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(54) PHASE CONJUGATE RELAY MIRROR APPARATUS FOR HIGH ENERGY LASER SYSTEM AND METHOD

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(22) Filed: **Oct. 17, 2002**

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(51) **Int. Cl.**[7] **H01S 3/00**
(52) **U.S. Cl.** **359/333**; 359/338
(58) **Field of Search** 359/338, 333; 250/201.9

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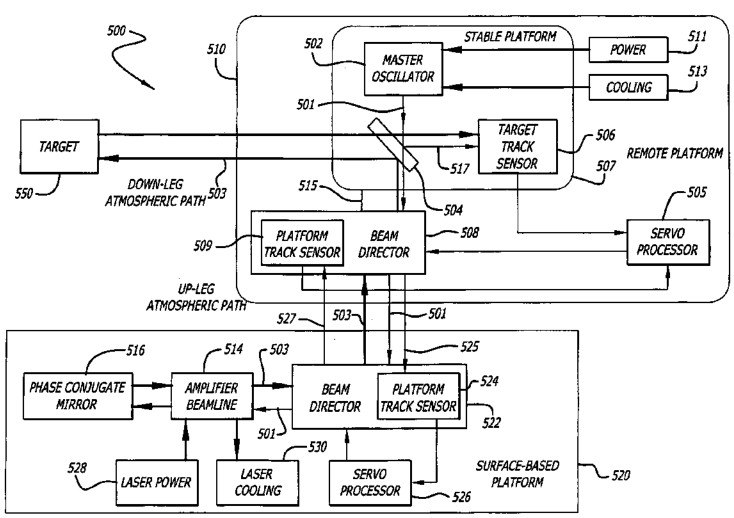
Primary Examiner—Mark Hellner
(74) *Attorney, Agent, or Firm*—John E. Guther; Leonard A. Alkov; Karl A. Vick

(57) **ABSTRACT**

A system for directing electromagnetic energy. The inventive system includes a first subsystem mounted on a first platform for transmitting a beam of the electromagnetic energy through a medium and a second subsystem mounted on a second platform for redirecting the beam. In accordance with the invention, the second platform is mobile relative to the first platform. In the illustrative embodiment, the beam is a high-energy laser beam. The first subsystem includes a phase conjugate mirror in optical alignment with a laser amplifier. The first subsystem further includes a beam director in optical alignment with the amplifier and a platform track sensor coupled thereto. In the illustrative embodiment, the second subsystem includes a co-aligned master oscillator, outcoupler, and target track sensor which are fixedly mounted to a stabilized platform, a beam director, and a platform track sensor. In the best mode, the stable platform is mounted for independent articulation relative to the beam director. A first alternative embodiment of the second subsystem includes first and second beam directors. The first beam director is adapted to receive the transmitted beam and the second beam director is adapted to redirect the received beam. In accordance with a second alternative embodiment, an optical fiber is provided for coupling the beam between the first platform and the second platform.

23 Claims, 7 Drawing Sheets



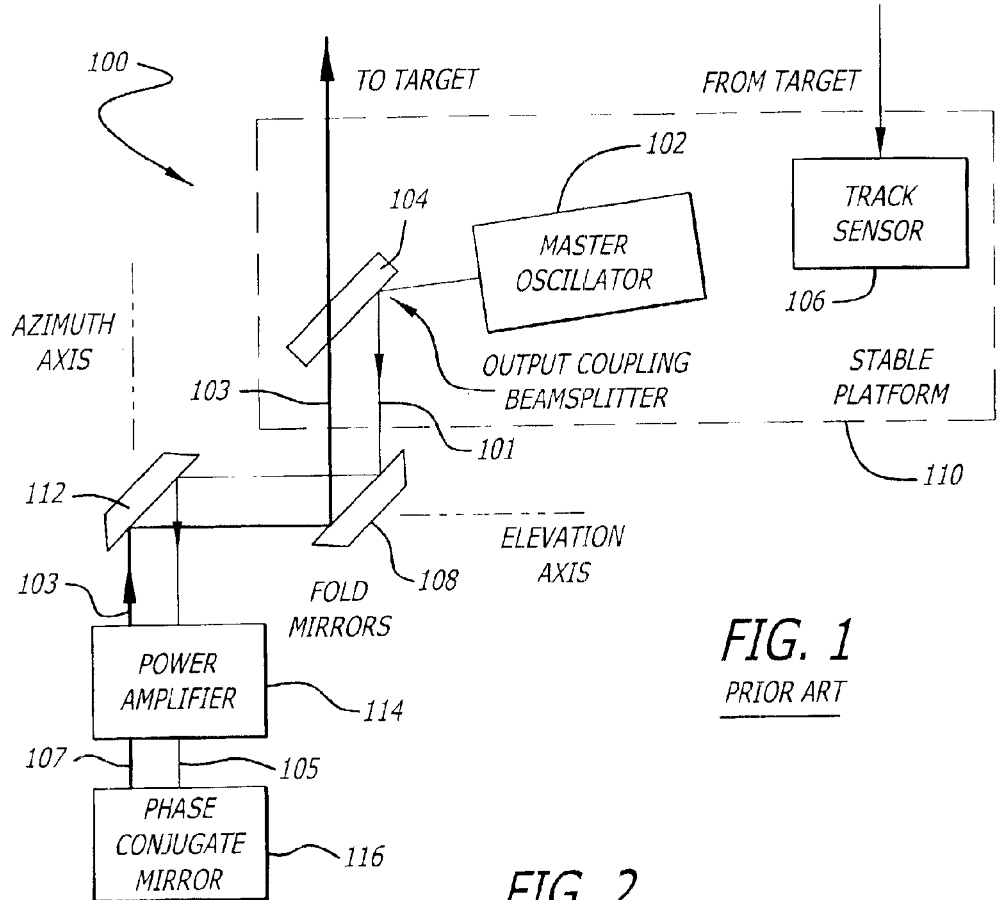
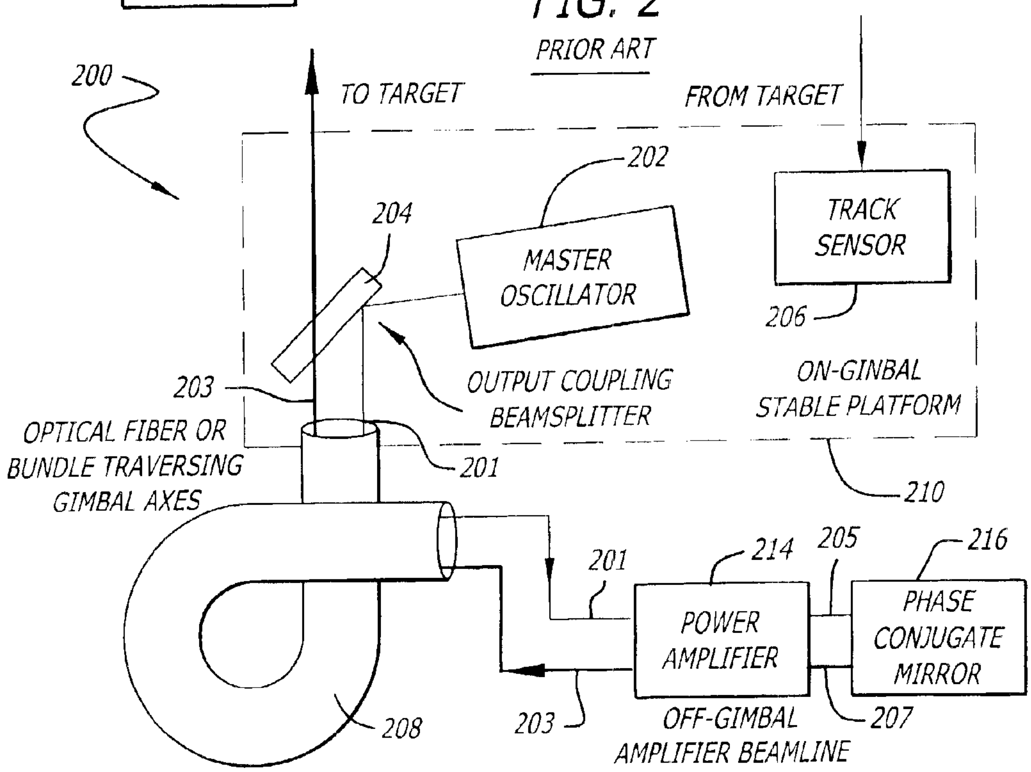


