UNITED STATES PATENT APPLICATION
FOR

DIRECTED ENERGY WEAPON USING A PLURALITY OF LASERS

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DIRECTED ENERGY WEAPON USING A PLURALITY OF LASERS

CROSS REFERENCES TO RELATED APPLICATIONS

[001] This application claims the benefit of U.S. Provisional Application No. 62/553,280 filed on September 1, 2017, which is hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION - Field of Invention

[002] This invention relates to the field of directed energy weapons and, in particular, to the use of lasers as a directed energy weapon.

BACKGROUND OF THE INVENTION – Prior Art

[003] A directed energy weapon using a laser at or near sea level has the problem that when the laser power is high enough to be useful the laser energy ionizes the atmosphere and defocuses the beam. This appears to be one of the reasons that the mega-watt class chemical oxygen-iodine laser (Coil) used by the now-canceled Airborne Laser was not used in a ground installation. A ground installation would have avoided the expense and space constraints of the 747 aircraft and, as a speed-of-light system, would have been more reliable than the THAAD kinetic-kill system.

[004] The use of a laser for long distances in atmosphere requires that the beam be corrected for atmospheric turbulence. An example of a such an adaptive optics system is the system developed for the Airborne Laser. (*See IDS Cite 1*: **Atmospheric Compensation and Tracking Using Active Illumination** by Charles Higgs, Herbert T. Barclay, Daniel V. Murphy, and Charles A. Primmerman; Volume 11, Number 1, 1998 Lincoln Laboratory Journal.)

OBJECTIVES AND ADVANTAGES

[005] In a world where rogue nations such as North Korea and Iran are developing long-range missiles with nuclear weapons payloads there is a need to have a laser-based directed energy weapon that can send its destructive energy at or near sea level without ionizing the atmosphere thereby defocusing the laser beam. With the present invention a ground installation can destroy or disable incoming aircraft and missiles. The system can also be deployed in an aircraft or an orbiting satellite to destroy or disable missiles either during their pre-launch phase, launch phase, or during their descent. The system deployed in an aircraft or an orbiting satellite can also destroy or disable ground targets. The system can also be used to produce an Electromagnetic Pulse (EMP) at the target.

[006] There is also a problem in destroying or disabling the small consumer drones that have become popular (and a problem). The term "drone" originally meant a remote-controlled aircraft usually used for target practice. Many of these drones were obsolete aircraft outfitted with a remote control system. As the technology evolved into systems that could be used for reconnaissance and then for armed strikes the term evolved into Remotely Piloted Vehicle (RPV), Remotely Operated Aircraft (ROA), and Unmanned Aerial Vehicle (UAV). Now it is back to "drones" again and they do not even have to be remotely operated other than by setting the GPS coordinates of their destination.

Hobbyists are flying drones near airports jeopardizing the safety of aircraft. *See IDS Cite 2* from the Washington Post: **FAA records detail hundreds of close calls between airplanes and drones**.

Hobbyists flying their drones to capture photos or video of fires have caused firefighting efforts to slow down or even stop. *See IDS Cite 3*.

Consumer drones are also being used to invade people's privacy. *See IDS Cite 4* from the Santa Clara High Technology Law Journal, Volume 33 Issue 2 Article 3, 1-3-2017, **Drones and Privacy in the Golden State** by Brandon Gonzalez:

> The Federal Aviation Administration (FAA) has signaled that it does not intend to regulate issues unrelated to drone flight and safety. Therefore, issues such as privacy will be left to the states to regulate. As a result, lawmakers in California have scurried to find a legislative solution for the protection of its citizens' privacy from this potentially invasive technology. Currently, California's legal landscape is insufficient to meet the potential threat of drone technology as is pertains to personal privacy because drone technology could not

have been anticipated when many of California's traditional privacy protections came of age in the 1960s and 1970s.

Whatever laws California and other states may pass to protect people's privacy from drones, enforcing them will be another matter. It will be like enforcing the Telephone Solicitation Law. It essentially won't happen.

