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(54) **Dual mode seeker**

(57) The present invention relates to a dual mode seeker (10) for a missile (1), a missile (1) comprising such dual mode seeker (10) and a method for assembling a dual mode seeker (10) for a missile (1). The dual mode seeker (10) comprises a first sensing system (11) configured to detect a target, a second sensing system (12) configured to detect a target, and a space envelope (13) configured to be arranged in a missile's nose (2). The first sensing system (11) comprises an active radar transmitter and a radar receiver. The second sensing system (12) comprises a passive optical detector. The space envelope (13) comprises a first channel (14) and a second channel (15) arranged adjacent to each other in a seeker's radial direction. The first sensing system (11) is arranged in the first channel (14) and the second sensing system (12) is arranged in the second channel (15) of the space envelope (13).

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Description

[0001] The present invention relates to a dual mode seeker for a missile, a missile comprising such dual mode seeker and a method for assembling a dual mode seeker for a missile.

[0002] In the guidance of missiles and other vehicles to a predesired target or destination, the target is usually acquired and tracked by means on the missile for detecting the target. Systems have been developed in the prior art for utilizing combinations of different detection methods in the seeker to maximize advantages afforded by each detection method.

[0003] US 4,085,910 A discloses a dual mode optical seeker for guided missile control mounted in a nose of a missile. This seeker includes an infra-red sensor for sensing the orientation of the missile relative to an infrared illuminated target, and an optical unit for determining the orientation of the missile relative to a visible target. The optical unit is stabilized in space about the pitch and yaw axes by means of a gyro stabilized platform unit which is separated therefrom and linked thereto by coupling rods which cause the optical unit to follow the stabilized platform in both yaw and elevation.

[0004] This dual mode optical seeker may, however, be improved in view of the detection methods and in view of the arrangement within the missile.

[0005] Hence, there may be need to provide a dual mode seeker for a missile, which is improved in view of the detection methods. Further, there may be need to provide a dual mode seeker, which is improved in view of the arrangement within the missile.

[0006] The object of the present invention is solved by the subject-matters of the independent claims, wherein further embodiments are incorporated in the dependent claims. It should be noted that the following described aspects of the invention apply for each of the dual mode seeker for a missile, the missile comprising such dual mode seeker and the method for assembling such dual mode seeker for a missile.

[0007] According to the present invention, a dual mode seeker for a missile is presented. The dual mode seeker comprises a first sensing system configured to detect a target, a second sensing system configured to detect a target, and a space envelope configured to be arranged in a missile's nose. The first sensing system comprises an active radar transmitter and a radar receiver. The second sensing system comprises a passive optical detector.

[0008] The space envelope comprises a first channel and a second channel arranged adjacent to each other in a seeker's radial direction. The first sensing system is arranged in the first channel and the second sensing system is arranged in the second channel of the space envelope.

[0009] In other words and exemplarily, the present invention relates to an architecture or packaging scheme for a dual mode seeker. The dual mode seeker may be integrated into a missile's front section. The dual mode seeker comprises an assembly of an active radar transmitter, a radar receiver and a passive optical detector into a common space envelope.

[0010] The dual mode seeker according to the present invention is improved in view of the detection methods, as a combination of an active radar detector and a passive optical detector is used. Thereby, the performance of the seeker in improved in view of a greater range, better accuracy, more frequency diversity, better tracking quality and better reliability. Further, the dual mode seeker is in particular suitable for the detection of small targets, very slow or very fast targets and helicopter detection.

[0011] The dual mode seeker according to the present invention is further improved in view of the arrangement within the missile. It is possible to develop, use, integrate and upgrade the dual mode seeker independently into an arbitrary missile with only reduced temporal and financial effort. In other words, the temporal and financial efforts are reduced in view of development of the dual mode seeker, adaption of the dual mode seeker to a particular missile, production of the dual mode seeker, maintenance etc. In contrast to the prior art, the problem of a space envelope with a common gimbal for both sensing systems is solved and the use of an expensive dome transparent for both wavelengths of both sensing systems is avoided.

