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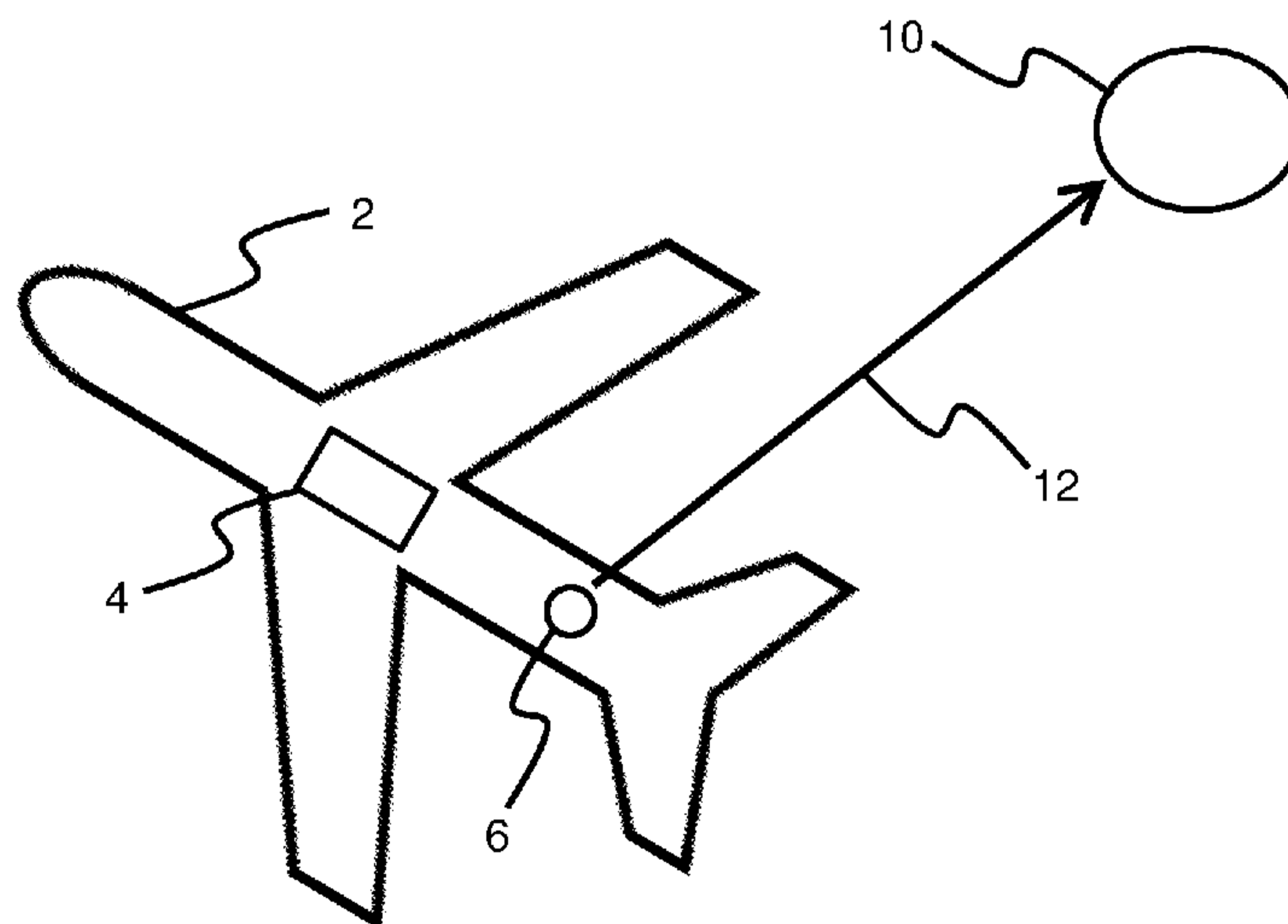
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**Declarations under Rule 4.17:**

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(54) Title: A WEAPON SYSTEM



*Fig. 2*

(57) Abstract: According to an aspect of the invention, there is provided a weapon system for use on a vehicle, comprising: a control system, the control system configured to, in response to a determination that a line-of-sight from the weapon system to a target of the weapon system is currently, or going to be obscured, trigger an alteration of a configuration of the vehicle such that the line-of-sight to the target is not obscured. Thus, the weapon system can ensure a line-of-sight of the target, allowing it to be successfully engaged.



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## A WEAPON SYSTEM

5           The present invention relates generally to a weapon system, and in particular to a weapon system for use on a vehicle. The present invention also relates generally to related vehicles and methods.

### BACKGROUND

10           If a weapon is to be used to protect a vehicle against incoming threats, for example missiles, one of the most challenging problems is to ensure that there is a complete  $4\pi$  steradian coverage of the area around the vehicle, or at least coverage that is as good as practically possible. Parts of the vehicle may obscure the sightlines of output or outlets of the weapon, for example apertures of the weapon, meaning that the area covered is less than  $4\pi$  steradians at any  
15 one time. Some systems, such as Directed Infrared Countermeasure Systems (DIRCMs) employ gimbals to increase coverage above what would be possible with a static installation. However, in reality, the number of gimballed apertures required to provide full coverage would be impractical, for example in terms of cost, weight, complexity, and so on, balanced against the related benefits of  
20 such coverage. As such, there exists a need for a method of extending the coverage provided by a weapon, in a practical manner, and for example up to the full  $4\pi$  steradians.