Besides, laws are for honest people. And while there do not appear to be instances of domestic terrorists using drones it is only a matter of time before they do.

The only real solution to dealing with miscreant drones is to destroy or disable them. The USAF would like the authority to do just that. *See IDS Cite 6:* **USAF Wants Authority To Down Drones After F-22 Near Miss**; Lara Seligman; *Aerospace Daily & Defense Report*; July 12, 2017.

[007] While consumer drones operate at a low altitude where they are sometimes within range of a good civilian firearm a shot that misses will continue on its ballistic trajectory and come down in a civilian area where it can cause death or injury to civilians or damage to civilian property.

A high power laser that misses will continue on where it could do damage. However, a shot from the ground is less likely to cause damage to people and objects on the ground. The primary danger is to piloted aircraft in the air. Also, the amount of laser power needed to blind or damage the sensors used in consumer drones is much less than the power needed to destroy or disable a real aircraft or a missile.

SUMMARY OF THE INVENTION

[008] In a first preferred embodiment a plurality of lasers are arranged in a circle where the power of each laser is below the atmospheric ionization threshold and where each laser is aimed to converge on a target using its own 2-axis mirror. An example of such a system uses 36 100kw lasers to produce a 3.6 Megawatt laser system. The system is mounted on a platform base that allows the elevation and azimuth of the laser system to be aimed at the target. A thermal imager can be used to provide the fine adjustment of the lasers since the point of convergence will ionize the atmosphere producing a very high temperature. As such it can be considered an adaptive optics system that corrects for atmospheric turbulence without requiring a separate guide laser. The point of convergence does not have to be on the target itself. For example, ionizing the atmosphere in the path of the target will create an atmospheric disturbance that may disrupt the aerodynamics of the target, especially a small target like a consumer drone.

When the system is operated in continuous mode (or in long bursts) the laser power will destroy or disable the target. When the system is used to produce a short high intensity pulse at or near the target the rapid ionization of the atmosphere will produce an electromagnetic pulse (EMP). This is done by either pulsing the lasers or by having the lasers rapidly converge to produce a pulse with a fast risetime. The pulse can be relatively short making it possible to operate the system at a low duty cycle. This allows the system to use a temporary energy storage system such as a capacitor bank or flywheel energy storage to reduce the demands on the system power source. This mode also reduces the cooling requirements for the lasers. When aimed at a ground target the EMP will penetrate the ground to disable a buried facility that has not been properly hardened against an EMP.

[009] In a second preferred embodiment the plurality of lasers are arranged in a line instead of a circle as in the first embodiment. Other arrangements of the lasers are possible as well.

[010] In a third preferred embodiment the first embodiment is augmented to reduce the chance that the laser strike will hit a friendly either directly or as the laser beams continue on their way after missing the target. This augmentation uses the GPS coordinates of the laser array and the GPS coordinates of all aircraft in the vicinity including consumer drones (friendly or not). When a friendly aircraft or drone is in the path of the proposed laser strike then the shot must not be taken. At the speeds of friendly aircraft and unfriendly consumer drones it will not be long before another targeting solution will present itself. In addition the Digital Terrain Elevation Database can be used so that shots will not be taken if the laser strike will hit terrain. This is useful in areas that are surrounded by mountains. This can also be augmented in areas with buildings or other structures by adding the buildings and other structures to the database. This also makes it possible to use the laser weapon that is not located directly on the ground. Because of the possibility of mountain terrain it is not sufficient that the laser array be at an altitude that is lower than the target’s altitude.

[011] In a fourth preferred embodiment the second embodiment is augmented as in the third embodiment.

[012] There is also the problem of detecting and locating consumer drones. Since the FAA (when authorized by Congress) can mandate safety standards for consumer drones it can require that consumer drones be equipped with a system similar to the current ADS-B system. However, it cannot be the same ADS-B system as it is currently constituted since the large number of consumer drones could overwhelm the system with the sheer number of transmissions.

