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(54) Missile tracking device

(57) A device for seeking and tracking targets from airborne missiles, which comprises one or two optical sensing units, each comprising a sensor barrel covered by a dome, a detector, drive means for rotating the sensor barrel about two perpendicular axis, and a processor for processing the signals produced by the detector and guiding the missile accordingly. The drive means comprise two motors for imparting to the barrel a pitching and a rolling motion. To eliminate aerodynamic drag, each sensing unit may be displaceable between a position retracted within the missile envelope and an extended position, in which part of its dome extends from the missile envelope. When two sensing units are provided, a target is tracked by operating only one of them, and when the target moves out of its field-of-regard, deactivating it and activating the other unit to continue tracking the target. When the sensing units are displaceable, they are in retracted position when the missile is launched, and, when the intended target is at close enough range, the unit on the side of the target is extended outside the missile envelope.

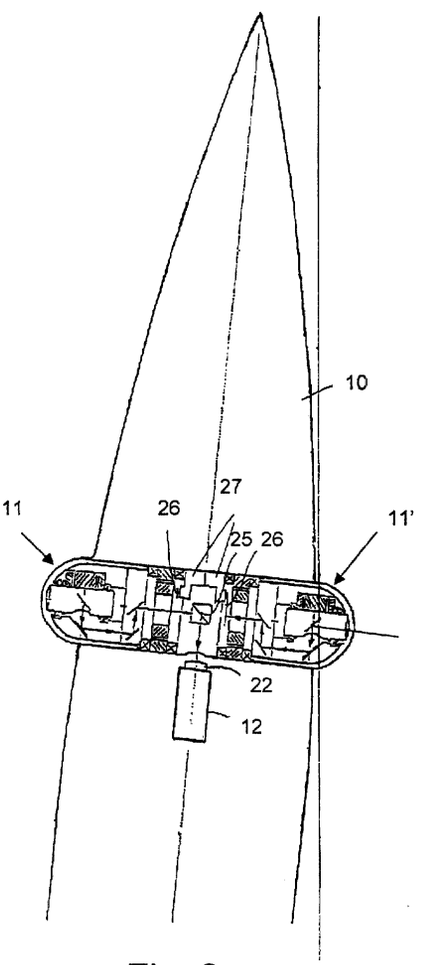

Fig. 2

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Description

Field of the Invention

[0001] This invention relates to tracking systems for aiborne missiles, and more particularly, to tracking devices that have a wider field-of-regard to prior art devices and yet do not significantly affect the aerodynamic performance of the missile.

Background of the Invention

[0002] Airborne missiles are provided with seeker and tracker heads for locating and homing on targets. Such heads comprise a detector or detectors, of any type known in the art, such as optical or radar detectors; a scanning mechanism, which actuates the detectors with a scanning motion; a shield or shields to protect the detectors from the environment; and electronic processing means for processing the information received from the detectors and guiding the missile accordingly.

[0003] At each moment and in each position, each detector has an instantaneous field-of-view, which depends on its structure, and can be defined as the solid angle that includes all the directions that are "seen", viz. from which a signal can reach the detector and be sensed by it. This will be called hereinafter briefly "the field-of-view". As the detector is scanned, the field-of-view changes. The sum of all possible fields-of-view, or, in other words, the solid angle that includes all the directions that can be "seen" by the detector in its scanning, will be called herein "the field-of-regard". The field-of-regard does not depend only on the structure of the detector, but depends also on the scanning mechanism and on the other parts of missile that may limit the width of the scanning and/or obstruct in certain positions the detector's field-of-view. Clearly, the seeker and tracker device is unable to detect a target that is outside its field-of-regard, and is unable to keep track of detected targets, if they move to outside its field-of-regard.

[0004] Obviously, a seeker and tracker device placed in front of the tip of the missile will have a wider field-of-regard, but it will cause air drag, particularly in high speed cruising, and damage the aerodynamic performance of the missile. Further, it will be greatly exposed to aerodynamic attrition and consequent overheating.

[0005] The prior art has not found any way to provide a wide field-of-view without creating aerodynamic and/or thermal drawbacks. Thus, USP 3,974,985 discloses a tracker comprising a rotatable lens barrel mounted on a turret mounted in a tubular section of a missile located aft of the missile tip. Such a tracker causes a limited air drag, but has a limited field-of-regard.

[0006] Israeli patent application discloses a missile having a homing head arranged in an intermediate position of the missile, which homing head is at a slant to the missile axis and views the environment through a lateral window. Such a device does not damage the aerodynamic performance of the missile, but has a poor field-of-regard.

