fibres
is sufficiently small so as not to unduly limit the
spatial resolution achieved by the image intensifier
tube 14.

The photocathode 26 has a surface of photo-
20 sensitive material that emits electrons in a spatial
pattern corresponding to the intensity of the optical
image formed upon it by objective lens 12 and through
the fibreoptic plate 20. A suitable photocathode has
a sensitivity to light extending from the visible
25 range into the near-infrared spectral range.

The electrons emitted from photocathode 26
impinge on the input surface of a microchannel plate
28 which multiplies the number of electrons by
thousands of times through the known process of cas-
30 caded secondary electron emission. The microchannel
plate 28 consists of millions of microscopically small
hollow glass tubes forming channels for electrons to
pass through. These tubes are fused into a disc-shap-
ed array. The walls of these channels are capable of
35 producing secondary electrons. A voltage is applied
between the two major surfaces of the multichannel
plate 28. i.e. the front and rear surfaces, so that

1 each microscopically small channel constitutes a sep-
arate, high-gain electron multiplier. The voltage
supply is suitably a battery, not shown, which may be
5 mounted within a receptacle in housing 10. When an
electron impinges upon the input surface of the micro-
channel plate 28, secondary electrons are released.
The secondary electrons are accelerated through the
channels by the applied voltage and collide with the
10 channel surface to dislodge additional secondary elec-
trons. These electrons, in turn, are accelerated and,
upon collision, generate still more electrons. This
process repeats itself, thereby producing electron
multiplication. By adjusting the voltage between the
two surfaces of the microchannel plate, the gain of
15 the multiplier can be controlled. These electrons,
now increased in number and energy, impinge on a
phosphor screen 30 positioned on the front surface
of a fibreoptic output plate 32. The phosphor is
suitably a yellow-green phosphor having a spectral
20 emission centred approximately around a wavelength of
550 nanometers. In similarity with the input fibre-
optic plate 20, the output fibreoptic plate 32 is
also comprised of a bundle of optical fibres so that
it transfers the image to the back surface, i.e. out-
25 put face 34 of fibreoptic plate 32. However, the
bundle is constructed with a 180-degree twist of the
fibres, in order to invert, i.e. reorient, the up-
side-down image produced by the objective lens 12,
which would otherwise be seen by a user.

30 Other known types of image intensifier tubes
whose construction is different from what is describ-
ed above can be substituted for the one illustrated and
described.

35 The intensified image of the field of view form-
ed at the output surface 34 of the fibreoptic plate 32,
representing scene 16 which - during use with a fire-
arm - may include a target at which the firearm is aim-

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1 ed, is projected by eyepiece lens 36 to the eye 38
of a viewer, as schematically shown by light rays 40
and 42.

5 Eyepiece lens 36 is mounted in an eyepiece tube
46 which threads into the back end of housing 10 so
as to be movable along the longitudinal, i.e. optical,
axis for focussing onto the image at output surface
34. A flexible eyecup 48 attached to the rear end of
10 tube 46 fits against the viewer's eye 38 to shield it
from ambient light and to reduce illumination of the
viewer's face. The eyepiece lens 36 has a long eye
relief and large exit pupil, so that users wearing
corrective eyeglasses need not press their faces
against the eyecup 48.

15 Referring now to Figure 2, there is illustrated
the mechanism which supports the light source assembly
50 for producing an aiming mark which, as it is pref-
erably a round, very small spot, may conveniently be
referred to as an aiming dot. As is described in
20 detail below, light source assembly 50, hence the aim-
ing dot, is movable with respect to housing 10. The
reason that it is preferably movable is that, when
housing 10 is rigidly fixed to a firearm (not shown),
the position of the aiming mark - or dot - is suitably
25 adjustable to compensate for elevation and windage,
i.e. to take into account gravity and wind forces.
Light source assembly 50 comprises a light-emitting
diode (LED) 52 recessed into the upper end of the
cylindrically shaped LED holder 54. At the lower end
30 of holder 54 is a recessed aperture 56 whose upper
end communicates with the output end of the light-
emitting diode. Within aperture 56, an optical fibre
58 is held vertically in place by an opaque bonding
adhesive 60 which fills the remaining open space of
35 the aperture 56. The upper end of optical fibre 58
abuts the light-emitting diode 52 causing the light
output from the diode to direct a light beam down the

1 length of the optical fibre 58.

Upon energisation of the light-emitting diode, the lower, i.e. output, end 62 of the optical fibre 58 becomes the aiming dot because it forms a bright beam of light appearing as a dot which, as described below, is imaged into the viewer's field of view. The diameter of the fibre 58 is preferably quite small, suitably in the range from 0.0003 to 0.010 of an inch (0.00076 to 0.0254 cm.), so as to provide an aiming dot which does not obscure even small targets, e.g. an aiming dot preferably no larger than 0.012 of an inch (0.0305 cm.) or no larger even than 0.010 of an inch (0.0254 cm.).