Therefore it is proposed that a Drone ADS-B system use a different frequency and further, that the data rate be substantially increased to improve the accuracy of the system for verifying Drone ADS-B transmissions taught, for example, in U.S. Patent 9,465,104 **ADS-B Radar** by the current Applicant. *See IDS Cite 5*. This will make it easier for drones to detect and locate other drones as well as aircraft.

[013] To improve the chances of detecting a rogue consumer drone, infrared thermal imaging can be used to detect and locate drones at night. To detect and locate drones when the Sun is shining consumer drones can be mandated to have a minimum UV reflectivity so they can be detected and located with UV imaging. The UV reflectivity can occur simply because of the UV reflectivity of the materials used in the drone or a UV reflecting coating can be added. There may be times during daylight when the Sun is obscured by clouds so that drones can be detected and located by infrared thermal imaging during those times.

BRIEF DESCRIPTION OF THE DRAWINGS

[014] Figure 1A is a general illustration showing the side view of a laser module consisting of a laser, a mirror, and a 2-axis mirror positioner.

[015] Figure 1B is a general illustration showing the top view of a laser module and the mirror. The mirror positioner is below the mirror and is not shown.

[016] Figure 2A is a general illustration showing the top view of a laser platform containing four laser modules arranged in a circle.

[017] Figure 2B is a general illustration showing the laser platform in Figure 2A on a base to provide azimuth and elevation control of the laser platform.

[018] Figure 3 is a general illustration showing the system in Figure 2A with a thermal imager.

[019] Figure 4A is a general illustration showing the top view of a laser platform containing four laser modules and a thermal imager arranged in a line.

[020] Figure 4B is a general illustration showing the laser platform in Figure 4A on a base to provide azimuth and elevation control of the laser platform.

[021] Figure 5A is a general illustration showing the Laser Module Controller for the Laser Module.

[022] Figure 5B is a general illustration showing a plurality of Laser Module Controllers under the control of the Master Controller.

DETAILED DESCRIPTION

[023] In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, it is understood that the invention may be practiced without these specific details. In other instances well-known circuits, structures, and techniques have not been shown in detail in order not to obscure the invention.

[024] The first embodiment uses a plurality of lasers arranged in a circle where the power of each laser is below the atmospheric ionization threshold and where each laser is aimed to converge on a target using its own 2-axis mirror. Figure 1A is a side view showing Laser Module 101 consisting of Laser 102, Mirror 104, and 2-Axis Mirror Positioner 105. This produces the aimable Laser Beam 103. Figure 1B shows a top view of Laser Module 101. The 2-Axis Mirror Positioner is mostly behind Mirror 104 and for clarity is not shown. Laser Beam 103 is coming out of the page.

Figure 2A shows four Laser Modules (Laser Modules 202, 203, 204, and 205) mounted on Laser Platform 201 arranged in a circle in a top view. For clarity only four Laser Modules are being used here.

Figure 2B shows Laser Platform 201 mounted on Azimuth-Elevation Mount 206. This allows the array of Laser Modules (Laser Array) to point at Target 207. The mirrors in the Laser Modules (202, 203, 204, and 205) cause the laser beams to converge on Target 207.

Figure 3 shows the addition of Thermal Imager 302 to the system producing Laser Platform 301. Thermal Imager 302 is used to provide the fine adjustment of the lasers since the point of convergence will ionize the atmosphere producing a very high temperature. It also allows for the correct for atmospheric turbulence.

[025] The second embodiment uses a plurality of lasers arranged in a line where the power of each laser is below the atmospheric ionization threshold and where each laser is aimed to converge on a target using its own 2-axis mirror. Figure 4 shows four Laser Modules (Laser Modules 402, 403, 404, and 405) mounted on Laser Platform 401 arranged in a line in a top view. For clarity only four Laser Modules are being used here. Also shown is Thermal Imager 406 for providing the fine adjustment of the lasers as well as for allowing for corrections for atmospheric turbulence.

