

MULTI-CHANNEL OPTICS

FIELD OF THE DISCLOSED TECHNIQUE

The disclosed technique relates to multiple channel optical systems in general, and to a multiple channel optical system for different ranges of wavelengths, in particular.

BACKGROUND OF THE DISCLOSED TECHNIQUE

Observation and location systems which provide several optical channels having different wavelength ranges, are known in the art and are commonly used for aiming, surveillance and alert applications as well as for many other implementations. Operation in various different wavelength ranges is mandatory because each application, (e.g., forward looking infrared - FLIR, light enhancement, laser range finder - LRF, laser designation, human vision) requires a different wavelength.

Multiple channel systems may further include transmitting optical channels, which illuminate, either broadly or specifically, the detected scene. The weight and size of each channel is conventionally proportional to physical dimensions of its primary receiving optical element. Multiple channel systems weight and size are conventionally proportional to the sum of its constituents.

It will be appreciated by those skilled in the art that certain optical elements which are suitable for one wavelength range may not be suitable for other wavelength ranges. For some combinations of wavelength ranges there do not exist optical materials and elements which are able to optimally convey all of these wavelength ranges there through.

Multiple channel systems which are directed at combining such wavelength ranges, include separate optical paths, each of these paths including an independent set of optical elements, which do not always

exhibit even a single common optical axis, thereby arising b
problems.

US patent No. 6,359,681 issued to Housand et al., a
"Combined Laser/FLIR Optics System" is directed to a sys
5 combines a FLIR and a laser ranging module, in a single system
FLIR unit and the laser illumination unit utilize the same apert
has to consist of several elements and designed to equalize the
refraction for both the IR energy and the laser energy.

US patent No. 4,561,775 issued to Patrick et al., a
10 "Thermally Integrated Laser/FLIR Rangefinder" is directed to a
which provides IR imaging, visible light imaging and a laser
module, in a single system. The system provides each of these

SUMMARY OF THE DISCLOSED TECHNIQUE

It is an object of the disclosed technique to provide a novel method and system for detecting radiation and transmitting radiation in a plurality of multiple optical channels.

5 In accordance with the disclosed technique, there is thus provided a multiple channel optical system which includes a primary optical channel and at least a secondary optical channel. The primary optical channel defines a primary optical aperture and includes at least a primary channel front optical element generally located within the primary
10 optical aperture. The primary optical channel is operative to serve at least a first range of wavelengths.

The secondary optical channel defines a window within the primary optical aperture. This window is physically configured within the primary optical channel front optical element by removing all of the optical
15 material of the primary optical channel front optical element which occupies the window. The secondary optical channel is operative to serve at least a second range of wavelengths. It is noted that the first range of wavelengths and the second range of wavelengths are different.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosed technique will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

5 Figure 1A is a schematic illustration of a multiple optical channel system, constructed and operative in accordance with an embodiment of the disclosed technique;

 Figure 1B is a schematic illustration of a front view of the receiving lens of the system of Figure 1A;

10 Figure 2 is a schematic illustration of a front receiving lens with a window formed therein, constructed and operative in accordance with another embodiment of the disclosed technique;

 Figure 3 is a schematic illustration of a front receiving lens with a window formed therein and further with a lens fitted in that window,
15 constructed and operative in accordance with a further embodiment of the disclosed technique;

 Figure 4 is a schematic illustration of a front receiving lens with a window formed therein and further with thermal insulation between the front receiving lens and the window, constructed and operative in
20 accordance with another embodiment of the disclosed technique;

 Figure 5A is a schematic side view of an optical assembly of a primary optical channel; and