### SUMMARY OF INVENTION

25           It is an aim of example embodiments to at least partially overcome or avoid one or more disadvantages of the prior art, described above or elsewhere, or to at least provide an improved or even an alternative weapon system to those already in existence.

According to the present invention there is provided an apparatus and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

According to an aspect of the invention, there is provided a weapon system  
5 for use on a vehicle, the weapon system comprising: a control system, the control system configured to, in response to a determination that a line-of-sight from the weapon system to a target of the weapon system is currently, or going to be obscured, trigger an alteration of a configuration of the vehicle such that the line-of-sight to the target is not obscured. Thus, the weapon system can  
10 ensure a line-of-sight of the target, allowing it to be successfully engaged.

The control system may be configured to trigger the alteration of the configuration of the vehicle such that the line-of-sight to the target is not obscured by an element of the vehicle. Thus, the control system can prevent damage to the vehicle, as the target will not be engaged if an element of the  
15 vehicle is in the line-of-sight of the weapon.

The control system may be configured to trigger an alteration of the vehicle so as to enable the weapon system to continuously engage the target during relative movement between the weapon system and the target. Thus, the control system can allow for continuous engagement of the target, with no obscuration.

20 The control system may be configured to determine whether the line-of-sight to the target is currently, or going to be obscured. Thus, a simple control system capable of co-operating with external sensors can be provided.

The weapon system may further comprise a directed-energy weapon configured to output an energy beam at the target. Thus, the weapon system  
25 can minimise the problems relating to ammunition supply, or to more accurately engage a target with greater efficiency or effectiveness. The directed-energy weapon may comprise a laser directed-energy weapon. Thus, the weapon

system can provide a weapon with a very high range, and with almost instant engagement.

The directed-energy weapon may comprise one or more apertures for outputting an energy beam, optionally one or more gimballed apertures. Thus, 5 the coverage around the vehicle can be increased. Use of a single aperture (or a relatively small number of apertures) may be possible, according to principles of the invention.

The control system may control the directed-energy weapon to employ one of the apertures, based on probability of successfully engaging the target. Thus, 10 the system can ensure that the most appropriate aperture, which provides the greatest probability of neutralising the threat, is employed. This may be balanced against the need to alter the configuration of the vehicle to avoid the obscuration, for example in terms of speed of engagement, efficiency of effectiveness of engagement, and so on.

15 The control system may be configured to, in response to the determination that the line-of-sight to the target is currently, or going to be obscured, override any vehicle configuration commands provided by a controller (e.g. user, or at least partially automated control system) of the vehicle, such that the line-of-sight to the target is not to be obscured. Thus, the control system can override 20 any commands in order to provide and prioritise protection of the vehicle.

The control system may be configured to trigger an alteration of the configuration of the vehicle by triggering an alteration of an attitude of the vehicle. Thus, the control system can quickly and easily ensure that the line-of-sight to the target is no longer obscured. Also, the direction of travel of the 25 vehicle is not impacted upon, minimising disruption to the travel, or control of travel, of the vehicle.

The vehicle may comprise one of: an air platform, a land vehicle, and a watercraft. Thus, the weapon system can be employed on a variety of vehicles in different environments.

5 According to another exemplary embodiment, provided is a vehicle having a control system according to an aspect of the invention. The vehicle could be built with the system, or the system could be retrofitted to the vehicle. This could be a software upgrade, or a hardware upgrade.

10 According to another exemplary embodiment, provided is a method of controlling a weapon system of a vehicle, comprising the steps of: in response to a determination that a line-of-sight from the weapon system to a target of the weapon system is currently, or going to be obscured, triggering an alteration of a configuration of the vehicle such that the line-of-sight to the target is not obscured.

15 The method may further comprise the step of, in response to determining that the line-of-sight from the weapon system to the target of the weapon system is currently, or going to be obscured, overriding any commands provided by a controller (e.g. user, or at least partially automated control system) of the vehicle, so that the line-of-sight is not to be obscured. Thus, the control system can override any commands in order to provide protection of the vehicle.

20 Altering the configuration of the vehicle may comprise altering an attitude of the vehicle. Thus, the control system can quickly and easily ensure that the line-of-sight to the target is no longer obscured.

25 Although a few preferred embodiments of the present invention have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications might be made without departing from the scope of the invention, as defined in the appended claims.