FIG. 1
PRIOR ART

FIG. 2
PRIOR ART



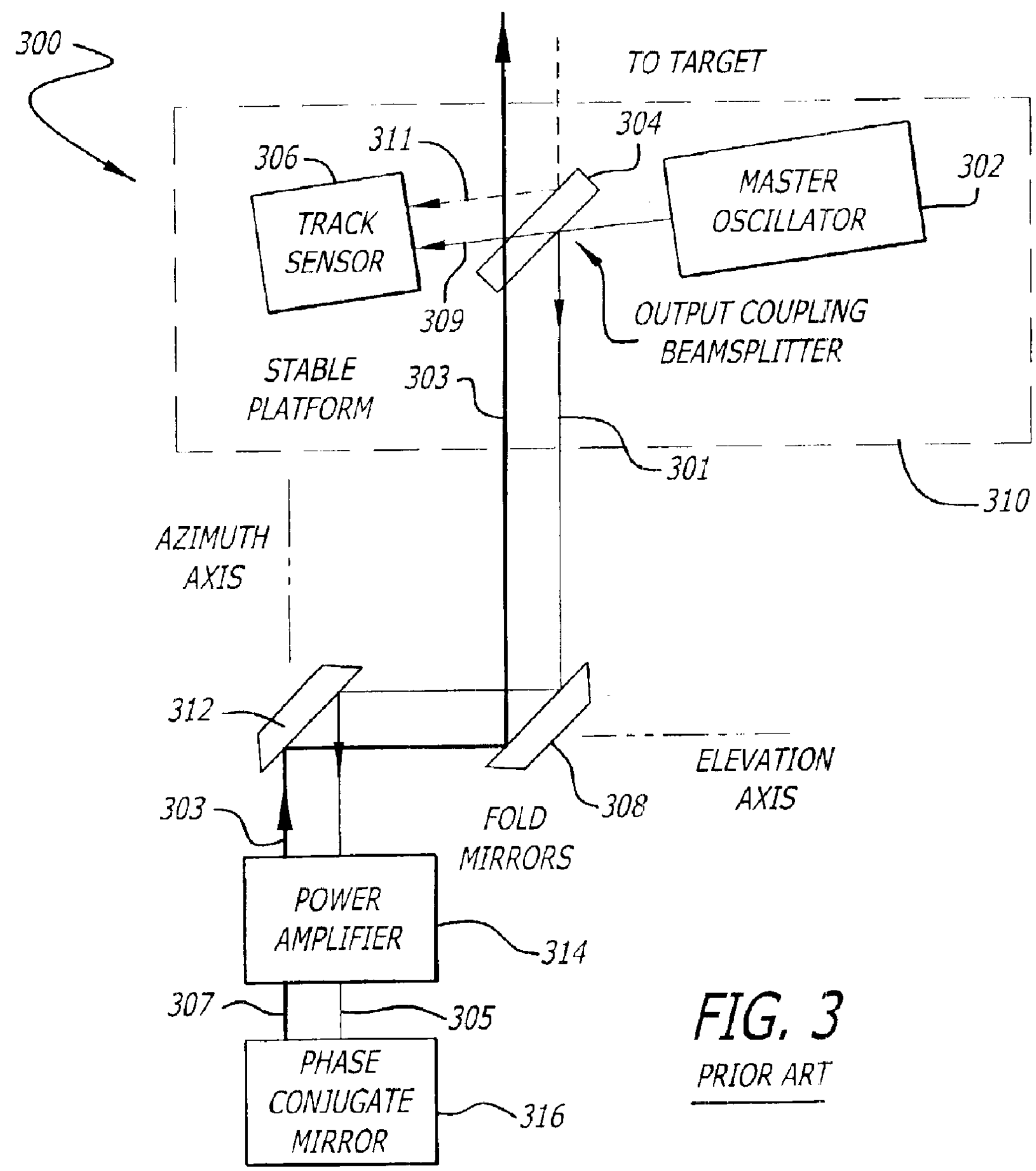
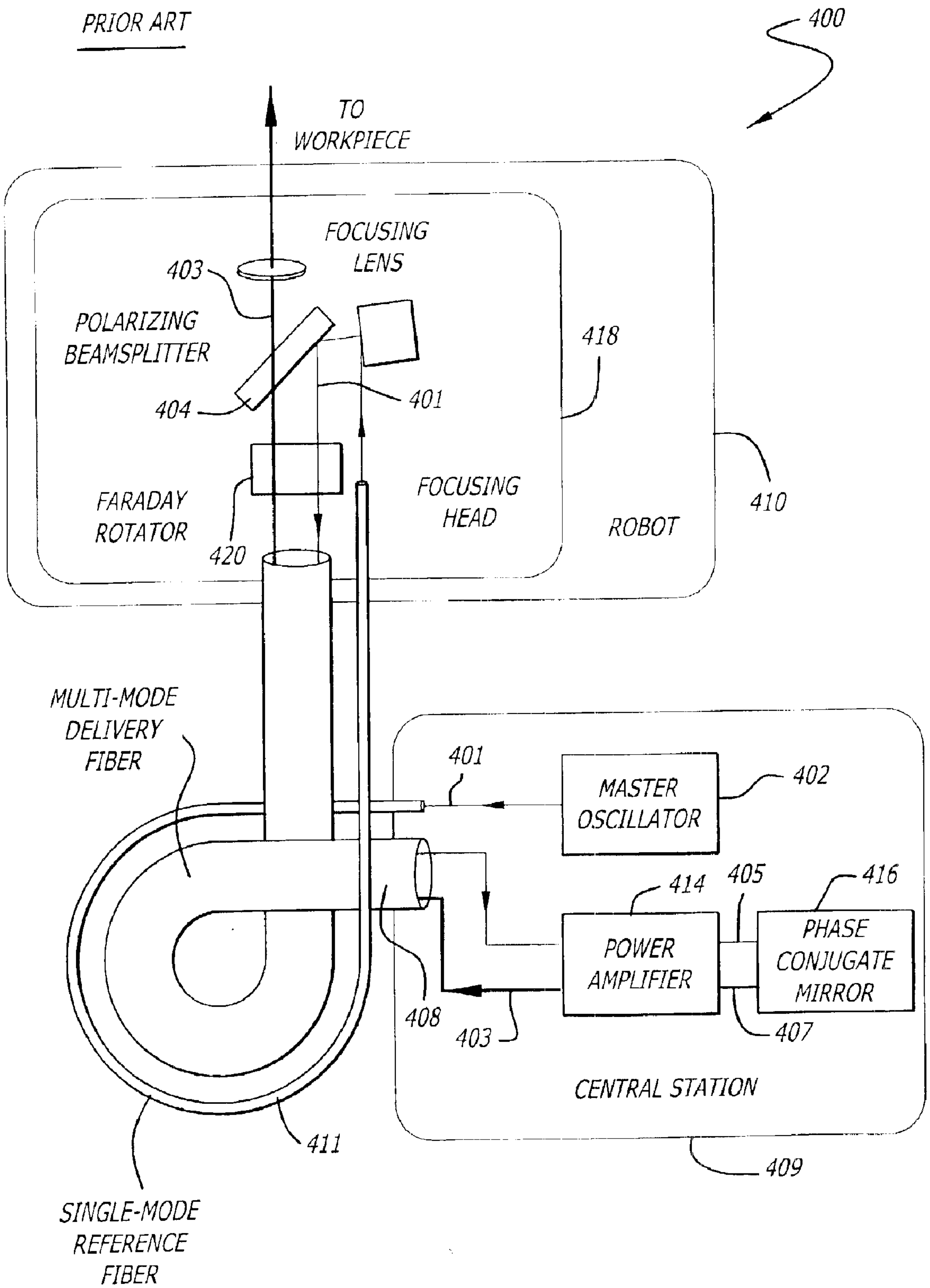