[0012] The dual mode seeker according to the present invention can be made fully compliant to all customers' requirements. The dual mode seeker can be used for rolling and non-rolling missiles. Only minor missile shape adaptation with only minor impact to the missile dynamics performance is necessary. It is possible to use current radar and optical sensing systems with only a mechanical integration and only minor mechanical modifications.

[0013] In an example, the active radar transmitter is a radiofrequency transmitter. In an example, the passive optical detector is configured for visible optics, infrared, Semi Active Laser and/or TV detection.

[0014] In an example, the first channel is arranged above the second channel in the seeker's radial direction. In other words, both channels may be arranged such that e.g. the radar channel is on top and e.g. the infrared channel is on bottom. The first channel may also be arranged below the second channel in the seeker's radial direction. The first channel and the second channel may also be arranged next to each other or at any other possible angular position, e.g. depending on the weight balance.

[0015] In an example, the first channel comprises a first aperture and the second channel comprises a second aperture. The first and the second apertures may differ from each other. In other words, e.g. the radar channel and e.g. the infrared channel may use separate apertures. The first and the second apertures may also be the same or may only partially differ from each other.

[0016] In an example, the first channel comprises a first line of sight orientation and the second channel com-

prises a second line of sight orientation. The first and/or the second line of sight orientation may form an angle with a seeker's longitudinal direction between 0 and 45°, preferably between 0 and 25°, and more preferably between 0 and 10°. Thereby, an angle between the first and second channels and/or the first and second sensing system of up to 90° can be achieved.

[0017] The seeker may further comprise control means configured to control the angles of the first and the second line of sight orientations independent of each other.

[0018] In an example, the first channel and the second channel are arranged with an offset to each other in the seeker's longitudinal direction. In example, the first sensing system and the second sensing system are arranged with an offset to each other in the seeker's longitudinal direction. The offset may allow minimizing a shadowing of one channel by the other, e.g. a shadowing of the infrared channel by the radar channel.

[0019] The offset may be determined relative to a predetermined point of the channels and/or the sensing systems, as e.g. the apertures of the channels, the beginning, the gravity centre, the end of the sensing systems and the like. The offset may amount to between 0.5 to 50 cm, preferably between 1 and 30 cm, more preferably between 5 and 20 cm. The offset may also amount to between 1 and 30 % of the total missile's length, preferably between 2 and 20 %, more preferably between 3 and 10 %.

[0020] In an example, the first channel is arranged essentially at the seeker's front end, while the second channel is further displaced to the seeker's back end. In an example, the first sensing system is arranged essentially at the seeker's front end, while the second sensing system is further displaced to the seeker's back end.

[0021] In an example, the first channel and the second channel are arranged parallel to each other in the seeker's radial direction. The first channel and the second channel may also be arranged slightly inclined to each other or slightly spreading relative to each other.

[0022] In an example, the dual mode seeker further comprises a common mechanical reference for the first sensing system and the second sensing system.

[0023] According to the present invention, also a missile comprising a dual mode seeker is presented, wherein the dual mode seeker is arranged in a nose of the missile.

[0024] According to the present invention, also a method for assembling a dual mode seeker for a missile is presented. It comprises the following steps:

a) providing a space envelope configured to be arranged in a missile's nose,
b) providing a first sensing system configured to detect a target,
c) providing a second sensing system configured to detect a target,
d) arranging the first sensing system in a first channel of the space envelope, and
e) arranging the second sensing system in a second channel of the space envelope.

[0025] The first and the second channels are arranged adjacent to each other in a seeker's radial direction. The first sensing system comprises an active radar - transmitter and a radar receiver. The second sensing system comprises a passive optical detector.

[0026] It shall be understood that the dual mode seeker for a missile, the missile comprising such dual mode seeker and the method for assembling a dual mode seeker for a missile according to the independent claims have similar and/or identical preferred embodiments, in particular, as defined in the dependent claims. It shall be understood further that a preferred embodiment of the invention can also be any combination of the dependent claims with the respective independent claim.

[0027] These and other aspects of the present invention will become apparent from and be elucidated with reference to the embodiments described hereinafter.