Figure 4B shows Laser Platform 401 mounted on Azimuth-Elevation Mount 406. This allows the array of Laser Modules (Laser Array) to point at Target 207. The mirrors in the Laser Modules (402, 403, 404, and 405) cause the laser beams to converge on Target 207. Figure 4B also shows Thermal Imager 406 in the system which is used to provide the fine adjustment of the lasers since the point of convergence will ionize the atmosphere producing a very high temperature. It also allows for the correct for atmospheric turbulence. Thermal Imager 406 can be omitted for some uses such as when the system is to be used for short distances only and when system calibration can be relied upon not to drift.

[026] In Figure 5A each Laser Module 101 has associated with it Laser Module Controller 501. Laser Module Controller 501 contains a Laser Power Supply and Controller for Laser 102 and a Controller for 2-Axis Positioner for 2-Axis Mirror Positioner 105.

[027] Figure 5B is the complete operating system for the first embodiment. Laser Module Controller 502 controls Laser Module 202, Laser Module Controller 503 controls Laser Module 203, Laser Module Controller 504 controls Laser Module 204, and Laser Module Controller 505 controls Laser Module 205. All are under the control of Master Controller 506. Master Controller 506 also controls Azimuth-Elevation Controller 512.

Master Controller 506 receives inputs from Drone ADS-B 511 system, standard ADS-B 510 system, the Digital Terrain Elevation Database 509, GPS 508 system, Thermal Imager 302, and Command Inputs 507. Command Inputs 507 include commands such as pointing at the target and firing the lasers. The lasers can be fired with a long duty cycle to destroy the target and/or a short pulse to create an EMP at or near the target. It is expected that Command Inputs 507 will be issued by a human operator either directly or indirectly such as when there are a plurality of Directed Energy Weapons using a Plurality of Lasers in a defense grid.

The second embodiment which uses a plurality of lasers arranged in a line instead of a circle uses a control system substantially the same as in Figure 5B.

[028] While preferred embodiments of the present invention have been shown, it is to be expressly understood that modifications and changes may be made thereto.

Claims

I Claim:

1. A directed energy weapon comprising two or more lasers where each one of said two or more lasers produces an amount of power less than that which will ionize the air and where the beams from said two or more lasers are aimed to converge at a target.

2. The directed energy weapon of claim 1 further comprising a thermal imager for providing the fine adjustment for converging said two or more lasers.

3. A method for producing a directed energy weapon comprising the steps of:

a. providing two or more lasers where each one of said two or more lasers produces an amount of power less than that which will ionize the air; and

b. aiming the beams from said two or more lasers to converge at a target.

4. The method of claim 3 further comprising the step of providing a thermal imager for providing the fine adjustment for converging said two or more lasers.

5. A method for reducing the chance that a directed energy weapon will hit a friendly either directly or as the beams from said directed energy weapon continue on their way after missing a target comprising the step of using the GPS coordinates of said directed energy weapon and the GPS coordinates of all aircraft in the vicinity and when a friendly aircraft is in the path of a proposed discharge of said directed energy weapon said proposed discharge is not performed.

6. The method of claim 5 further including the step of using the digital elevation database so that said proposed discharge of said directed energy weapon is not taken if it will hit terrain.

7. The method of claim 5 further including the step of using the data of the location of buildings and other structures so that said proposed discharge is not taken if it will hit said buildings and other structures.

ABSTRACT OF THE DISCLOSURE

A directed energy weapon using a laser at or near sea level has the problem that when the laser power is high enough to be useful the laser energy ionizes the atmosphere and defocuses the beam. The solution to this problem is to use a plurality of lasers preferably arranged either in a circle or in a line where the power of each laser is below the atmospheric ionization threshold and where the lasers are aimed to converge on the target. As an alternative the lasers can be configured to produce a short high intensity ionization pulse to produce an electromagnetic pulse at or near the target.