FIG. 3
PRIOR ART

FIG. 4

PRIOR ART



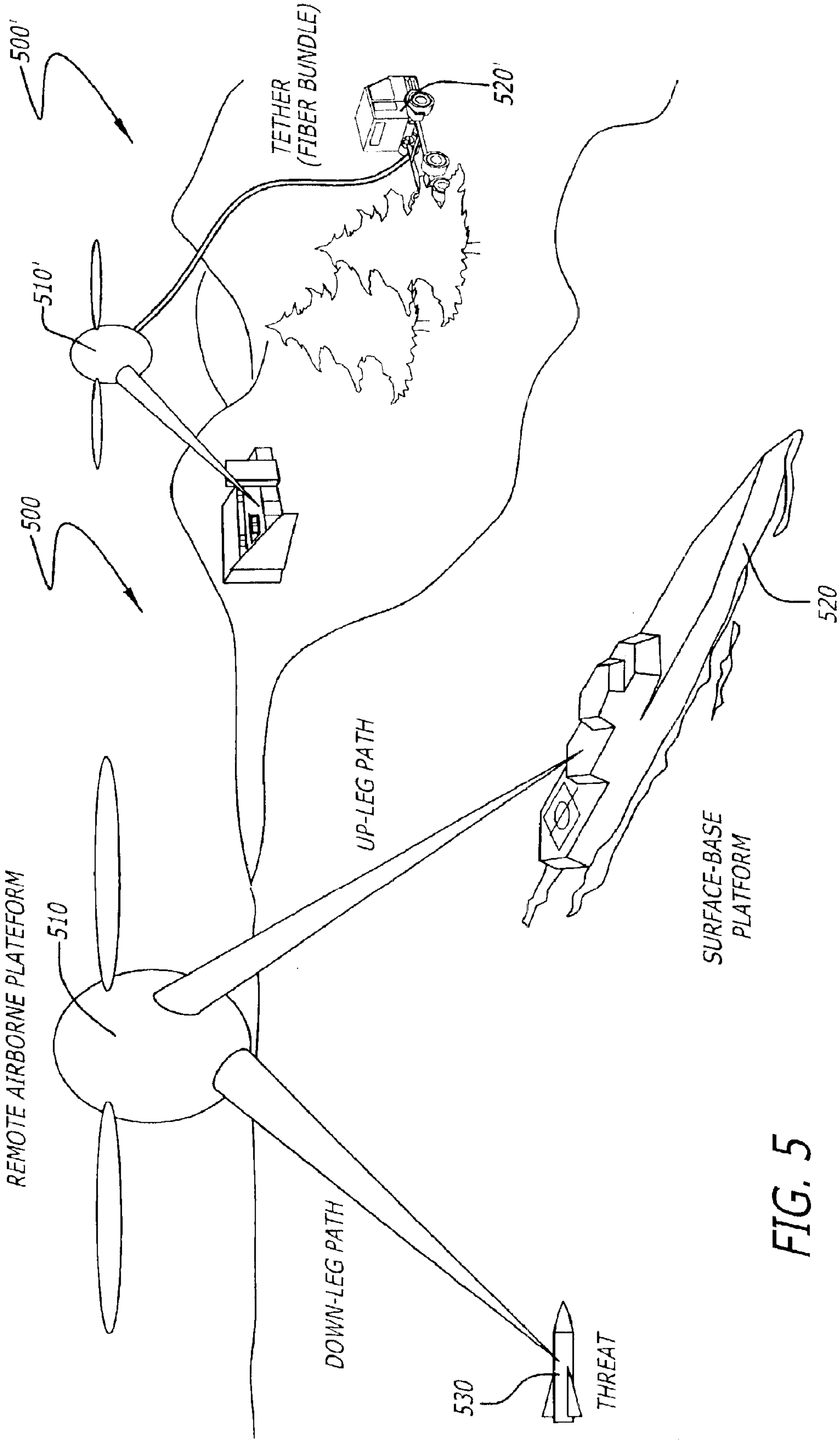

500'
TETHER
(FIBER BUNDLE)
520'
510'
500
520
REMOTE AIRBORNE PLATEFORM
510
UP-LEG PATH
SURFACE-BASE
PLATFORM
DOWN-LEG PATH
THREAT
530