 Figure 5B is a schematic side view of the optical assembly of Figure 5A after being modified to accommodate a secondary optical
25 channel, constructed and operative in accordance with a further embodiment of the disclosed technique.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The disclosed technique overcomes the disadvantages of the prior art by allocating an area within the largest optical element of the primary optical channel, for the optics of a secondary optical channel. It is noted that this largest optical element is conventionally placed at the front of the optical assembly of the primary optical channel (e.g., the receiving lens). All of the material of that largest optical element, within that allocated area is removed, thereby forming a window, and an optical element which is associated with the secondary optical channel may be inserted in the cavity formed within this allocated area. According to the disclosed technique, many cavities can be formed within the largest optical element, each associated with a different optical channel, as long as the largest optical element retains sufficient optical area for receiving enough light radiation required for the detector to operate properly. It is noted that each of the optical channels, including the primary optical channel, can serve for receiving light radiation (i.e., for detection purposes) transmitting light radiation (i.e., for laser marking, illuminating, and the like) or both (i.e., using beam splitters, beam combiners, and the like).

Reference is now made to Figures 1A and 1B. Figure 1A is a schematic illustration of a multiple optical channel system, generally referenced 100, constructed and operative in accordance with an embodiment of the disclosed technique. Figure 1B is a schematic illustration of a front view of the receiving lens of the system of Figure 1A. System 100 includes an optical section 140, an image processing section 142 and a display section 144 (e.g., an eyepiece).

Optical section 140 may include a plurality of optical elements such as lenses, mirrors, beam splitters, beam combiners, optical radiation detectors, optical radiation sources, and the like. Optical section 140 defines a plurality of optical channels, each respective of a different range of wavelengths (e.g., near, medium and far Infra-Red, visible light, Ultra-Violet light, various laser ranges). It is noted that according to one

embodiment of the disclosed technique, a range of wavelengths may include a single wavelength.

In the example set forth in Figure 1, an optical section 140 defines three optical channels. A first optical channel includes an external shield 102 (i.e., a housing), lenses 104 and 106, and an image detector 108 (e.g., FLIR). Image detector 108 may be of the cooled or un-cooled detector type. The first optical channel is operative to detect light at relatively long wavelengths such as Infra-Red (IR) radiation (e.g., thermal radiation). Lens 104 is a receiving lens, and is substantially large in diameter in order to collect a substantial amount of energy emitted by the scene of interest. External shield 102 functions as a housing, which covers the bore defining at least a portion of the first optical channel.

In the example set forth in Figure 1, receiving lens 104 is made of a material which is optimally optically transmissive (i.e., transparent) to radiation in long wavelengths, but as such has less than optimal transmissivity for other wavelengths (e.g., visible light, ultra-violet radiation). According to the disclosed technique, windows 112 and 132 are bored in receiving lens 104 to accommodate additional optical channels, for such other wavelengths. It is noted that according to the disclosed technique, the shape of these windows can be round, elliptical, polygonal, conical, rectilinear, and the like.

A second optical channel passes through window 112 bored in lens 104 and includes a lens 114, mirrors 116 and 118, and lenses 120, 122 and 124. It ends in an eyepiece (i.e., display section 144) or any other human interface. The second optical channel is operative to detect light within the range of visible light wavelengths (e.g., daylight visible radiation) and may include a daylight detector such as charge-coupled device – television (CCD-TV) 126, and the like. Lens 114 is the receiving lens of the second optical channel and is made of a material which exhibits transmissivity for visible light wavelengths which is better than that exhibited by lens 104 for this wavelength range.

A third optical channel passes through window 132 bored in lens 104 and includes mirrors 134 and 136, a laser source (not shown) and a receiver (not shown). This third optical channel is operative to transmit laser radiation produced by that laser source (e.g., implementing a laser range finder, a laser designator, a laser locator, a combination thereof). It is noted that lens 104 exhibits poor transmissivity for the wavelength which characterizes the laser radiation produced by the laser source.

According to another embodiment of the disclosed technique, each of the second optical channel and the third optical channel is thermally isolated from the other and from the first optical channel. It is noted that the isolation can be cooled or un-cooled.

According to a further embodiment of the disclosed technique, the configuration of the various windows within a primary channel front optical element (e.g., the front lens), is rigid. Hence, coordination of the functionalities of the different channels and inter-calibration there between (i.e., bore-sighting) are well retained while operating in a vibrational environment.