[0007] UK patent application GB 2 284 465 A discloses a seeker head movable between two positions: a first position in which it extends forwardly of the missile tip and a second position in which it is retracted aft of said tip. In the first position it has a wide field-of-regard and can search for a target, while in the second position it has a very narrow field-of-regard which is intended to permit it to track a detected target. Such a seeker head, however, not only involves a mechanical complication and serious overheating problems when in said first position, but is able to track a detected target, in said second position, only if the target's movement is not quick or sharply angled. While said application states that, if an infrared detector is used, a cooling system may be used for cooling the interior of the seeker head, no cooling system is shown or described.

[0008] It is therefore a purpose of this invention to provide a seeker and tracker system for missiles, which is free of the drawbacks of the prior art.

[0009] It is another purpose to provide such a system that has a wide field-of-regard, and yet has no significant influence on the aerodynamic performance of the missile.

[0010] It is a further purpose to provide such a system that is capable of tracking a detected target no matter how it moves.

[0011] It is a still further purpose to provide such a system that is not affected by heat developed from air attrition.

[0012] It is a still further purpose to provide such a system that does not involve any mechanical complication.

[0013] It is a still further purpose to provide such a system that achieves concurrently all the objects and advantages achieved separately by prior art systems, and further, objects and advantages that are not achieved by them.

Summary of the Invention

[0014] The seeker and tracker device according to the invention comprises;

I - at least an optical sensing unit (briefly, hereinafter, "sensing unit"), comprising a lens barrel or sensor barrel, which preferably has an axis in a transverse plane of the missile;

II - a dome, projecting from the side of the missile and covering the sensor barrel, said barrel extending into said dome beyond the side surface of the missile;

III - a detector, preferably coaxial with the missile;

III - drive means for rotating the sensor barrel about two perpendicular axis; and

IV - a processor for processing the signals produced by the detector and guiding the missile accordingly.

[0015] Of the aforesaid two perpendicular axis, one (that can be called the "inner" one) is connected to the sensor barrel while the other (that can be called the "outer" one) is connected to the first. Said two axes together constitute a gimbal suspension.

[0016] The sensing unit comprises a lens (objective lens) barrel, extending into the dome beyond the side surface of the missile and having a field-of-view that depends on the optical characteristics of its components, first drive means comprising a first (pitch) motor and an inner joint for imparting to said barrel a pitching motion about a first axis, second drive means comprising a second (roll) motor and an outer joint for imparting to said barrel a rolling motion about a second axis, and optical deviating means, generally comprising mirrors or prisms, for transmitting the optical signals sensed by the objective lens to the detector, which receives them through an ocular lens. It should be understood that the expressions "ocular lens" or "objective lens" include the case in which one or the other or both of the "lenses" is an optical sensor comprising more than one optical component, e.g. more than one lens or a combination of lenses and other optical components. Such optical sensors are well known to skilled persons and need no further description. Therefore the "lens barrel" will be synonymously called the "sensor barrel".

[0017] The rotation of the sensor barrel about its axis will be called herein "roll" or "rolling motion". By "pitch" or "pitching motion" is meant herein rotation about an axis perpendicular to the axis of the sensor barrel. When no pitching motion has occurred, said axis is in its average position, viz. it lies on a plane perpendicular to the missile axis. The pitching swings it fore and aft of the average position. The combination of the pitching and the rolling motions generates a practically hemispherical, or 180°x360°, field-of-regard for the optical sensor.

[0018] The sensing unit is located in an intermediate portion of the missile. A radar antenna dish or conformal antenna strips can be housed in the portion of the missile forward of the sensing unit.

[0019] The device of the invention is periscopic and transmits the picture as it is without additional mechanical motion. The pitching motion becomes a rolling motion of the picture. This motion can be computed and it is possible to neutralize said rolling motion or at least to take it into account at the time of signal processing and of calculation of the tracking error.

[0020] In a preferred embodiment of the invention, cooling means are provided for the sensing unit, which comprise a cooling fluid reservoir, a cowling for directing a flow of coolant fluid released from the tank to the rear surface of the dome, and motor and transmission means for rotating the dome about its axis, whereby every portion of its surface in turn will come into contact with the coolant. The cooling fluid may be, for example, a gas such as nitrogen or argon under a pressure of e.g. 2000 psi, or ethylene glycol under low pressure.