FIG. 5

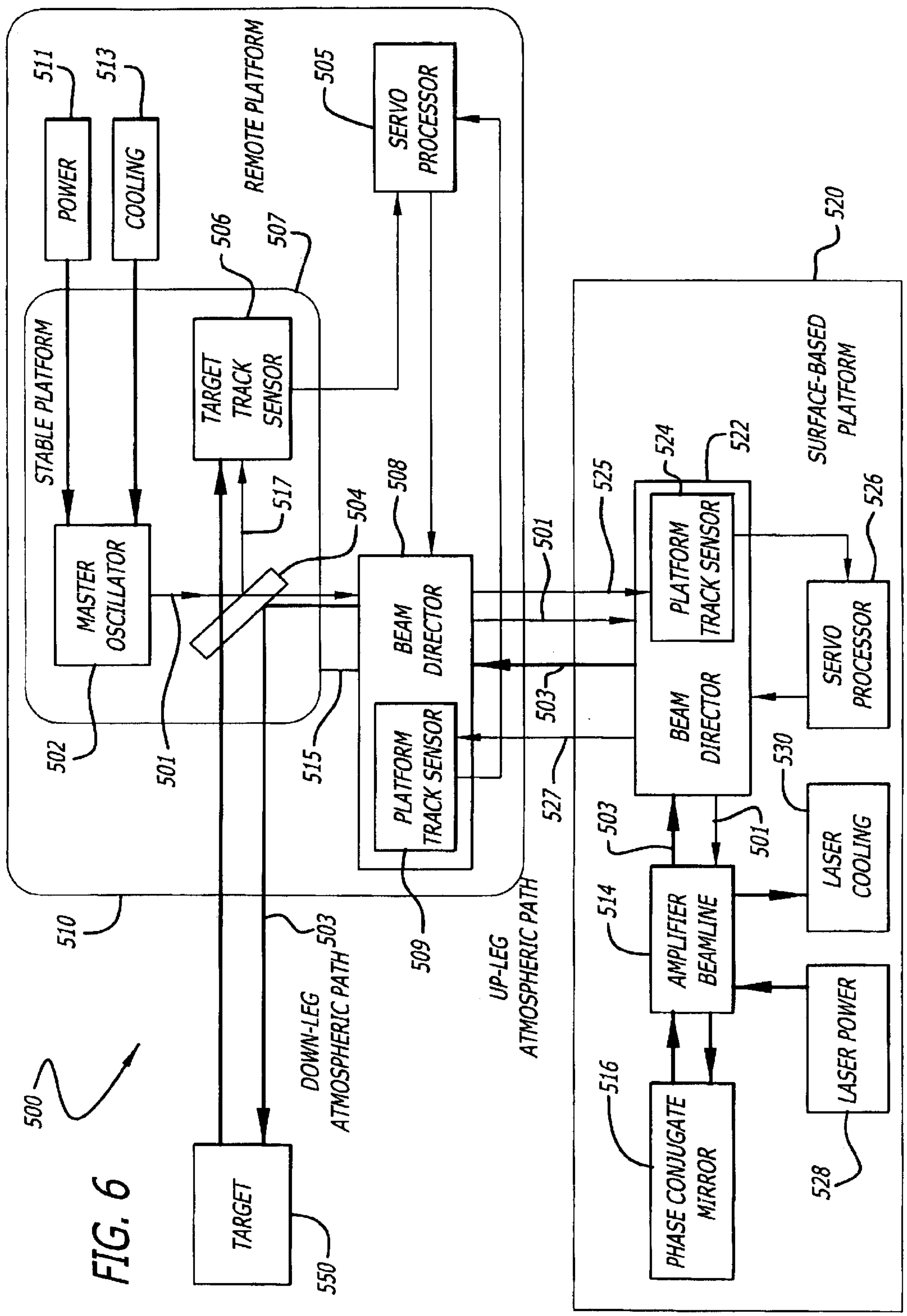

500
REMOTE PLATFORM
510
POWER
511
COOLING
513
SERVO PROCESSOR
505
STABLE PLATFORM
507
TARGET TRACK SENSOR
506
MASTER OSCILLATOR
502
501
504
517
BEAM DIRECTOR
508
PLATFORM TRACK SENSOR
509
515
503
501
525
503
527
UP-LEG ATMOSPHERIC PATH
DOWN-LEG ATMOSPHERIC PATH
TARGET
550
SURFACE-BASED PLATFORM
520
PLATFORM TRACK SENSOR
524
522
BEAM DIRECTOR
SERVO PROCESSOR
526
LASER COOLING
530
AMPLIFIER BEAMLINE
514
503
501
LASER POWER
528
PHASE CONJUGATE MIRROR
516