LIST OF FIGURES

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example only, to the accompanying diagrammatic Figures in which:

Figures 1 and 2 schematically depict a weapon system for use on a vehicle  
5 according to an example embodiment;

Figure 3 schematically depicts a weapon system for use on a vehicle according to another example embodiment;

Figure 4 schematically depicts a control system of a weapon system for use on a vehicle according to an example embodiment; and

10 Figure 5 depicts example methodology according to an example embodiment.

## DESCRIPTION

Figure 1 schematically depicts a weapon system for use on a vehicle 2. The vehicle 2 could be any vehicle useful for the particular application, and  
15 capable of carrying or otherwise being connected to a weapon system. For instance, the vehicle 2 could be a military vehicle, such as a land-based vehicle, a naval vessel, or an aircraft. The vehicle is movable in at least one axis. Furthermore, the vehicle could be a manned vehicle, or an unmanned vehicle. In this particular example, and strictly by way of example only, the vehicle 2 is  
20 an aircraft.

In this particular example, the vehicle 2 comprises a weapon 6. The weapon 6 could be any ranged weapon, such as a missile, or a directed-energy weapon (“DEW”) configured to output an energy beam at a target. Typically, and for particular synergy with the present invention, the weapon 6 is a line-of-sight  
25 weapon, in terms of firing a projectile or a beam that is unguided, and so where line-of-sight is an important factor, especially near the vehicle.

In particular, the weapon 6 could be a laser directed energy weapon (“LDEW”). The weapon 6 may be employed to protect the vehicle 2 against incoming threats, such as missiles. However, one of the most challenging problems is maximising the coverage, e.g. field of view of the weapon 6, around the vehicle 2, as parts of the vehicle may obscure the sightlines of the weapon 6. For example, and strictly by way of example only, as shown in Figure 1, a line-of-sight 12 of the weapon 6 to a target 10 may be obscured by a wing part of the vehicle 2. In this situation, deploying the weapon 6 to attack or generally engage the target 10 would result in damage to the vehicle 2, as the weapon 6 shot would encounter the wing part of the vehicle 6, instead of the target 10.

The weapon system 6 for use on a vehicle 2 also comprises a control system 4. The control system 4 could be, for example, a processor configured to perform the tasks described below. In detail, the control system 4 may receive a determination that the line-of-sight 12 from the weapon 6 to the target 10 is currently, or going to be, obscured. This determination could be received from an external device, a radar, or a sensor attached to the vehicle 2. This determination could also be received, via a network, from an air traffic control tower. In one embodiment, the control system 4 itself performs the determination. The result of the determination could indicate, for example, that the line-of-sight 12 from the weapon 6 to the target 10 is currently obscured, or that it is going to be obscured in the near future, for example in the next thirty seconds or in an expected or desired engagement period with the target 10.

In response to a determination that the line-of-sight 12 from the weapon 6 to the target 10 is currently, or going to be, obscured, the control system 4 is configured to trigger an alteration of a configuration of the vehicle 2 such that the line-of-sight 12 is not obscured. That is, the control system 12 provides appropriate commands to actuators of the vehicle 2 to alter the configuration of the vehicle 2. For example, and strictly by way of example only, if the vehicle 2 is an aircraft, the control system 4 may give a command to flight control surfaces (such as ailerons of the aircraft) to alter the configuration of the vehicle 2 such



that the line-of-sight 12 is not obscured. The alteration of the configuration of the vehicle 2 could be one or more of a change in an orientation of the vehicle, a change in an attitude of the vehicle, and a change in a shape of the vehicle. For example, the vehicle or a portion of the vehicle might turn and the vehicle change  
5 movement direction, the vehicle or a portion of the vehicle might turn and the vehicle maintain movement direction, or a portion of the vehicle could simply be moved out of the way of the line-of-sight (e.g. a turret, a barrel, or a variable sweep wing, could be moved).

Figure 2 is another view of the same vehicle 2 as depicted in Figure 1, and  
10 for the ease of understanding, the same reference numerals have been used. The vehicle 2 of Figure 2 is in a different configuration to that of Figure 1. In detail, referring to Figure 2, and compared with Figure 1, the vehicle 2 has changed its orientation such that the line-of-sight 12 to the target 10 is not obscured by any element of the vehicle. Since the line-of-sight 12 to the target  
15 10 is not obstructed by the wing (or any other component) of the vehicle 2, employing the weapon 6 to engage the target 10 would not damage the vehicle 2. Ideally, the weapon system should be able to continuously engage the target 10 during relative movement between the weapon system and the target 10. By altering the configuration of the vehicle 2 in concert with the movement of the  
20 target 10 such that the line-of-sight 12 is not obscured, continuous engagement may be achieved. This might involve repeated or continuous re-configuration of the vehicle.

The vehicle 2 could be a manned vehicle, or an unmanned vehicle. For example, and strictly by way of example only, the vehicle 2 could be any one of  
25 a conventionally piloted vehicle, an optionally piloted vehicle, and an unmanned aerial or terrestrial vehicle. In case of a conventionally piloted vehicle, the control system 4 may override any vehicle configuration commands provided by the pilot (e.g. user) of the vehicle, or controller in general (e.g. including commands or input or control from a control system, for example an at least partially  
30 automated control system), in order to provide and prioritise protection of the

vehicle 2, and any accompanying personnel on board, from a threat. For example, if the line-of-sight 12 from the weapon 6 to the target 10 is determined not to be obscured, and the pilot inputs a command which would cause the line-of-sight 12 from the weapon 6 to the target 10 to be obscured, the control system  
5 4 overrides the commands provided by the pilot, such that the line-of-sight 12 remains unobscured.