[0021] In another preferred embodiment of the invention, at least two sensing units are provided, angularly spaced about the periphery of the missile, and preferably coaxial and on opposite sides of the missile, whereby it can be said that they are the specular image one of the other. Optical means, such as an optical coupler, is also provided, selectively to render one or the other of the sensing units operative, by directing to the detector only the optical signals originating from said operative unit. Shutter means are preferably provided for preventing optical signals, received by the sensing unit that is not operative at the moment, from interfering with the optical signals transmitted by the operative sensing unit. The optical coupler and the shutters are controlled by the processor. When a target, that is being tracked by a sensing unit, moves out of the field-of-regard of that unit, and therefore the signals concerning it cease to be transmitted to the detector and from it to the processor, this latter deactivates said unit and activates the other unit.

[0022] When two sensing units are provided, each has a field-of-regard that is approximately emispheric, viz. approaches 180x360°. Therefore, together, the two sensing units have complementary fields-of-regard which practically cover the entire space around the missile.

[0023] This invention therefore comprises a method of tracking targets from missiles, which comprises providing in the missile two optical sensors having complementary and symmetrical fields-of-regard; tracking a target by means of an operative optical sensor while maintaining the other sensor inoperative; and when a targets moves out of the field-of-regard of said operative optical sensor, deactivating it and activating the other optical sensor to continue tracking the target.

Brief Description of the Drawings

[0024] In the drawings:

Fig. 1 is a schematic axial cross-section of the fore portion of a missile having a sensing unit and a detector mounted thereon;

Fig. 2 is a like cross-section at a larger scale showing two sensing units, a portion of the missile being broken off;

Fig. 3 is a cross-section similar to Fig. 1, but additionally showing cooling means;

Fig. 4 is a view from the outside of the cooling means;

Fig. 5 is a cross-section similar to Fig. 1, but additionally showing a radar antenna dish;

Fig. 6 is a cross-section similar to Fig. 2, but additionally showing conformed antenna strips.

Detailed Description of Preferred Embodiments

[0025] In Fig. 1, the fore portion of a missile is schematically indicated at 10. Numeral 11 generally desig-

nates a sensing unit, which extends from a outer surface of the missile and is protected by a dome 14 of optical material. 12 is a detector axially mounted in the missile. Sensing unit 11 comprises a sensor barrel 13 which is actuated for pitching motion by a motor 15 and is supported by bearing 16. An outer axis 17 is provided for permitting a rolling motion, actuated by rolling motor 20 supported on bearings 21. Sensor barrel 13 has an opening 18 through which the optical signals pass. They impinge on a succession of mirrors 19 and on a central mirror 23, placed so as to reflect the optical signals to detector 12 provided with an ocular lens 22.

[0026] Fig. 2 shows a similar missile 10 in which two sensing units 11 and 11' are mounted opposite to each other and on the same axis, so that unit 11' is the specular image of unit 11. Each sensing unit is identical to sensing unit 11 of Fig. 1, and therefore its components are the same and need not be described once more. Detector 12, with ocular lens 22, is equal or equivalent to detector 12 of Fig. 1. Additionally, an optical coupler 25 is provided in place of central mirror 23 of Fig. 1, to reflect the optical signals from either sensing unit 11 or 11' into the detector. Shutters 26 and shutter actuators 27 are also provided.

[0027] Figs. 3 and 4 illustrate a cooling system for a single sensing unit, as that of Fig. 1, but it is clear that the same cooling system can be used for both sensing units, when two are present as in Fig. 2. The missile and the sensing unit are indicated by the same numerals as in Fig. 1. Additionally, a motor 30 and a gearing 31 are provided for rotating dome 14 on supports 32. A cowling 33 leads a cooling fluid from a reservoir, not shown, to the dome. The cooling fluid is discharged as indicated by the arrows 34. Because the dome rotates, all its surface is successively exposed to the cooling gas and cooled.

[0028] Fig. 5 shows the same apparatus as in Fig. 1, with the addition of a radar antenna dish 40 mounted on a pedestal 41.

[0029] Fig. 6 shows the same apparatus as in Fig. 1, with the addition of conformed antenna strips 42. Obviously, such antennae could be mounted in missiles provided with two sensing units, as in Fig. 2.

[0030] While embodiments of the invention have been described for purposes of illustration, they are not limitative and skilled persons may carry out the invention with many adaptations, modifications and variations.

Claims

1. Seeker and tracker device for airborne missiles, which comprises:

   I - at least an optical sensing unit comprising a sensor barrel;
   II - a dome, projecting from the side of the missile and covering said sensor barrel, said barrel extending into said dome beyond the side surface of the missile;
   III - a detector;
   III - drive means for rotating said sensor barrel about two perpendicular axis; and
   IV - a processor for processing the signals produced by the detector and guiding the missile accordingly.