Reference is now made to Figures 2, 3 and 4. Figure 2 is a schematic illustration of a front receiving lens 150 with a window 152 formed therein, constructed and operative in accordance with another embodiment of the disclosed technique. Lens 150 defines an optical axis 154.

Window 152 can be formed in a plurality of methods such as molding lens 150 using a mandrel which defines window 152. Alternatively, window 152 can be formed by drilling or boring through lens 150. Lens 150 is operative to be a part of one optical channel, while window 152 is operative to be a part of another optical channel. Each of these optical channels can be used either for transmitting light radiation, receiving light radiation or both (e.g., using beam combiners and beam splitters). Each of these optical channels is operative to be transmissive at a different range of wavelengths. Each of the windows formed in lens 150

may be fitted with an optical filter or an optical power element (e.g., lens, prism).

Figure 3 is a schematic illustration of a front receiving lens 160 (similar to receiving lens 150 of Figure 2) with a window 162 (similar to window 152 of Figure 2) formed therein, constructed and operative in accordance with a further embodiment of the disclosed technique. Lens 160 defines an optical axis 164 and is associated with a first optical channel. In the example set forth in Figure 3, a lens 170 is inserted into the cavity defined by window 162. Lens 170 defines an optical axis 172 and is associated with a second optical channel. Lens 172 and lens 160 are made of a material, each transmitting light at different ranges of wavelengths. These different ranges of wavelengths may be mutually exclusive (i.e., not overlapping at all). Accordingly, lens 160 serves a first optical channel and lens 170 serves another optical channel, each associated with a different one of the ranges of wavelengths.

According to the disclosed technique, any gap between the perimeter of a secondary optical channel front element (e.g., filter or optical power element) and the walls (i.e., boundaries) in the bored window within the primary optical channel front optical element, may be sealed by means such as filling material or elements, to prevent movement of particles (e.g., dust, gases, dirt, liquids) from one side of the primary optical channel front optical element to the other. In the example set forth in Figure 3, an O-ring 174, made of an elastic material is fitted in the gap formed between lens 170 and the window 162 bored in lens 160.

Figure 4 is a schematic illustration of a front receiving lens 180 (similar to receiving lenses 150 and 160 of Figures 2 and 3, respectively) with a window 182 (similar to windows 152 and 162 of Figures 2 and 3, respectively) formed therein, constructed and operative in accordance with another embodiment of the disclosed technique. Lens 180 defines an optical axis 184 and is associated with a first optical channel. In the example set forth in Figure 4, a lens 190 (similar to lens 170 of Figure 3) is

inserted into the cavity defined by window 182. Lens 190 defines an optical axis 192 and is associated with a second optical channel having a mirror 196 that deflects the energy towards additional elements (not shown) outside the optical aperture of the first optical channel. Lens 190 is made of a material which is transmissive at a first range of wavelengths. Lens 180 is made of a material which is transmissive at a second range of wavelengths.

In some cases, energy that is not passing through lens 190, mirror 196 and the other elements (not shown) is emitted randomly within the optical aperture of the first channel and may reach the detector of the first channel. This random re-radiation is in a wavelength range to which the first channel detector may be sensitive. This random energy, when received at the detector, increases the noise level at the detector output and deteriorates the performance of the first channel.

According to the embodiment presented in Figure 4, an isolation shroud 194 (i.e., radiation isolator) is installed around the second optical channel to isolate it from the first optical channel. Thus, re-radiation of energy from the body of elements of the secondary channel cannot reach the detector of the first channel. It is noted that isolation shroud 194 is installed around every element (e.g. lens, mirror, beam combiners and splitters) associated with the second optical channel and which may be a source of radiation propagation into the first optical channel aperture.

According to the disclosed technique, the primary channel is the largest in size because it is associated with a range of wavelengths exhibiting the lowest energy (e.g., Infra-Red), so as to accumulate enough of that energy for the respective sensor to detect. The re-radiation that needs to be isolated is in fact heat (i.e., Infra-Red radiation) and cooling of the isolation shroud makes it a sink, avoiding any radiation that may occur from the shroud itself. According to a further embodiment of the disclosed technique, this shroud is cooled through a heat transfer body and an external refrigeration unit.