Similarly, if the line-of-sight 12 from the weapon 6 to the target 10 is determined to be obscured, the control system 4 overrides the commands provided by the pilot, such that the line-of-sight 12 becomes unobscured.

10 Continuous engagement without obscuration is especially important in case of directed-energy weapons, where the target might need to be continuously engaged for a given amount of time in order to ensure adequate damage to the target. Furthermore, there may be a rapidly changing, dynamic situation, where targets are being engaged in a rapidly changing manner. Such  
15 a situation, of course, increases the risk of an object other than the intended target being unintentionally engaged and/or damaged by the weapon system. It is, of course, desirable to avoid this situation.

According to an example embodiment, it has been realised that the risk of unintentional damage to objects other than the intended target can be largely  
20 reduced or even avoided by providing a control system for a weapon system that is configured to, in response to a determination that the line-of-sight from the weapon to the target is currently, or going to be, obscured, alter a configuration of the vehicle such that the line-of-sight from the weapon to the target is not obscured.

25 As discussed above, the line-of-sight from the weapon 6 to a target 10 may be obscured by parts of the vehicle 2, meaning that the area covered by the weapon 6 is less than  $4\pi$  steradians, thereby reducing the effectiveness of the weapon system in protecting the vehicle 2 from incoming threats such as missiles. Some systems, such as Directed Infrared Countermeasure Systems

(DIRCMs) employ gimbals to increase coverage above what would be possible with a static installation. However, the number of gimballed apertures required to provide full coverage would be impractical.

Figure 3 illustrates a weapon system for use on a vehicle according to another example embodiment. In this embodiment, the weapon 6 is a directed-energy weapon, and comprises one or more apertures 8 for outputting an energy beam. The one or more apertures 8 may be gimballed in order to further increase coverage. The control system 4 controls the weapon 6 to employ one of the one or more of the apertures 8 based on probability of successfully engaging the target. That is, if it is determined that the line-of-sight 12 from the weapon 6 to the target 10 is currently, or going to be obscured, the control system 4 may control the weapon 6 to employ one of the one or more apertures 8, such that the line-of-sight 12 from the employed aperture 8 to the target 10 is not obscured. This feature, combined with altering the configuration of the vehicle, further contributes to the increased coverage of the weapon system. The choice or implementation of configuration change and/or aperture usage might involve a calculation as to the most efficient and effective option.

Figure 4 illustrates the control system 4 in more detail. The control system 4 is configured to receive an input 7. Said input can be, for example, an input indicating a determination has been made that the line-of-sight 12 from the weapon 6 to the target 10 is currently, or going to be, obscured (or currently is obscured), or an input relating to the relative position of the target 10 with respect to the weapon system, acquired from an external sensor. In response to receiving the input 7 relating to the relative position of the target 10 with respect to the weapon system, the control system 4 can determine whether the line-of-sight 12 is currently, or going to be, obscured. Alternatively, the control system 4 can simply receive the determination from elsewhere, e.g. from an external processor. The control system 4 is configured to output an output 9. Said output 9 can be, for example, an output to trigger the alteration of the configuration of the vehicle 2, said output generated by the control system 4 in response to the

determination that the line-of-sight 12 is currently, or going to be obscured. The output 9 may be transmitted, for example, to the vehicle's actuators, or any other control systems directly or indirectly controlling the actuators. The described control system 4 may be implemented in hardware, in software, or a combination  
5 of both.

Importantly, the control system 4 is designed as such to enable retrofitting of said control system 4 onto vehicles other than the exemplary vehicle 2. That is, other vehicles comprising weapons may also benefit from the weapon system described herein. Indeed, other vehicles can be retrofitted with control system  
10 4. Retrofitting might not require hardware modifications. Instead, the invention might be implemented via a software modification or upgrade.

Figure 5 describes general methodology associated with recently described embodiments. The method is for controlling a weapon system of a vehicle. The method comprises determining that a line-of-sight from the weapon  
15 system to a target of the weapon system is currently, or going to be obscured S100, and in response thereto, triggering an alteration of a configuration of the vehicle such that the line-of-sight to the target is not obscured S110.

Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this  
20 application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any  
25 method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example  
5 only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel  
10 combination, of the steps of any method or process so disclosed.

**CLAIMS**

1. A weapon system for use on a vehicle, the weapon system comprising:  
a control system configured to, in response to a determination that a line-of-sight  
5 from the weapon system to a target of the weapon system is currently, or going  
to be obscured, trigger an alteration of a configuration of the vehicle such that  
the line-of-sight to the target is not obscured.
2. The weapon system according to claim 1, wherein the control system is  
10 configured to trigger the alteration of the configuration of the vehicle such that  
the line-of-sight to the target is not obscured by an element of the vehicle.
3. The weapon system according to claim 1 or 2, wherein the control system  
is configured to trigger the alteration of the vehicle so as to enable the weapon  
15 system to continuously engage the target during relative movement between the  
weapon system and the target.
4. The weapon system of any preceding claim, wherein the control system is  
configured to determine whether the line-of-sight to the target is currently, or  
going to be obscured.
- 20 5. The weapon system according to any preceding claim, further comprising:  
a directed-energy weapon configured to output an energy beam at the  
target.