The light-emitting diode 52 is selected to emit light of one specific colour, such as red, which contrasts with the yellow-green colour of the output image formed by image intensifier tube 14. An intensity control, not shown, may be used to adjust the intensity of the light output from the diode, and thereby of the aiming dot, to optimize brightness and contrast, and to minimize optical flare. The diode is connected by lines 53 to the same battery which is used for energising the image intensifier tube 14. Among the advantages of a light-emitting diode over conventional incandescent sources are its small size, high brightness, and low power requirements.

Light in the beam leaving the output end 62 of fibre 58 is reflected from a beam combiner which is a partially reflective mirror 64 which is tilted at substantially 45 degrees so as to direct the light along the optical axis 92 through the eyepiece lens 36 and to the viewer's eye 38. Thus, the light dot produced at output end 62 is projected along the optical axis and appears to a viewer observing the field of view as a virtual image of the output end 62, constituting the aiming dot. The beam combiner mirror 64 is supported by being bonded to the slanted edge sur-

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1 face of an obliquely cut tube 66 which is, in turn,
rigidly fastened to housing 10.

5 The beam combiner mirror 64 is a wavelength-
selective, i.e. dichroic, mirror which favours re-
flection of the light of the colour emitted by the
light source, i.e. diode 52, and which favours trans-
mission of the light of the colour of the image pro-
duced upon the output surface of the image intensifier
10 tube 14. For example, with the above-described image
intensifier tube 14 having a yellow-green output image
and a light-emitting diode 52 emitting in the red
spectral region, a typical beam combiner mirror 64
would transmit more than 90% of the green light and
reflect more than 90% of the red light. The mirror
15 is suitably made up of one or more dielectric layers
supported by a suitable transparent substrate. Such
beam combiner mirrors are well known and available
from many commercial sources.

20 A support block 68 for the light source, name-
ly the diode 52, includes bore 70 into which is threa-
ded the source holder 54. By rotation, source holder
54 can be displaced upwardly and downwardly in bore
70. Such adjustment as to height - in the representa-
tion of Figure 2 - is made by the manufacturer until
25 the viewer can simultaneously see both the virtual image
of the aiming dot represented by the end 62 of the
optical fibre 58 and the image of the viewed scene
16 in simultaneous focus. This simultaneous focus
condition occurs when the optical path lengths from
30 beam combiner mirror 64 to fibreoptic end 62, and from
beam combiner mirror 64 to image output surface 34,
shown as "a" and "a'" respectively, are approximately
equal. In other words, the desirable adjustment is
reached when the virtual image of optical fibre end
35 62 formed by lens 36 is located at output surface 34.
Such an adjustment eliminates the parallax between the
virtual image of the aiming dot and the viewed scene,

1 so that the viewer can move his eye without causing
relative motion between the image of the aiming dot
and the scene. Once this proper focus is established
by adjustment of the position of holder 54 within bore
5 70, holder 54 is locked in that position in any suitable
manner, such as, for example, by applying a liquid
cement onto the threaded surfaces between holder 54
and bore 70.

Referring now to Figures 2 through 4, the configurations of the windage and elevation adjustment mechanisms are described. The source support block 68 has its ends resting on guide surfaces 72 formed by an opening 74 in the top of housing 10, as best seen in Figure 4. A retaining plate 75 lightly holds support block 68 against guide surfaces 72. Both the housing 10 and support block 68 are suitably of aluminum, with the support block 68 being hardened by anodization so as to slide without binding on guide surfaces 72. A small amount of lubricant, such as
20 silicone oil, is applied to the area of surfaces 72 which come in sliding contact with support block 68 to ensure smooth sliding. Retaining plate 75 is preferably made of brass.

An enclosure 76 covers the windage and elevation adjustment mechanisms. Projecting from enclosure 76 are elevation adjustment knob 78 and windage adjustment knob 80, both of which are threaded through the walls of enclosure 76. As shown in Figure 2, a spherical projection 82 on elevation knob 78 engages a
30 socket 84 in a 45-degree wedge 86. Turning the elevation adjustment knob 78 raises or lowers the wedge 86 whose slanted surface bears against a pair of cylindrical cams 88 in the form of rollers supported for rotation by brackets 90 on block 68, so as to
35 cause block 68 to move backward or forward a precisely controlled distance in the directions of the optical axis 92, i.e. along the length of housing 10.

1 Such a movement causes a corresponding vertical displacement of the virtual image of the aiming dot formed by fibre end 62. With beam combiner 64 tilted at 45
5 the guide surfaces 72 oriented parallel to the optical axis, the result is that the optical distance between aiming dot 62 and eyepiece lens 36 remains constant as the fibre optic end 62 forming the aiming dot is moved by elevation adjustment knob 78. As thus becomes readily apparent, the virtual image of the aiming
10 dot remains in focus during this motion.