FIG. 6

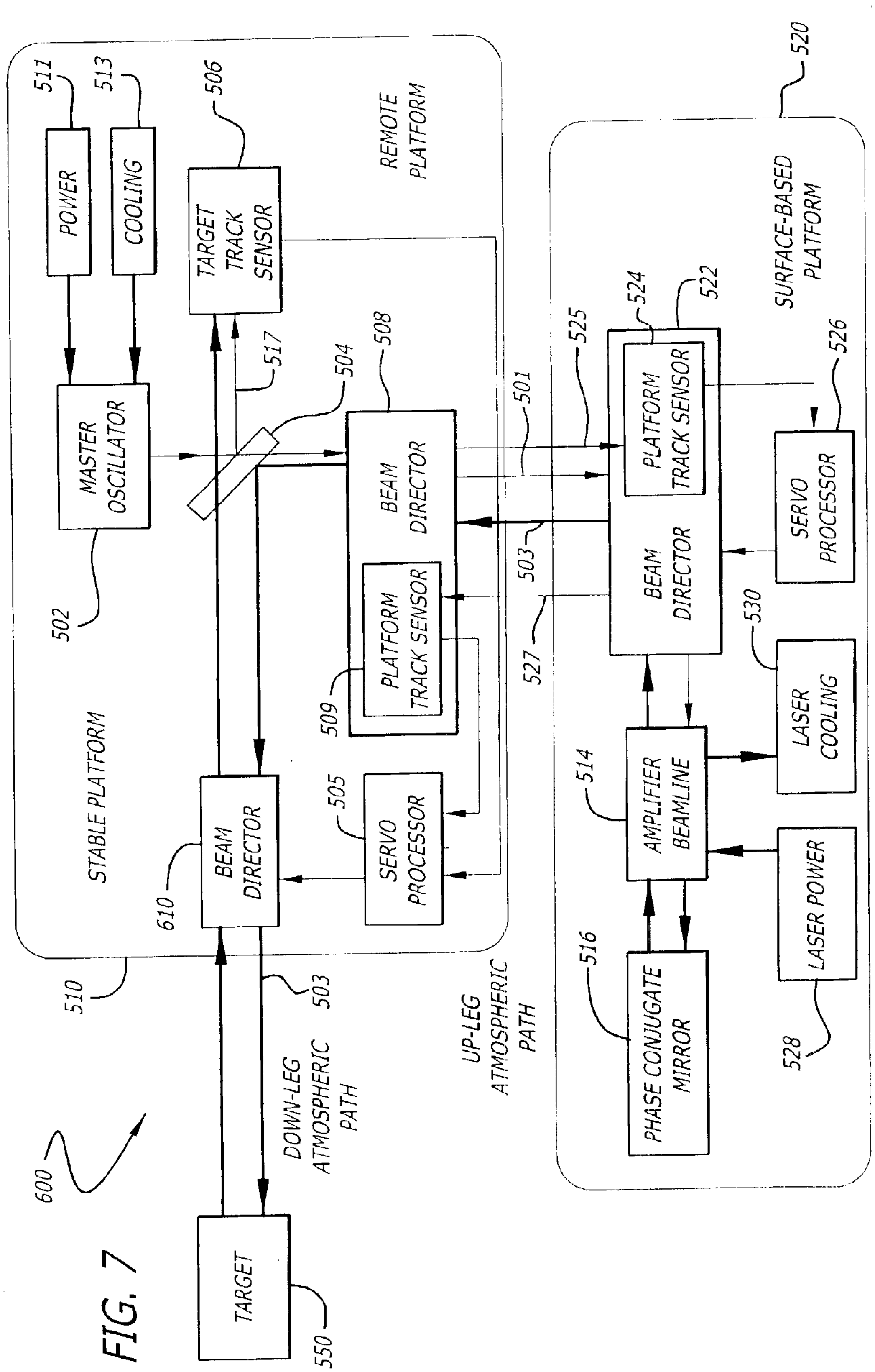

POWER
COOLING
TARGET TRACK SENSOR
REMOTE PLATFORM
MASTER OSCILLATOR
BEAM DIRECTOR
PLATFORM TRACK SENSOR
STABLE PLATFORM
BEAM DIRECTOR
SERVO PROCESSOR
SURFACE-BASED PLATFORM
PLATFORM TRACK SENSOR
SERVO PROCESSOR
BEAM DIRECTOR
LASER COOLING
AMPLIFIER BEAMLINE
LASER POWER
PHASE CONJUGATE MIRROR
UP-LEG ATMOSPHERIC PATH
DOWN-LEG ATMOSPHERIC PATH
TARGET
511
513
506
517
504
508
501
525
524
522
520
526
502
503
527
509
530
505
514
610
510
503
516
528
600
550

FIG. 7

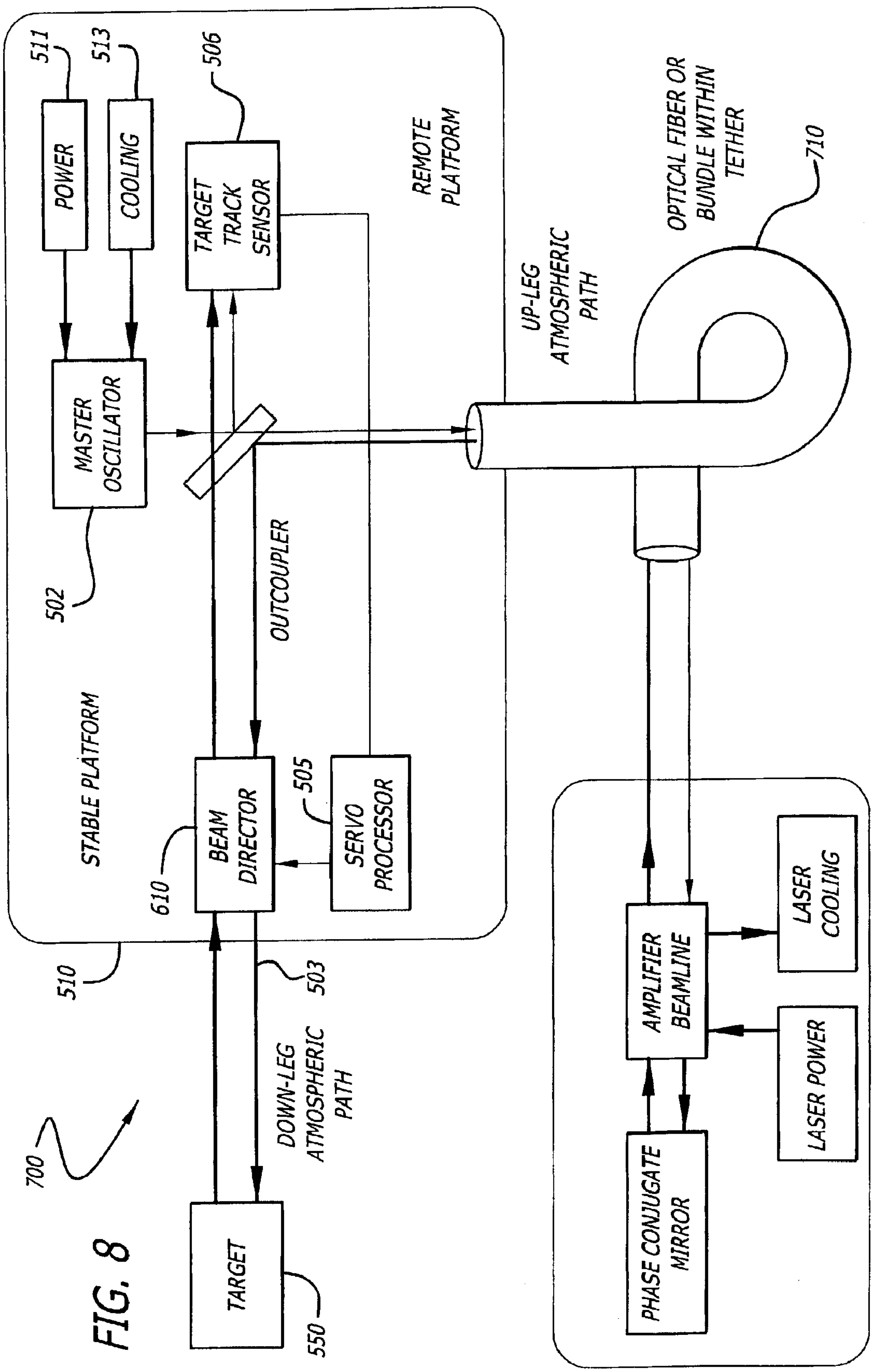

700
POWER
511
COOLING
513
TARGET TRACK SENSOR
506
REMOTE PLATFORM
MASTER OSCILLATOR
502
OUTCOUPLER
STABLE PLATFORM
BEAM DIRECTOR
610
505
SERVO PROCESSOR
510
503
DOWN-LEG ATMOSPHERIC PATH
TARGET
550
UP-LEG ATMOSPHERIC PATH
OPTICAL FIBER OR BUNDLE WITHIN TETHER
710
AMPLIFIER BEAMLINE
LASER COOLING
LASER POWER
PHASE CONJUGATE MIRROR

FIG. 8

PHASE CONJUGATE RELAY MIRROR APPARATUS FOR HIGH ENERGY LASER SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to systems and methods for directing electromagnetic energy. More specifically, the present invention relates to high-energy lasers and optical arrangements therefor.

2. Description of the Related Art

High-energy lasers are currently being used for, numerous military applications including point and area defense along with numerous offensive roles. Unfortunately, high-energy laser systems are typically expensive, heavy and quite large. These systems typically consume a large amount of prime power and present a high thermal load to a host platform.