6. The weapon system according to any preceding claim, wherein the directed-energy weapon comprises one or more apertures for outputting an energy beam.

5

7. The weapon system according to claim 6, wherein the one or more apertures are gimballed.

8. The weapon system according to claims 6-7, wherein the control system is further configured to control the directed-energy weapon to employ one of the apertures, based on a probability of successfully engaging the target.

9. The weapon system according to any one of claims 1 to 8, wherein the control system is further configured to, in response to a determination that the line-of-sight to the target is currently, or going to be obscured, override any vehicle configuration commands provided by a controller of the vehicle, such that the line-of-sight to the target is not to be obscured.

10. The weapon system according to any one of claims 1 to 9, wherein the control system is configured to trigger an alteration of the configuration of the vehicle by triggering an alteration of an attitude of the vehicle.

11. The weapon system according to any one of claims 1 to 10, wherein the vehicle comprises one of: an air platform, a land vehicle, and a watercraft.

12. A vehicle comprising the system of any preceding claim.

13. A method of controlling a weapon system of a vehicle, comprising the steps  
5 of:

in response to a determination that a line-of-sight from the weapon system to a target of the weapon system is currently, or going to be obscured, triggering an alteration of a configuration of the vehicle such that the line-of-sight to the target is not obscured.

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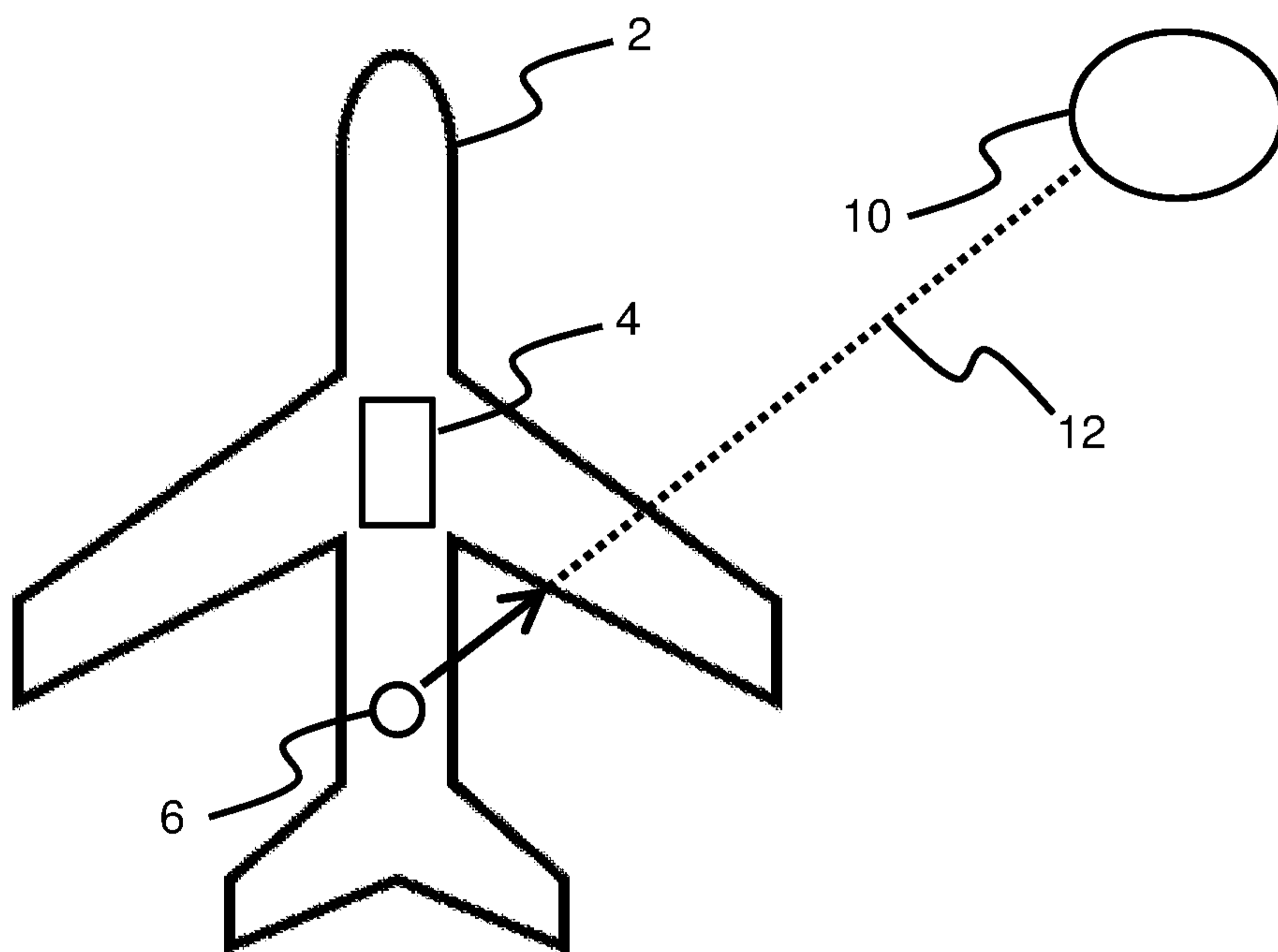
14. The method according to claim 13, further comprising the step of:

in response to determining that the line-of-sight from the weapon system to the target of the weapon system is currently, or going to be obscured, overriding any commands provided by a controller of the vehicle, so that the line-  
15 of-sight to the target is not to be obscured.

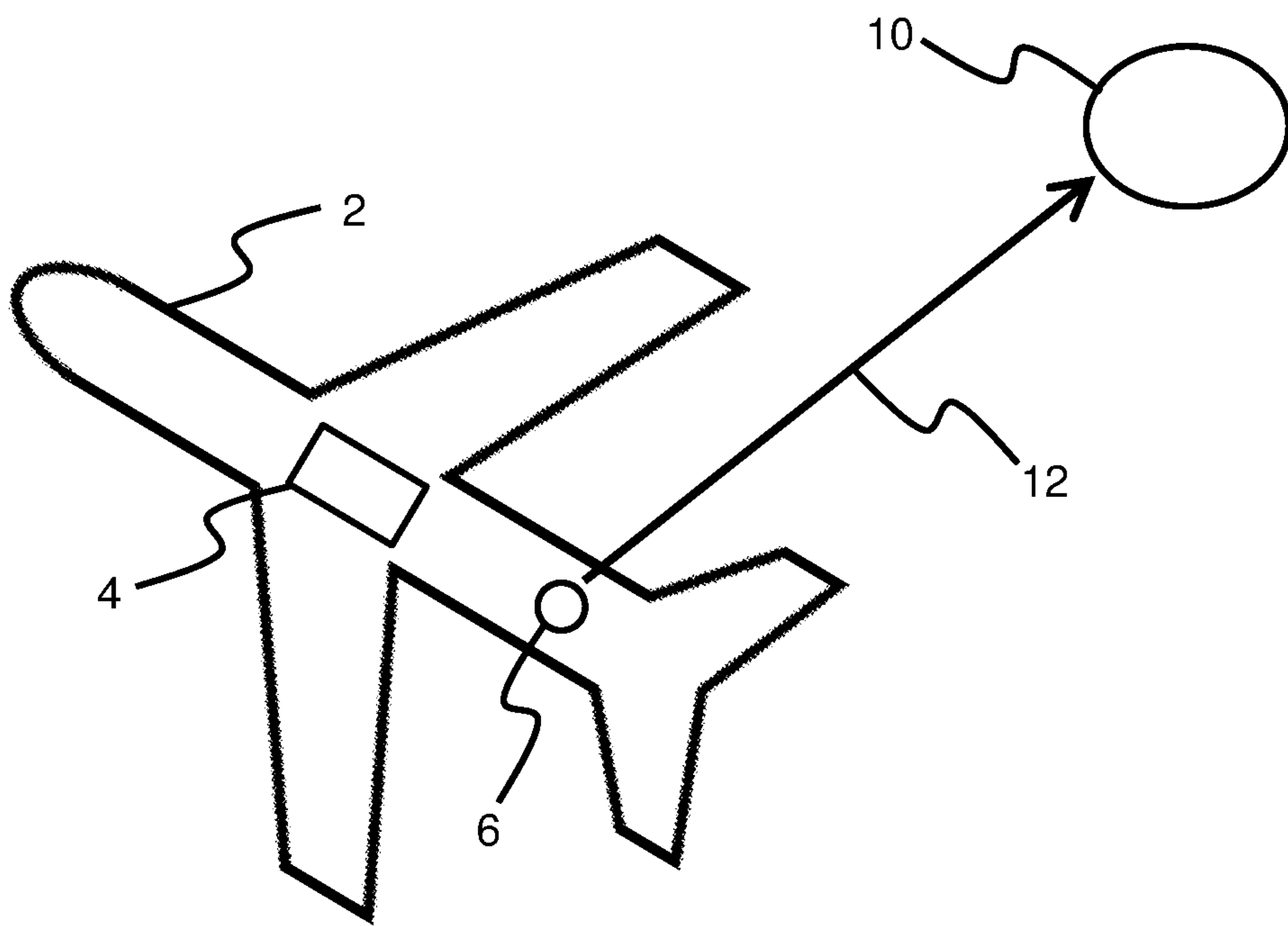
15. The method according to any preceding claim, wherein altering the configuration of the vehicle comprises altering an attitude of the vehicle.