Reference is now made to Figures 5A and 5B. Figure 5A is a schematic side view of an optical assembly of a primary optical channel. The optical assembly includes a front receiving lens 202, a rear lens 204 and a detector 206. Figure 5A further includes schematic light beam paths which are projected onto detector 206 via lenses 202 and 204.

Figure 5B is a schematic side view of the optical assembly of Figure 5A after being modified to accommodate a secondary optical channel, constructed and operative in accordance with a further embodiment of the disclosed technique. A window 210 is formed in front receiving lens 202 through which a thermal radiation insulation 214 is installed in addition to a diverting mirror 212 which directs light received (or transmitted) through window 210, by approximately 90 degrees.

Figure 5B further includes schematic light beam paths which substantially resemble the light beam paths presented in Figure 5A. It is noted that the removal of optical material which filled up window 210 does not significantly degrade the quality of the image projected onto image detector 206. At most the missing optical material may affect the radiation intensity of image projected onto image projector 206.

It will be appreciated by persons skilled in the art that the disclosed technique is not limited to what has been particularly shown and described hereinabove. Rather the scope of the disclosed technique is defined only by the claims, which follow.

CLAIMS

1. Multiple channel optical system comprising:
 - a primary optical channel defining a primary optical aperture, said primary optical channel including at least a primary channel front optical element generally located within said primary optical aperture, said primary optical channel being operative to serve at least a first range of wavelengths; and
 - at least a secondary optical channel, defining a window within said primary optical aperture, said window being physically configured within said primary optical channel front optical element by substantially removing all of the optical material of said primary optical channel front optical element occupying said window, said at least one secondary optical channel being operative to serve at least a second range of wavelengths,
 - wherein said first range of wavelengths and said at least second range of wavelengths are substantially non-overlapping.
2. The multiple channel optical system, according to claim 1, wherein at least a selected one of said primary optical channel and said at least secondary optical channel, further includes at least a radiation detection module.
3. The multiple channel optical system, according to either of claims 1 and 2, wherein said at least selected one of said primary optical channel and said at least secondary optical channel, further includes at least a radiation production module.
4. The multiple channel optical system, according to claim 2, wherein said at least a radiation detection module is selected from the list consisting of:

Infra-Red cooled detector; and

Infra-Red un-cooled detector.

- 5 5. The multiple channel optical system, according to claim 1, wherein at least one of said at least secondary optical channel further comprises an optical filter fitted in the respective said window.
- 10 6. The multiple channel optical system, according to claim 5, wherein any gap between said optical filter and said respective window is sealed.
- 15 7. The multiple channel optical system, according to claim 1, wherein at least one of said at least secondary optical channel further comprises an optical power element fitted in the respective said window.
- 20 8. The multiple channel optical system, according to claim 7, wherein any gap between said optical power element and said respective window is sealed.
- 25 9. The multiple channel optical system, according to claim 1, wherein at least one of said at least secondary optical channel comprises a radiation isolator, isolating at least one of said at least secondary optical channel from at least said primary optical channel.
- 30 10. The multiple channel optical system according to claim 1, further comprising a housing completely covering a bore defined by said primary optical channel.
11. The multiple channel optical system according to claim 1, further comprising a thermally isolating housing completely covering a bore defined by said primary optical channel.

12. The multiple channel optical system, according to claim 1, wherein said primary channel front optical element is at least more transmissive with respect to said first range of wavelengths than with respect to said at least second range of wavelengths.

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13. The multiple channel optical system, according to claim 1, wherein said primary channel front optical element is transmissive with respect to said first range of wavelengths and is not transmissive with respect to said at least second range of wavelengths.

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14. The multiple channel optical system, according to claim 1, wherein the configuration of said window in said primary channel front optical element is substantially rigid.

15. Multiple channel optical system, according to any of claims 1-14 substantially as described hereinabove.

16. Multiple channel optical system, according to any of claims 1-14 substantially as illustrated in any of the drawings.

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