When used for surface ship self protection, a high-energy laser would suffer from atmospheric absorption, scattering and turbulence. For this application, incoming threats are attacked head-on, creating a targeting challenge and attacking the threat where it is least vulnerable. In addition, high-energy lasers located at the deck level of a ship have a limited visible horizon and therefore provide a somewhat limited 'keep out' distance.

Airborne platforms with high-energy lasers are conventionally somewhat vulnerable and expensive and may place an air crew in harm's way.

Thus, a need exists in the art for an inexpensive, lightweight system or method for deploying a high-energy laser with minimal exposure of the warfighter.

SUMMARY OF THE INVENTION

The need in the art is addressed by the system for directing electromagnetic energy of the present invention. The invention addresses the problem of placing a large, high power consumption, high thermal load high-energy laser (HEL) system on an airborne platform. For surface ship self protection, an airborne platform is advantageous for several reasons: (1) it provides a better atmospheric transmission path (lower absorption, lower scattering, less turbulence); (2) it allows threats such as anti-ship cruise missiles to be attacked from the side where they are more vulnerable; and (3) it provides a longer keep-out distance due to the longer visible horizon. For ground attack, an airborne platform provides a large engagement zone and can operate behind enemy lines. Manned aircraft, however, put the air crew in harm's way. Large manned platforms and Unmanned Combat Air Vehicles (UCAV) required to carry a full HEL system payload are more vulnerable and less expendable than smaller unmanned airborne vehicles (UAVs), which are typically used as sensor platforms. The problem is to achieve a HEL self defense or ground attack capability from a small, inexpensive remotely piloted vehicle (RPV) platform.

The inventive system includes a first subsystem mounted on a first platform for transmitting a beam of the electromagnetic energy through a medium and a second subsystem mounted on a second platform for redirecting the beam. In accordance with the invention, the second platform may be mobile relative to the first platform.

In the illustrative embodiment, the beam is a high-energy laser (HEL) beam. The first subsystem includes a phase conjugate mirror in optical alignment with a laser amplifier. The first subsystem further includes a beam director in

optical alignment with the amplifier and a platform track sensor coupled thereto. In the illustrative embodiment, the second subsystem includes a co-aligned laser master oscillator, target track sensor, and outcoupler arrangement fixedly mounted to a stabilized platform; a beam director: and a platform track sensor. In the best mode, the stabilized platform is mounted on the inner gimbal of the beam director such that the line of sight from the beam director portion of the first subsystem can be articulated to coincide with the target. The function of the second subsystem is similar to that of an orbiting relay mirror as described in the Tom Clancy novel *The Cardinal of the Kremlin*, pp. 43 and 147, Berkley Books (paperback), 1988 and by Friedman, et al in *Advanced Technology Warfare*, pp. 84–85, Harmony Books, New York, 1985.

A first alternative embodiment of the second subsystem includes first and second beam directors. The first beam director is adapted to receive the transmitted beam and the second beam director is adapted to redirect the received beam. In this embodiment, the laser master oscillator, target track sensor, outcoupler and both beam directors are fixedly mounted to the first platform.

In accordance with a second alternative embodiment, an optical fiber is provided for coupling the beam between the first platform and the second platform.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing a self-aligning phase conjugate laser concept implemented in accordance with conventional teachings.

FIG. **2** is an alternate embodiment of the self-aligning phase conjugate laser concept illustrated in FIG. **1**.

FIG. **3** is a block diagram showing an auto-boresight technique for the self-aligning phase conjugate laser implemented in accordance with conventional teachings.

FIG. **4** shows a fiber beam cleanup scheme implemented in accordance with conventional teachings.

FIG. **5** is an operational diagram illustrating two applications of the teachings of the present invention.

FIG. **6** is a block diagram showing an illustrative implementation of a phase conjugate relay mirror system implemented in accordance with the teachings of the present invention.

FIG. **7** shows an alternate embodiment of the invention, in which the master oscillator, target track sensor, and outcoupler are mounted directly on the remote platform, rather that on a stabilized platform that is articulated relative to the beam director.

FIG. **8** shows a second alternate embodiment of the invention.

DESCRIPTION OF THE INVENTION

Illustrative embodiments and exemplary applications will now be described with reference to the accompanying drawings to disclose the advantageous teachings of the present invention.

While the present invention is described herein with reference to illustrative embodiments for particular applications, it should be understood that the invention is not limited thereto. Those having ordinary skill in the art and access to the teachings provided herein will recognize additional modifications, applications, and embodiments within the scope thereof and additional fields in which the present invention would be of significant utility.

The teachings of the present invention are best appreciated with a brief review of certain prior teachings.

FIG. **1** is a block diagram showing a self-aligning phase conjugate laser concept disclosed by Byren and Rockwell in the early 1980s (U.S. Pat. Nos. 4,812,639 and 4,853,528) the teachings of which are incorporated herein by reference. This concept is based on the phase conjugate master oscillator/power amplifier (PC MOPA) approach disclosed in numerous predecessor patents, e.g., Bruesselbach in U.S. Pat. No. 4,734,911 entitled "Efficient Phase Conjugate Laser" the teachings of which are incorporated herein by reference.

In the embodiment of FIG. **1**, a small master oscillator **102** is located on the innermost gimbal (or stabilized platform) **110** of a high power laser pointing and tracking system **100**. A phase conjugate laser amplifier **114** is located off gimbal. An output coupling beamsplitter or "outcoupler" **104** is used (1) to insert a beam **101** from a master oscillator **102** into a phase conjugate leg, defined between the outcoupler **104** and a phase conjugate mirror **116** and (2) to extract the high power beam **103** out of the phase conjugate leg after amplification.

An optional second harmonic generation (SHG) crystal is also described in this patent and the predecessors, which advantageously converts the laser wavelength for certain in-band anti-sensor applications while preserving high beam quality at the converted wavelength.

Several methods of outcoupling may be used depending on the application, dichroic (for the SGH option), polarization beamsplitting (as in Bruesselbach), interferometric/polarization (as in Rockwell, U.S. Pat. No. 5,483,342 entitled "Polarization Rotator with Frequency Shifting Phase Conjugate Mirror and Simplified Interferometric Outcoupler"), and interferometric (as in O'Meara, U.S. Pat. No. 5,126,876 entitled "Master Oscillator Power Amplifier with Interference isolated Oscillator"). The teachings of these references are incorporated herein by reference as well.

The master oscillator **102** is aligned with reference to the optical line-of-sight of a target track sensor **106** such that, after reflection off the outcoupler optic **104**, the oscillator beam **101** travels along the common track sensor line-of-sight but in a direction opposite the target. The oscillator beam is then routed along a Coudé path through the coarse gimbals to a location off-gimbal where it passes through the laser power amplifier beamline **114** and into the phase conjugate mirror **116**.

At this point the beam **105** has been distorted by thermal lensing, wedging, and stress birefringence within the power amplifier, and its line-of sight has been deviated by thermal and structural compliance of the gimbals and optical bench, wobble (or runout) in the gimbal bearings, gimbal axis non-orthogonality, and base motion coupled into the gimbals through bearing friction/stiction and cable spring forces.