[0028] Exemplary embodiments of the invention will be described in the following with reference to the accompanying drawings:

Fig. 1 shows a schematic drawing of an example of a missile with a dual mode seeker, and
Fig. 2 shows a schematic overview of steps of a method for assembling a dual mode seeker for a missile.

[0029] **Fig. 1** shows schematically and exemplarily an embodiment of a missile 1 comprising a dual mode seeker 10, wherein the dual mode seeker 10 is arranged in a nose 2 of the missile 1. The dual mode seeker 10 comprises a first sensing system 11 to detect a target, a second sensing system 12 to detect the target, and a space envelope 13 arranged in the missile's nose 2.

[0030] The first sensing system 11 comprises an active radar transmitter and a radar receiver. The active radar transmitter is a radiofrequency transmitter. The second sensing system 12 comprises a passive optical infrared detector.

[0031] The space envelope 13 comprises a first channel 14 and a second channel 15 arranged adjacent to each other in a seeker's radial direction. The first sensing system 11 (radar) is arranged in the first channel 14 and the second sensing system 12 (infrared) is arranged in the second channel 15 of the space envelope 13.

[0032] The first channel 14 is arranged above the second channel 15 in the seeker's radial direction. In other words, both channels are arranged such that the radar channel is on top and the infrared channel is on bottom. The first channel 14 and the second channel 15 are arranged parallel to each other in the seeker's radial direction.

[0033] The first channel 14 is arranged essentially at the seeker's front end, while the second channel 15 is further displaced to the seeker's back end. Also the first sensing system 11 is arranged essentially at the seeker's

front end, while the second sensing system 12 is further displaced to the seeker's back end.

[0034] The first channel 14 comprises a first aperture 16 and the second channel 15 comprises a second aperture 17. The first and the second apertures 16, 17 differ from each other. In other words, the radar channel and the infrared channel use separate apertures 16, 17.

[0035] The first channel 14 comprises a first line of sight orientation 18 and the second channel 15 comprises a second line of sight orientation 19. The dual mode seeker 10 further comprises control means to control the first and the second line of sight orientations 18, 19 independent of each other. The dual mode seeker 10 further comprises a common mechanical reference for the first sensing system 11 and the second sensing system 12.

[0036] The first channel 14 and the second channel 15 are arranged with an offset to each other in the seeker's longitudinal direction. Also the first sensing system 11 and the second sensing system 12 are arranged with an offset to each other in the seeker's longitudinal direction.

[0037] **Fig. 2** shows a schematic overview of steps of a method for assembling a dual mode seeker 10 for a missile 1. The method comprises the following steps, not necessarily in this order:

- In a first step S1, a space envelope 13 configured to be arranged in a missile's nose 2 is provided.
- In a second step S2, a first sensing system 11 configured to detect a target is provided.
- In a third step S3, a second sensing system 12 configured to detect a target is provided.
- In a fourth step S4, the first sensing system 11 is arranged in a first channel 14 of the space envelope 13.
- In a fifth step S5, the second sensing system 12 is arranged in a second channel 15 of the space envelope 13.

[0038] The first and the second channels 15 are arranged adjacent to each other in a seeker's radial direction. The first sensing system 11 comprises an active radar transmitter and a radar receiver. The second sensing system 12 comprises a passive optical detector.

[0039] It has to be noted that embodiments of the invention are described with reference to different subject matters. In particular, some embodiments are described with reference to method type claims whereas other embodiments are described with reference to the device type claims. However, a person skilled in the art will gather from the above and the following description that, unless otherwise notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters is considered to be disclosed with this application. However, all features can be combined providing synergetic effects that are more than the simple summation of the features.

[0040] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing a claimed invention, from a study of the drawings, the disclosure, and the dependent claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A dual mode seeker (10) for a missile (1), comprising

   - a first sensing system (11) configured to detect a target,
   - a second sensing system (12) configured to detect a target, and
   - a space envelope (13) configured to be arranged in a missile's nose 2, wherein the first sensing system (11) comprises an active radar transmitter and a radar receiver,
   wherein the second sensing system (12) comprises a passive optical detector,
   wherein the space envelope (13) comprises a first channel (14) and a second channel (15) arranged adjacent to each other in a seeker's radial direction, and
   wherein the first sensing system (11) is arranged in the first channel (14) and the second sensing system (12) is arranged in the second channel (15) of the space envelope (13).