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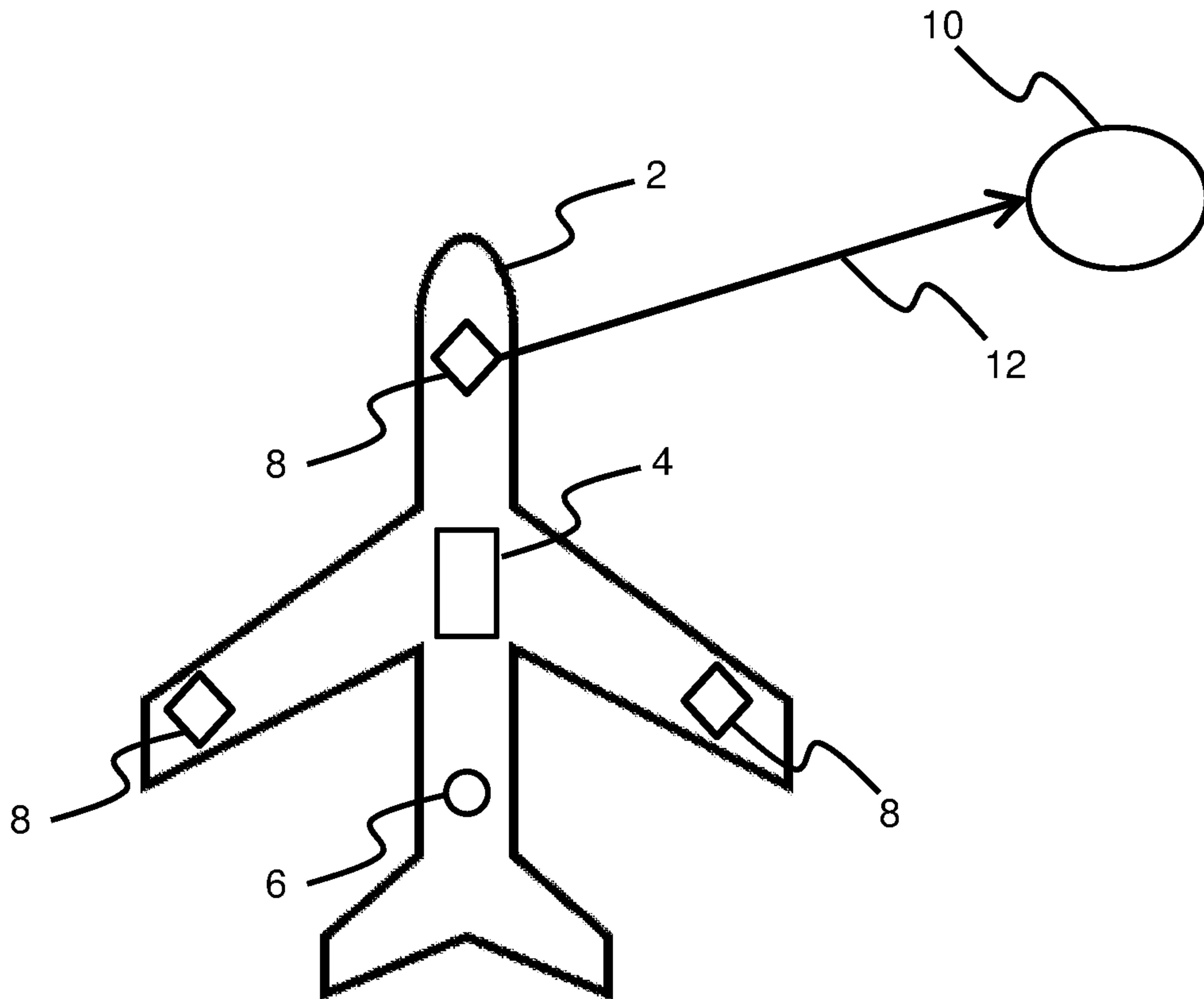