The phase conjugate mirror **116** reverses the wavefront of the amplified beam **105** upon reflection, producing a phase conjugate return beam **107** that self-compensates for all of the aforementioned optical aberrations and gimbal line-of-sight errors as it retraces the path through the distorting elements. The high power beam **103** that emerges through the outcoupler **104** is therefore aligned with the injected oscillator beam **101** and is pointed in precisely the same direction as the track sensor **106** line-of-sight. The laser system **100** is thereby able to accurately engage targets simply by pointing the tracker to the aimpoint. This approach obviates the need for precision active auto-alignment systems used previously to compensate line-of-sight errors in the gimbal and provides alignment correction automatically and with the high bandwidth of the phase conjugate mirror.

FIG. **2** is an alternate embodiment of the self-aligning phase conjugate laser concept illustrated in FIG. **1**. In this embodiment, the optical path through the gimbal trunions is implemented with a large core optical fiber or bundle of optical fibers **208**. Again, a phase conjugate mirror **216** corrects all of the phase distortions and depolarization between the outcoupler **204** and phase conjugate mirror **216**, which now includes the fiber **208**. As in the first embodiment, the high power beam **203** that emerges remains aligned to the injected oscillator beam without the need for complex auto-alignment systems.

FIG. **3** is a block diagram showing an auto-boresight technique for the self-aligning phase conjugate laser, disclosed by Byren in U.S. Pat. No. 4,798,462. In this reference, the tracker is oriented to view the target by reflection off the same outcoupler device used in the self-aligning phase conjugate laser described above. A portion **309** of the master oscillator beam **301** is allowed to leak through the outcoupler **304** in order to provide a fudicial reference for the laser line of sight. This fudicial reference is sensed by the tracker (which must operate in-band to the laser) and is used as the boresight reference (or crosshairs) for tracking the target. Due to the reflection symmetry at the outcoupler **304**, when the target aimpoint line of sight **311** is aligned with the oscillator beam fudicial reference, the high power beam **303** will hit the target aimpoint. With this approach, boresight errors associated with the oscillator, outcoupler, and tracker are automatically corrected.

FIG. **4** shows a fiber beam cleanup scheme disclosed by Rockwell and Bartelt in U.S. Pat. No. 5,208,699, entitled "Compensated, SBS-free Optical Beam Amplification and Delivery Apparatus and Method," the teachings of which are incorporated by reference herein. This system **400** may be used in a robotic industrial laser application in which a central station **409**, containing a laser master oscillator **402**, laser power amplifier **414**, and phase conjugate mirror **416**, delivers laser energy over a pair of optical delivery fibers **408** and **411** to the focusing head **418** of an industrial robot **410**. The low power, high quality master oscillator beam **401** is delivered to the focusing head **418** through a low-power, single-mode, polarization-preserving optical fiber **411**. This "reference" beam **401** is then reflected by a polarizing beamsplitter (outcoupler) **404** and the polarization is rotated by a non-reciprocal polarizing element, such as a Faraday rotator **420**, having the property that after two opposite passes through the element, the polarization is rotated 90 degrees. The low power beam **401** is then coupled into a large multi-mode delivery fiber **408** and delivered back to the central station **409**, where it is amplified on a first pass through the amplifier beamline **414**. At this point the beam **405** is highly aberrated and depolarized due to optical phase distortions in the delivery fiber and power amplifiers. The beam **405** is then reflected by a vector phase conjugate mirror **416** that returns the phase conjugate of the incident wavefront with all polarization states remaining in the same phase relationship. The phase conjugated beam **407** then retraces its path to the focusing head **418**, correcting for the optical distortions along the path. The amplified and corrected beam **403** then passes the non-reciprocal rotator and is outcoupled through the polarizing beamsplitter, emerging with essentially the same high beam quality as the reference beam **401** from the master oscillator **402**.

The advantage of this scheme is that the high brightness laser beam can now be focused to a small spot on the workpiece, while simultaneously providing a deep focal region and long working distance. The simultaneous provision of a small focused beam size, deep focal region, and long working distance are advantageous for robotic metal cutting applications where narrow kerf width, long standoff distances, and relaxed proximity tolerances enable faster cutting speeds, simplify programming of robotic motion, and reduce debris back-spatter on focusing lenses.

FIG. **5** is an operational diagram illustrating two applications of the teachings of the present invention. The application illustrated on the left side of the figure is one in which several elements of a high-energy laser such as a master oscillator (MO), a tracker, and outcoupler (none of which are shown in FIG. **5**) are integrated on a free-flying, unmanned platform **510** and a phase conjugate amplifier (not shown) is located on a second platform **520**, e.g., a surface ship. This embodiment allows the HEL system **500** to engage anti-ship threats, such as sea-skimming cruise missiles **530**, from above where the detection and engagement ranges are longer, the atmospheric turbulence and scattering is less, and the target is more vulnerable (side aspect).

An alternative application **500**' is depicted in the right of the figure. Here, the remote elements are integrated on a tethered un-manned rotocraft platform **510**' and the phase conjugate amplifier is located on a second platform **520**', in this case a combat vehicle such as a High Mobility Multi-Wheeled Vehicle (HMMWV). This embodiment allows the HMMWV to engage air and ground targets while protected by terrain features and provides a much larger field of engagement than afforded by a ground-based system. The tether may carry a fiber optic cable or bundle, which provides a flexible optical path between the remote airborne platform and surface-based platform.

FIG. **6** is a block diagram showing an illustrative implementation of a phase conjugate relay mirror system implemented in accordance with the teachings of the present invention. In accordance with the present teachings, a lightweight and inexpensive relay mirror arrangement is located on a remote platform to redirect a high power electromagnetic (e.g. HEL) beam originating from a surface-based platform. While the invention is utilized in connection with a surface-based platform, those skilled in the art will appreciate that the invention is not limited thereto. The present teachings may be utilized with one or more platforms that are not located on a surface of a body without departing from the scope of the present teachings. As shown FIG. **6**, in an illustrative embodiment of the invention, the system **500** includes a master oscillator (MO) **502**, an outcoupler **504**, and a target track sensor **506** mounted on a remote platform **510**. The remote platform **510** may be an unmanned aerial vehicle (UAV), tethered rotocraft or aerostat, elevated boom attached to a surface vehicle, elevated mast portion of a surface ship, space vehicle, or any other suitable manned or unmanned structure, articulating member, or craft without departing from the scope of the present teachings. The master oscillator **502**, outcoupler **504** and target track sensor **506** are located on a stable platform **507**. A conventional power supply **511** and cooling unit **513** are provided for the master oscillator **502** off the stable platform **507**. The system **500** further includes a first beam director **508** located on the remote platform **510**. A platform track sensor **509** is located on the beam director **508**. The stable platform **507** is articulated relative to the body axes of the remote platform **510** by the beam director **508** through a mechanical linkage **515**. The stable platform **507** is pointed in the direction of a target **550** by the beam director **508** under the control of a conventional servo processor **505** which receives angular error signal inputs from the target track sensor **506** and the platform track sensor **509**. The beam director **508** therefore serves to orient the stable platform **507** such that the target track sensor's (**506**) line-of-sight (LOS) is pointed precisely toward the target aimpoint.