2. Dual mode seeker (10) according to claim 1, wherein the active radar transmitter is a radiofrequency transmitter.

3. Dual mode seeker (10) according to claim 1 or 2, wherein the passive optical detector is configured for infrared, SAL and/or TV detection.

4. Dual mode seeker (10) according to one of the preceding claims, wherein the first channel (14) comprises a first aperture (16) and the second channel (15) comprises a second aperture (17), wherein the first and the second apertures (16, 17) differ from each other.

5. Dual mode seeker (10) according to one of the preceding claims, wherein the first channel (14) comprises a first line of sight orientation (18), the second channel (15) comprises a second line of sight orientation (19), and the seeker further comprises control means configured to control the first and the second

line of sight orientations (18, 19) independent of each other.

6. Dual mode seeker (10) according to one of the preceding claims, wherein the first channel (14) is arranged above the second channel (15) in the seeker's radial direction.

7. Dual mode seeker (10) according to one of the preceding claims, wherein the first channel (14) and the second channel (15) and/or the first sensing system (11) and the second sensing system (12) are arranged with an offset to each other in the seeker's longitudinal direction.

8. Dual mode seeker (10) according to one of the preceding claims, wherein the first channel (14) and/or the first sensing system (11) is arranged essentially at the seeker's front end, while the second channel (15) and/or the second sensing system (12) is further displaced to the seeker's back end.

9. Dual mode seeker (10) according to one of the preceding claims, further comprising a common mechanical reference for the first sensing system (11) and the second sensing system (12).

10. A missile (1) comprising a dual mode seeker (10) according to one of the preceding claims, wherein the dual mode seeker (10) is arranged in a nose (2) of the missile (1).

11. A method for assembling a dual mode seeker (10) for a missile (1), comprising the following steps:

- providing a space envelope (13) configured to be arranged in a missile's nose (2),
- providing a first sensing system (11) configured to detect a target,
- providing a second sensing system (12) configured to detect a target,
- arranging the first sensing system (11) in a first channel (14) of the space envelope (13), and
- arranging the second sensing system (12) in a second channel (15) of the space envelope (13),

wherein the first and the second channels (15) are arranged adjacent to each other in a seeker's radial direction,
wherein the first sensing system (11) comprises an active radar transmitter and a radar receiver, and
wherein the second sensing system (12) comprises a passive optical detector.