2. Device according to claim 1, wherein the sensor barrel has an axis in a transverse plane of the missile.

3. Device according to claim 1, wherein the detector is coaxial with the missile and provided with an ocular lens.

4. Device according to claim 1, further comprising drive means for the sensing unit, which drive means comprise a pitch motor for imparting to said barrel a pitching motion, and a roll motor for imparting to said barrel a rolling motion.

5. Device according to claim 3, wherein the sensor unit comprises an objective lens, and which further comprises optical deviating means for transmitting the optical signals sensed by said objective lens to the detector, which receives them through the ocular lens.

6. Device according to claim 1, comprising at least two sensing units are provided, angularly spaced about the periphery of the missile.

7. Device according to claim 6, comprising two sensing units which are coaxial and on opposite sides of the missile

8. Device according to claim 6, further comprising optical means for selectively rendering one or the other of the sensing units operative, by directing to the detector only the optical signals originating from it.

9. Device according to claim 6, further comprising shutter means for preventing optical signals, received by the sensing unit that is not operative, from interfering with the optical signals transmitted by the operative sensing unit.

10. Device according to claim 7, wherein each of the two sensing units has a field-of-regard that approaches 180x360°.

11. Device according to claim 1 or 6, wherein the sensing units are located in an intermediate portion of the missile and antenna means, chosen from a radar antenna dish and conformal antenna strips, is housed in the portion of the missile forward of the

sensing units.

12. Device according to claim 1 or 6, further comprising cooling means for the sensing unit, which comprise a cowling for directing a flow of coolant fluid to the rear surface of the dome and motor and transmission means for rotating the dome about its axis, whereby every portion of its surface in turn will come into contact with the coolant.

13. Device according to claim 12, wherein a gap is left between the fore edge of the cowling and the rear surface of the dome, to permit the cooling fluid to be discharged to the environment.

14. Method of tracking targets from missiles, which comprises providing in the missile two optical sensors having complementary and symmetrical fields-of-regard; tracking a target by means of an operative optical sensor while maintaining the other sensor inoperative; and when a target moves out of the field-of-regard of said operative optical sensor, deactivating it and activating the other optical sensor to continue tracking the target.