*Fig.1*

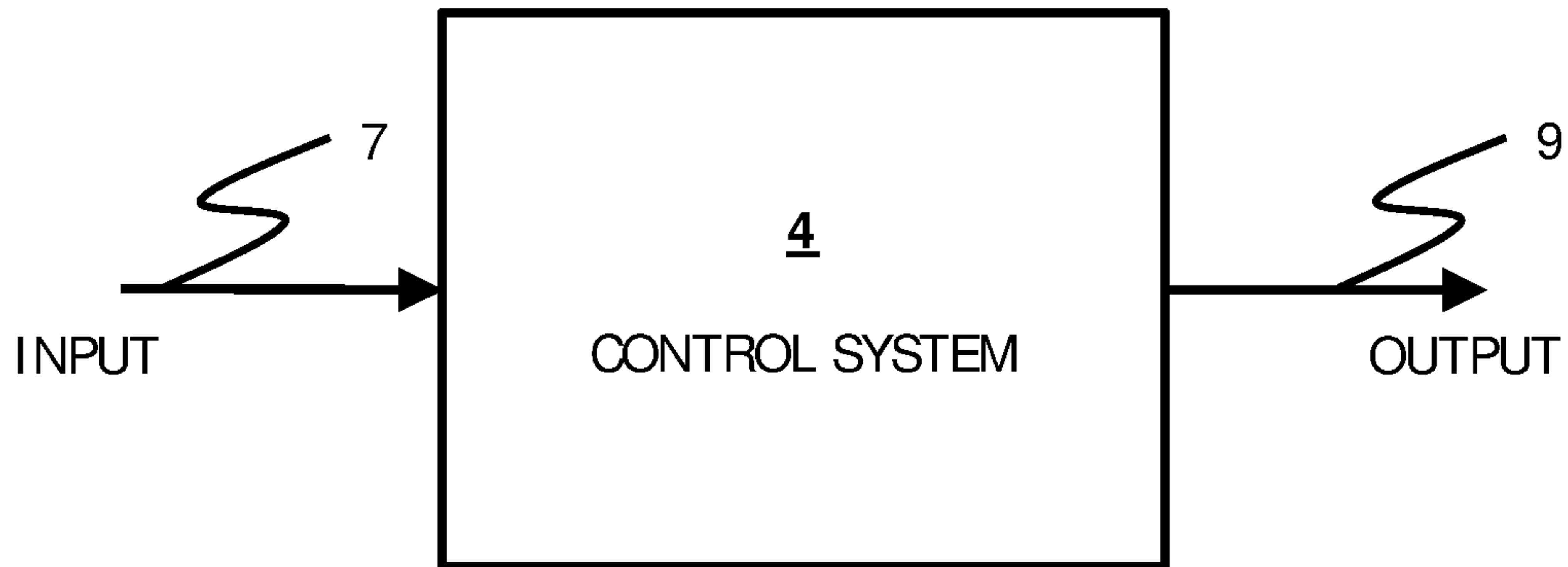


*Fig. 2*

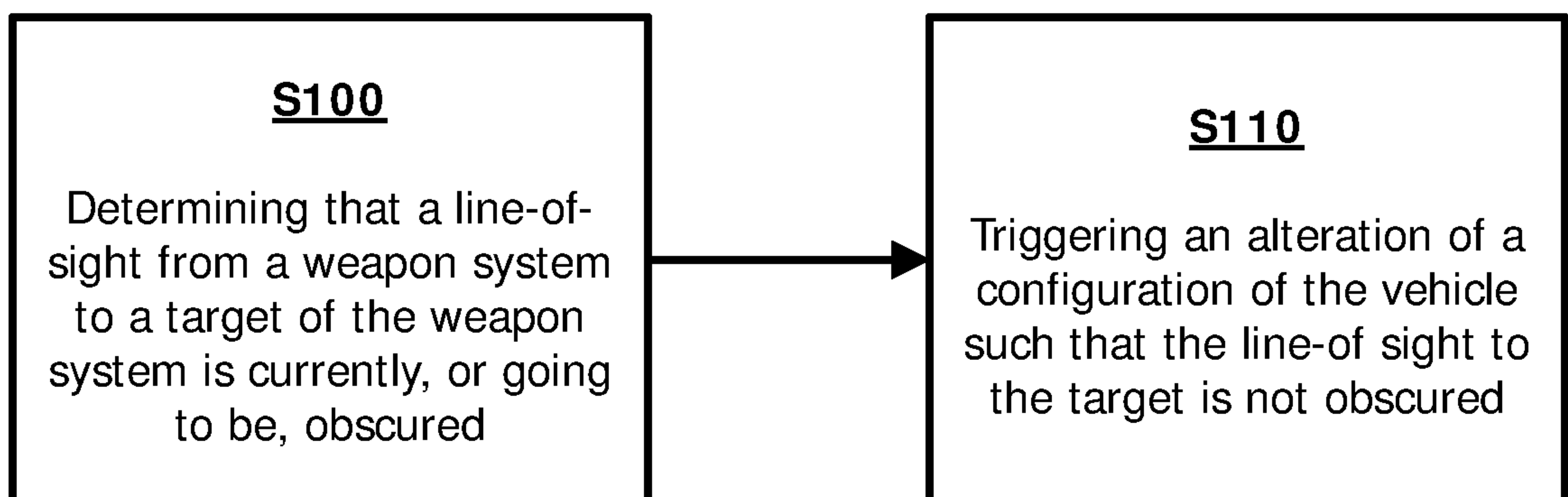


*Fig. 3*

4/4



*Fig. 4*



*Fig. 5*

**INTERNATIONAL SEARCH REPORT**

International application No PCT/GB2020/052801
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**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. B64C13/16 B64D7/00 F41H13/00 G05D1/00 F41H7/00  
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**  
 Minimum documentation searched (classification system followed by classification symbols)  
 F41H B64D B64C G05D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
 EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 837 918 A (SEPP GUNTHER [DE]) 17 November 1998 (1998-11-17) column 2, lines 12-21 column 4, lines 7-45 column 4, line 59 - column 5, line 1 -----	1-15
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A	US 2018/046187 A1 (MARTIROSYAN HAYK [US] ET AL) 15 February 2018 (2018-02-15) paragraph [0073] -----	1-15

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of the actual completion of the international search

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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