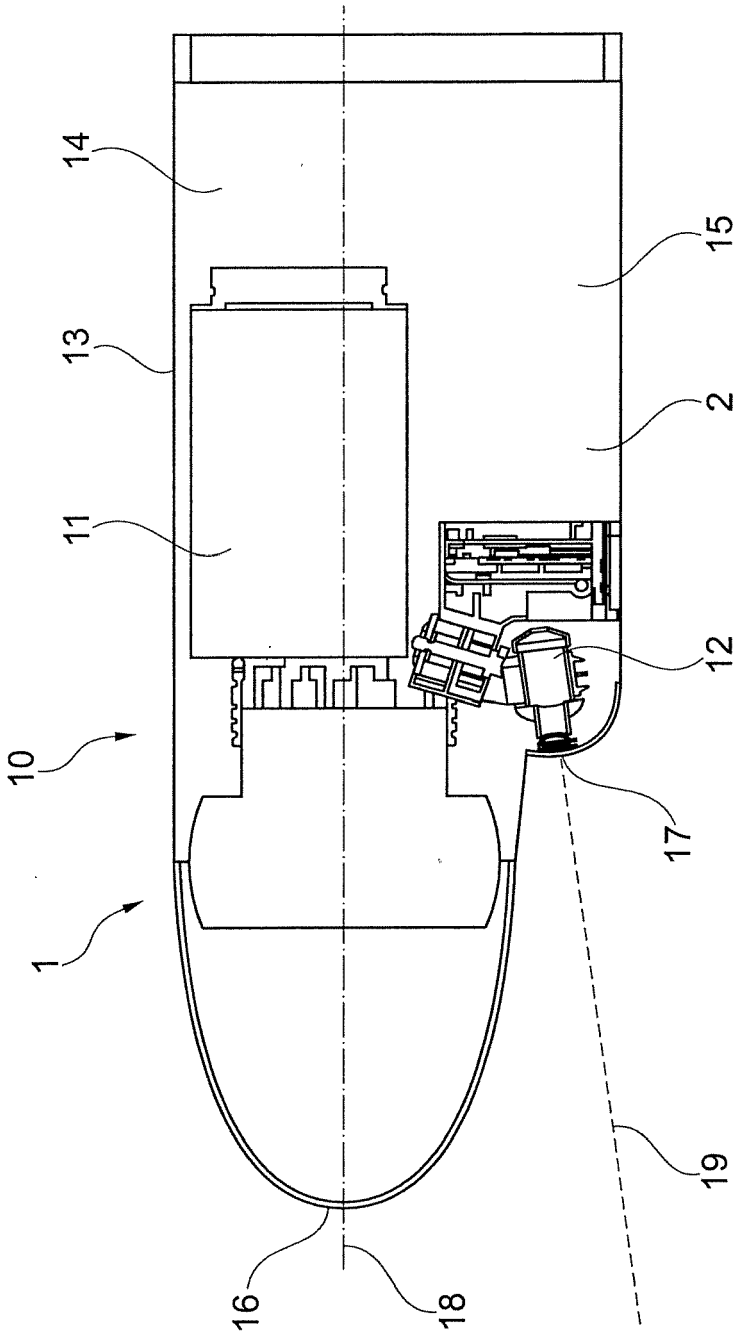

Fig. 1

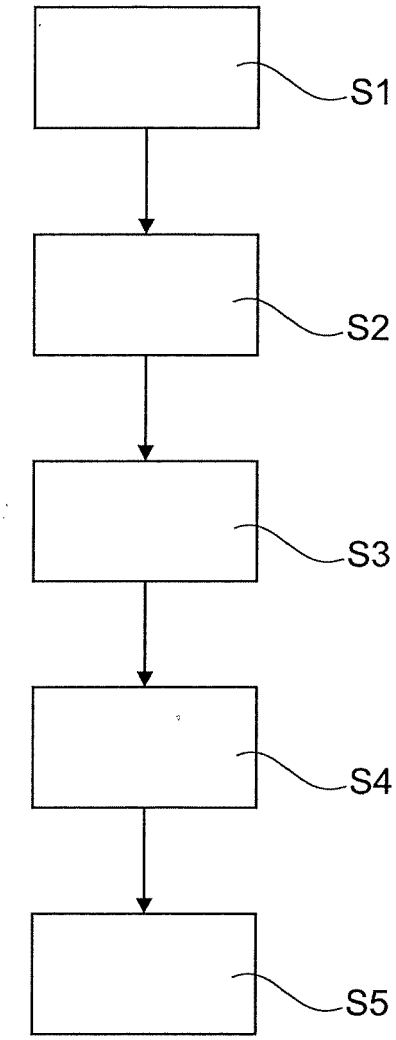

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 14 42 5074

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 482 353 A2 (BODENSEEWERK GERAETETECH [DE]) 29 April 1992 (1992-04-29) * abstract; figure 2 * * column 3, line 13 - line 32 *	1-11	INV. F41G7/00 F41G7/22
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A	* abstract; figures 1,2 * * page 7, line 22 - page 9, line 14 *	6	
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A	* abstract; figures 2b,2c * * paragraph [0035] - paragraph [0047] *	6	
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A	* abstract; figure 2A * * paragraph [0033] - paragraph [0039] *	5	
A	FR 2 944 593 A1 (SAGEM DEFENSE SECURITE [FR]) 22 October 2010 (2010-10-22) * abstract; figures 3,4 * * page 6, line 1 - page 9, line 2 *	1-11	TECHNICAL FIELDS SEARCHED (IPC) F41G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	25 November 2014	Vial, Antoine

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 42 5074

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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25-11-2014

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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