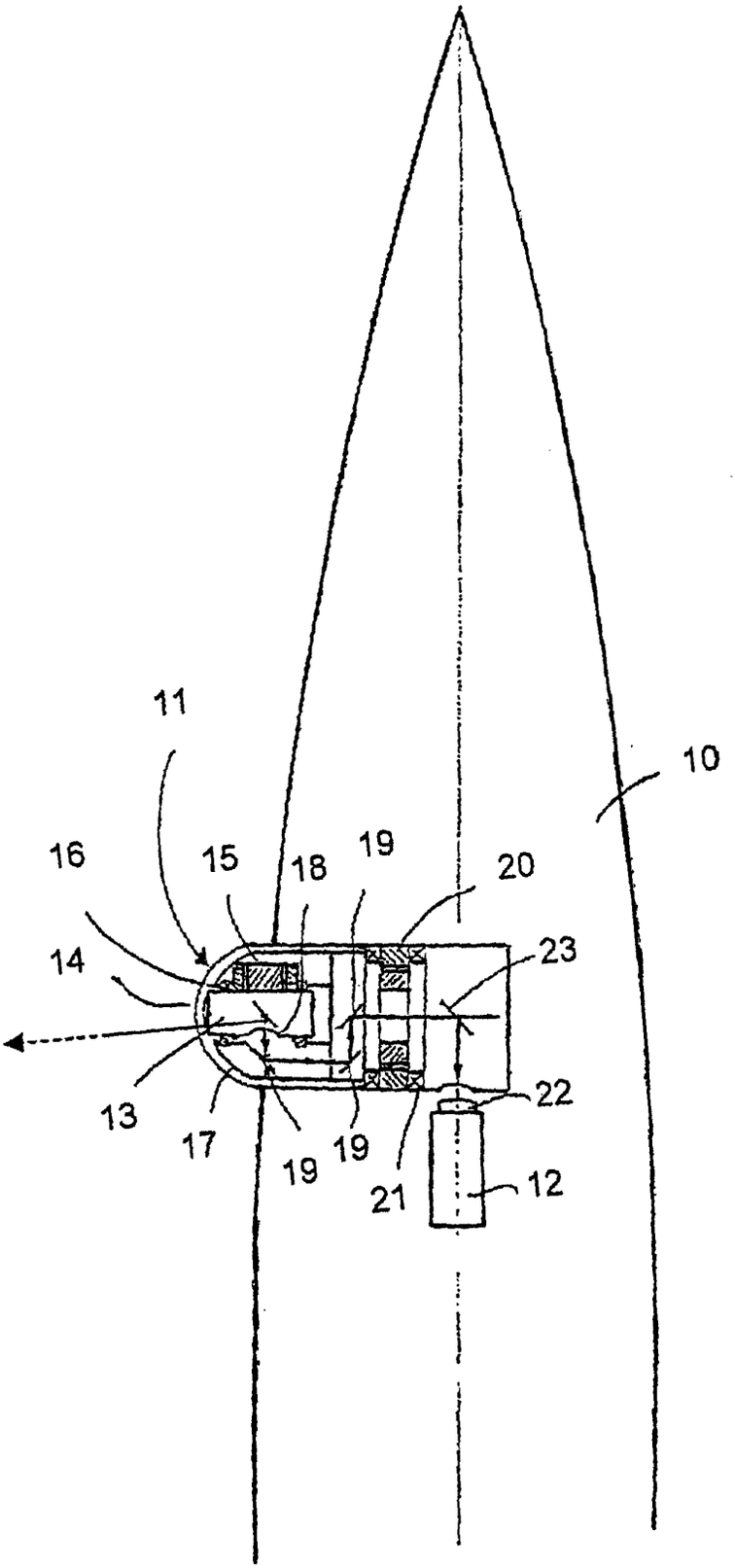

Fig. 1

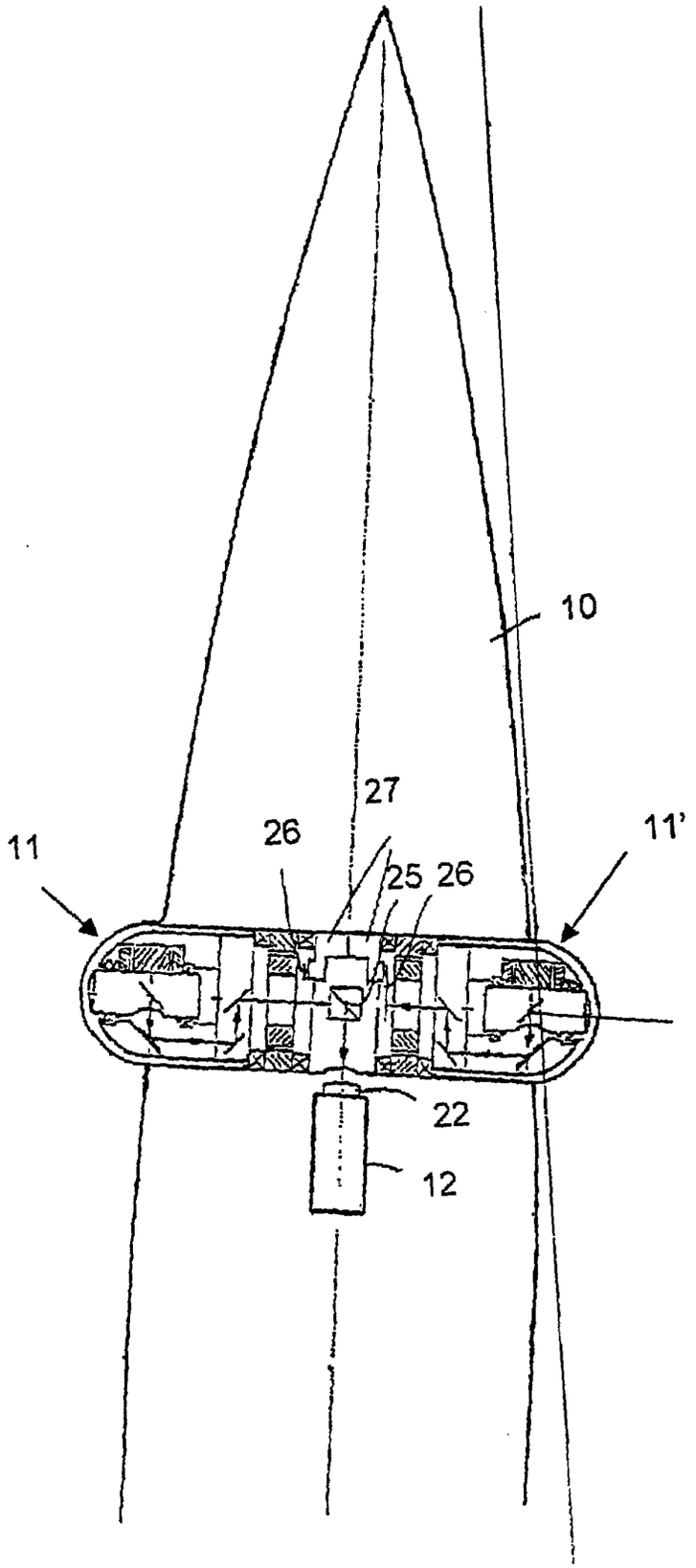