Referring to Figures 3 and 4, it is seen that windage adjustment knob 80 has a spherical projection 94 which engages a socket 96 in support block 68.
15 Turning the windage adjustment knob 80 causes the support block 68 to slide along guide surfaces 72 transversely to the length of housing 10, that is, in a direction perpendicular to the motion caused by the elevation adjustment knob 78, thereby moving the virtual image of the aiming dot to the left or right of
20 the viewer. By controlled rotation of the elevation knob 78 and of the windage knob 80, the virtual image of the fibre output end 62 forming the aiming dot can be superimposed on a target within the viewed scene
25 16. Thus, displacing the image of the aiming mark projected upon the output surface of the image intensifier tube to compensate for elevation and windage is achieved by displacing the aiming mark source, namely fibre output end 62, in mutually orthogonal directions
30 oriented substantially parallel to the output surface of the image intensifier tube.

As shown in Figure 3, a coil spring 98 is attached by one of its ends to a corner region of enclosure 76 and by its other end to support block 68,
35 so as to bias the block 68 against the windage adjustment knob 80 and against wedge 86.

Figure 5 illustrates an alternative embodiment

1 of a light source assembly for producing a light beam
which constitutes the aiming dot. In Figure 5, the
optical fibre has been replaced with an opaque disc
100 having an aperture 102. Disc 100 is mounted on
5 the shoulder of recessed aperture 56. Aperture 102
is illuminated by the light-emitting diode 52 to form
a light beam constituting the aiming dot which is pro-
jected into the field of view of intensifier tube 14
in the manner described above. As with the optical
10 fibre, the diameter of the aperture 102 is preferably
from 0.0003 to 0.010 of an inch (0.00076 to 0.0254 cm.).
Such apertures are available through commercial suppliers
of components used in the field of laser technology.

The compact size and light weight of the sight-
15 ing device of the present invention make it particu-
larly suitable for use on a rifle and at night. The
small size of the aiming dot will not obscure the tar-
get upon which it is superimposed. Its brightness
and its colour, when contrasting with the viewed scene,
20 make it particularly suitable for fast, accurate aim-
ing.

Although the present invention has been des-
cribed and illustrated with reference to a particular
embodiment, many modifications apparent to those of
25 ordinary skill in the art may be made without depart-
ing from the scope of the present invention.

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1 CLAIMS

1. A sighting device comprising: an image intensifier device, capable of rendering a target visible at an output surface of the device under conditions of poor illumination; and means for imaging an illuminated aiming mark substantially at the output surface of the image intensifier device; said imaging means comprising an eyepiece lens through which a viewer can observe the output surface of the image intensifier device, a light source for providing the illumination for the aiming mark, and beam combiner means for directing the light from the light source through the eyepiece lens, so that the viewer will observe a virtual image of the aiming mark superimposed on the image on the output surface of the image intensifier device.

2. A sighting device according to claim 1, wherein an optical fibre is provided such that the image of the aiming mark is an image of an end of the optical fibre.

3. A sighting device according to claim 1, wherein an aperture is provided such that the image of the aiming mark is an image of the aperture.

4. A sighting device according to claim 1, 2 or 3, wherein the beam combiner means comprises a partially reflective mirror.

5. A sighting device according to any one of the preceding claims, wherein the image intensifier device is operable to produce upon its output surface an image of one colour and the image of the aiming mark is of a contrasting colour.

6. A sighting device according to claim 5 when appended to claim 4, wherein the partially reflective mirror is a dichroic mirror which favours reflection of the light of the colour of the image of the aiming mark and which favours transmission of the light of the colour of the image produced upon the output surface by the image intensifier tube.





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1 7. A sighting device according to any one of the preceding claims, wherein a light source in the form of a light-emitting diode is provided to produce the image of the aiming mark.

5 8. A sighting device according to claim 7, when appended to claim 5, wherein the light-emitting diode is operable to emit red light and the image intensifier device is operable to generate at its output surface images in a contrasting colour.

10 9. A sighting device according to claim 8, wherein the image generated upon the output surface of the image intensifier tube is yellowish-green.

15 10. A sighting device according to any one of the preceding claims and comprising means for displacing the image of the aiming mark.

20 11. A sighting device according to claim 10, wherein the means for displacing the image of the aiming mark is operable to displace the image in mutually orthogonal directions, so as to permit compensation for elevation and windage.

25 12. A sighting device according to claim 11, wherein the means for displacing the image of the aiming mark include a light source support block for holding the aiming mark, guide surfaces upon which the support block can slide in one and the other of the two mutually orthogonal directions, means for controllably moving the support block in one of the directions, so that the image of the aiming mark as seen by a viewer moves in a first direction, and means for controllably moving the support
30 block in the other direction, so that the image of the aiming mark seen by a viewer moves in the direction at right angles to said first direction.

35 13. A sighting device according to any one of the preceding claims, wherein the image of the aiming mark is not substantially greater than 0.010 of an inch (0.0254cm.).

14. A sighting device substantially as hereinbefore

1 described with reference to the accompanying drawings.

15. A firearm having a sighting device according to any one of the preceding claims.

The text of the specification has been reproduced by photocopying the applicants original typescript. It may contain a few amendments which are difficult to read. The original typescript containing these amendments may be inspected on the premises of the Patent Office