Fig. 2

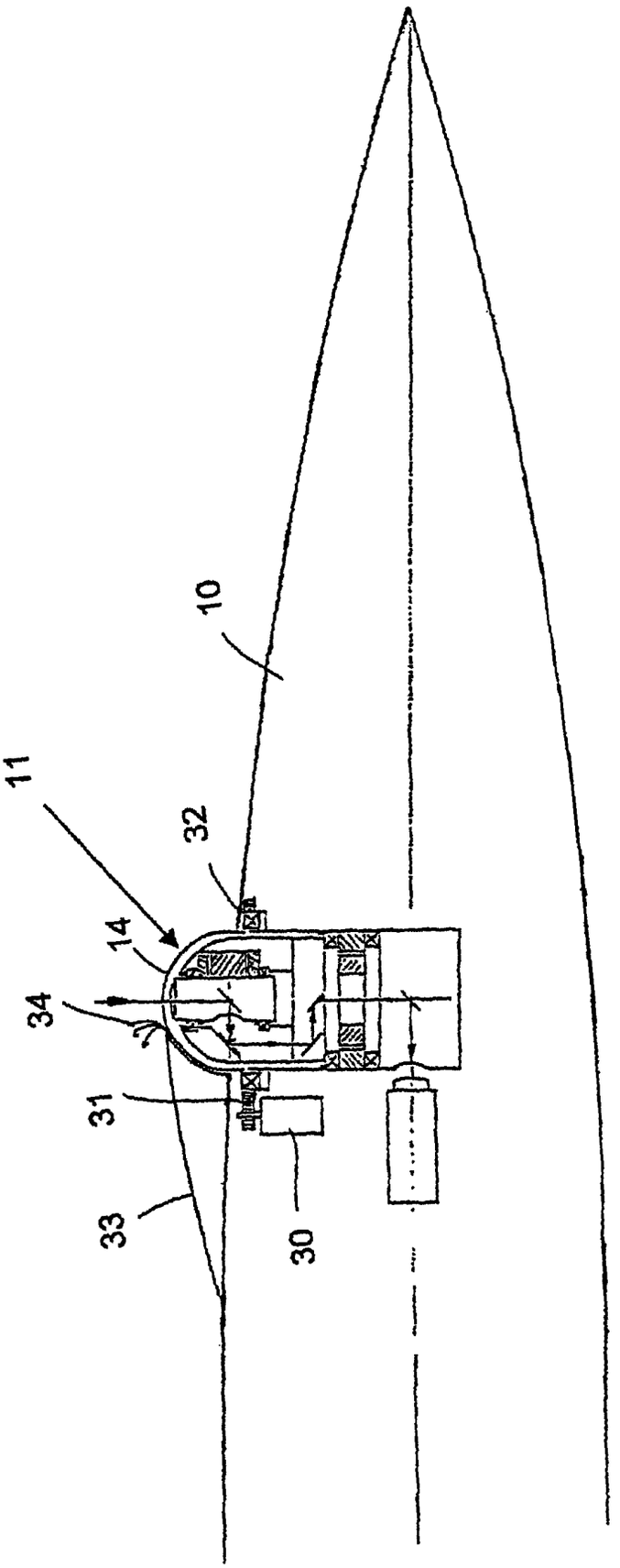

Fig. 3

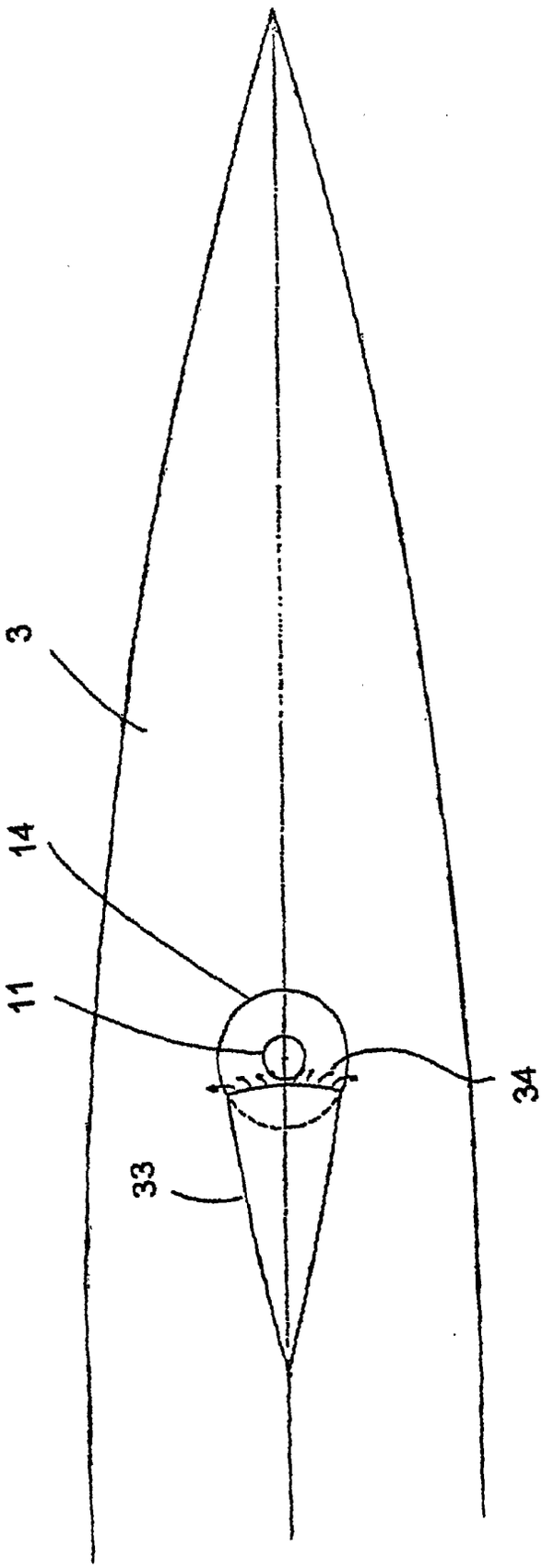

Fig. 4

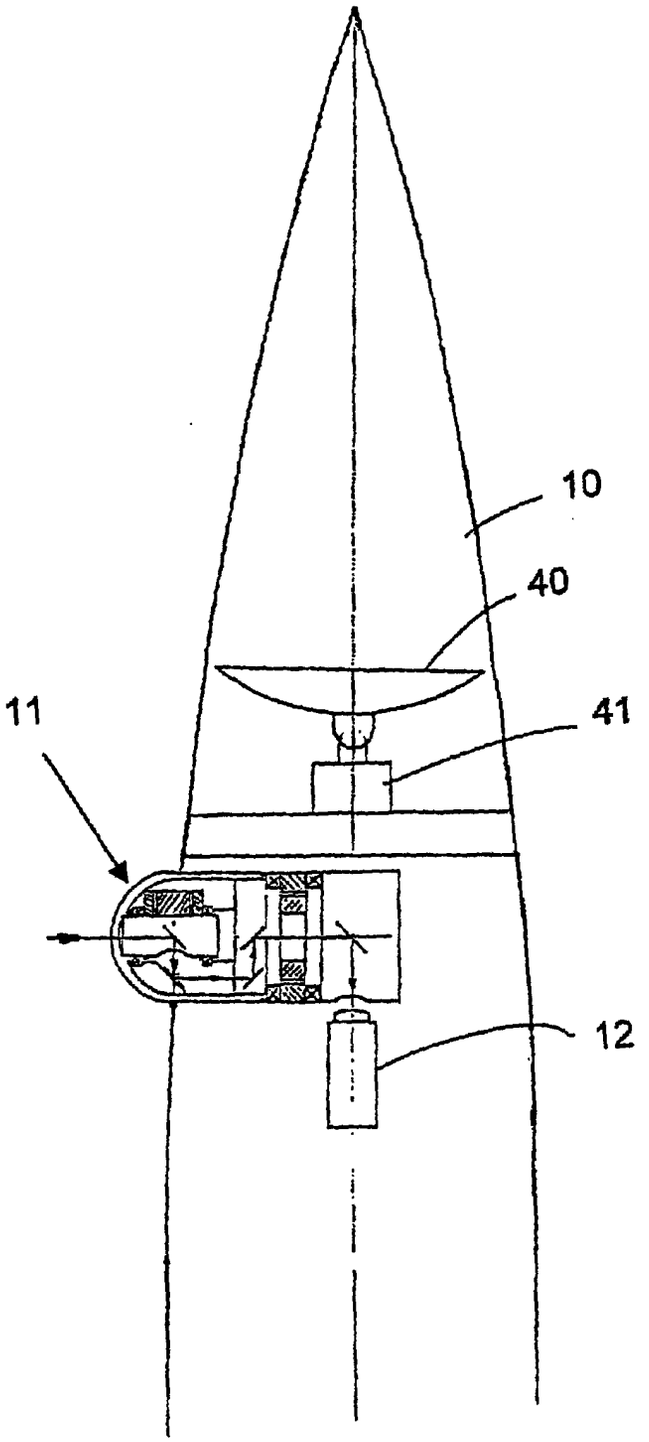

Fig. 5

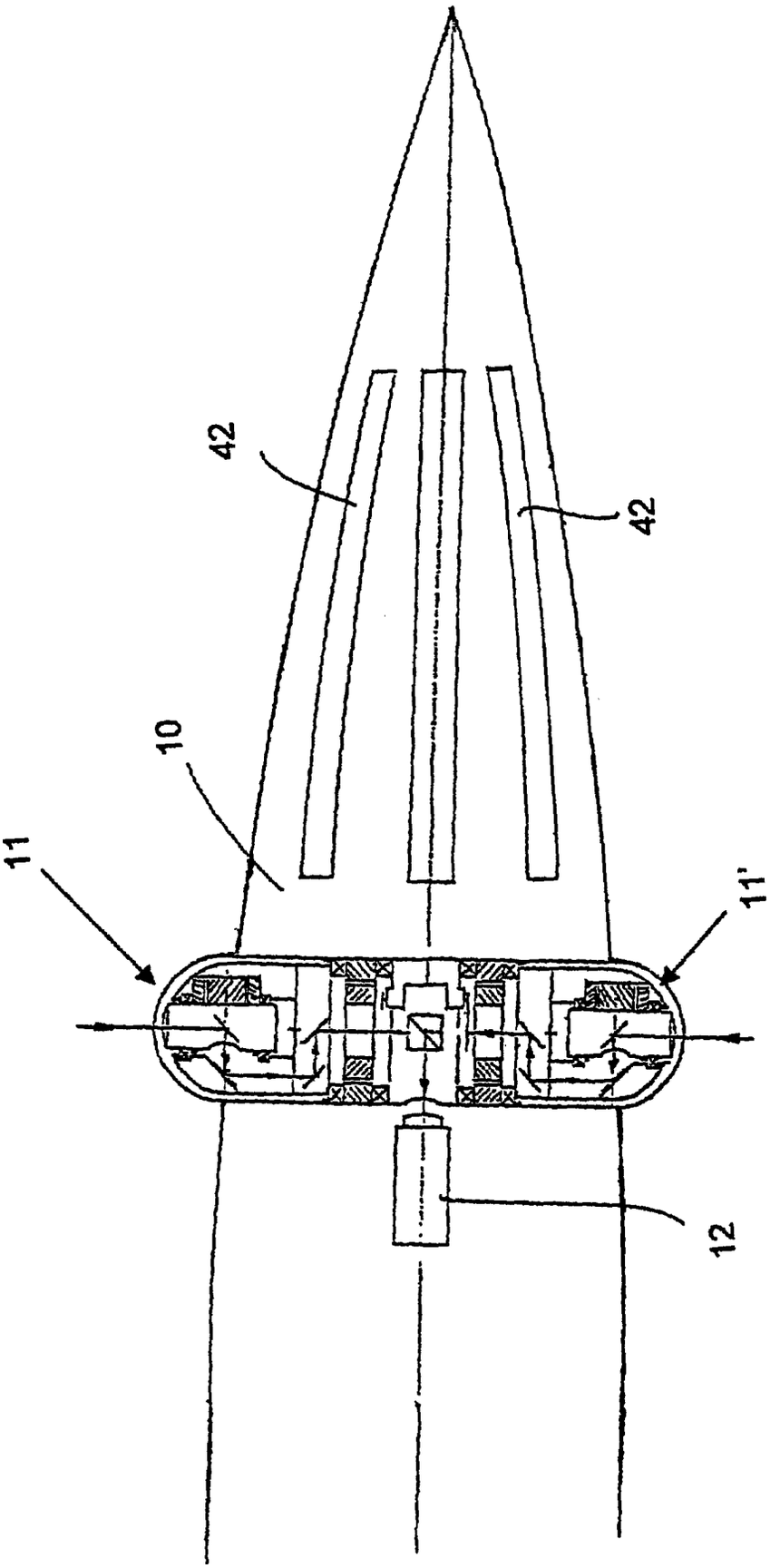

Fig. 6