The beam director **508** also functions to coarsely point the LOS of the master oscillator beam **501** toward the surface-based platform **520** by means of a first platform track sensor **509** located on. The target track sensor **506**, master oscillator **502**, and outcoupler **504** are configured and aligned such that the master oscillator beam **501**, after reflecting off the outcoupler **504**, is co-aligned with the target track sensor line-of-sight (LOS). In this configuration, when the target track sensor LOS is pointed at the target aimpoint, a HEL beam **503** that is propagating opposite the direction of the master oscillator beam **501** will, upon reflection off the outcoupler **504**, be directed to the target aimpoint.

A second beam director **522** is located on the surface-based platform **520**. The second beam director **522** coarsely points the LOS of a phase conjugate amplifier beamline, consisting of a series of laser power amplifiers (amplifier beamline) **514** and a phase conjugate mirror **516**, toward the remote platform **510** under the control of a conventional servo processor **526** with input from a second platform track sensor **524**. The phase conjugate mirror **516**, ensures that the amplified HEL beam **503**, after double-passing the up-leg atmospheric path, the optics within the two beam directors, and the amplifier beamline, will propagate opposite the direction of the master oscillator beam **501**, thus satisfying the alignment condition described above.

The platform track sensors **509**, **524** may use passive optical means to track the up-leg apertures of the surface-based platform **520** and remote platform **510**, respectively; or may use active optical tracking means with the aid of additional optical alignment beams **525**, **527** located on the beam directors **508**, **522**.

A conventional power supply **528** and a cooling unit **530** are provided for the amplifier beamline **514**.

The embodiment of FIG. **6** may make use of the tracker auto-boresight approach described in Byren in above referenced U.S. Pat. No. 4,798,462 by using a portion **517** of the master oscillator beam **501** as the fudicial boresight reference. If the master oscillator **502** operating wavelength is not within the target track sensor's passband, a separate alignment beam that is within said passband may be integrated within the master oscillator **502** and serve the function of the boresight reference. This allows the master oscillator **502** to be removed and replaced with minimal optical alignment and also enhances alignment retention, particularly if the boresight source and master oscillator **502** share a common pre-expanding telescope.

This is believed to be the first application of nonlinear optical phase conjugation for correcting the up-leg path of a relay mirror HEL delivery system. It extends the self-aligning phase conjugate mirror concept disclosed by Byren and Rockwell in the above-referenced U.S. Pat. Nos. 4,798,462; 4,812,639; and 4,853,528, the teachings of which have been incorporated herein by reference, by including the surface-based amplifier beamline, up-leg atmospheric path, and relay mirror pointing within the compensated path of a phase conjugate mirror.

FIG. **7** shows an alternate embodiment of the invention, in which the master oscillator, target track sensor, and outcoupler are mounted directly on the remote platform, rather that on a stabilized platform that is articulated relative to the beam director. This embodiment may be advantageous for some applications requiring master oscillator and/or target track sensor components that are large and heavy and therefore inconvenient to mount on-gimbal. In this embodiment, a second beam director **610** is used to direct the line-of-sight of the target track sensor and HEL beam to the target.

FIG. **8** shows a second alternate embodiment of the invention. In the embodiment of FIG. **8**, an optical fiber **710** or bundle of optical fibers is used to guide the lines of sight of the master oscillator and high power beams across the up-leg atmospheric path. This embodiment eliminates the need for the platform track sensors and associated beam directors to perform coarse line-of-sight control over the up-leg atmospheric path. This is similar to the scheme disclosed by Rockwell and Bartelt in U.S. Pat. No. 5,208,699, the teachings of which have been incorporated herein by reference. However, this embodiment includes the fiber cable as part of the remote vehicle tether, a feature not shown, disclosed, nor anticipated by Rockwell and Bartelt.

The line-of-sight control, high-power optics, optical imaging, tracking, lasing, power generation, and cooling components and software as well as the HEL pointing and tracking techniques used in this invention, and illustrated in the above-referenced embodiments, may be a conventional design and construction.

Thus, the present invention has been described herein with reference to a particular embodiment for a particular application. Those having ordinary skill in the art and access to the present teachings will recognize additional modifications, applications and embodiments within the scope thereof.

It is therefore intended by the appended claims to cover any and all such applications, modifications and embodiments within the scope of the present invention.

Accordingly,

What is claimed is:

1. A system for directing electromagnetic energy comprising:

a master oscillator for generating a beam of electromagnetic energy;

first means for amplifying said beam of electromagnetic energy to form an amplified beam;

second means for redirecting said amplified beam; and

third means for correcting aberrations in said amplified beam introduced by said first means,

wherein said first means is mounted on a first platform, and said master oscillator and said second means are mounted on a second platform, said second platform being mobile relative to said first platform.

2. The invention of claim **1** wherein said second means includes a relay mirror arrangement.

3. The invention of claim **2** wherein said second means includes a beam director.

4. The invention of claim **3** wherein said second means includes a platform track sensor.

5. The invention of claim **4** wherein said second means includes an outcoupler.

6. The invention of claim **5** wherein said beam director and said outcoupler are mounted for mutually independent articulation.

7. The invention of claim **5** wherein said relay mirror is integral with said outcoupler.

8. The invention of claim **1** wherein said second means includes first and second beam directors, said first beam director being adapted to receive said amplified beam and said second beam director being adapted to redirect said amplified beam.

9. The invention of claim **1** wherein said beam of electromagnetic energy is a laser beam and said first means includes a high-energy laser amplifier.

10. The invention of claim **9** wherein said third means includes a phase conjugate mirror in optical alignment with said laser amplifier.

11. The invention of claim **10** wherein said first means includes a beam director in optical alignment with said laser amplifier.

12. The invention of claim **11** wherein said first means further includes a platform track sensor.

13. The invention of claim **1** further including an optical fiber for coupling said amplified beam between said first platform and said second platform.

14. A system for directing electromagnetic energy comprising:

a master oscillator for generating a laser beam;

first means for amplifying said laser beam to form an amplified laser beam, said first means including:

a high-energy laser amplifier, and

a phase conjugate mirror in optical alignment with said amplifier to correct aberrations in said amplified beam introduced by said amplifier; and

second means for redirecting said amplified laser beam, said second means including:

a beam director and

an outcoupler mounted for independent articulation relative to said beam director;

wherein said first means are mounted on a first platform, and said master oscillator and said second means are mounted on a second platform mobile with respect to said first platform.

15. A method for directing electromagnetic energy comprising the steps of:

generating a beam of electromagnetic energy on a second platform;

transmitting said beam of electromagnetic energy through a medium to a first platform;

amplifying said beam on said first platform to form an amplified beam;

correcting aberrations in said beam introduced by said amplifier;

transmitting said amplified beam from said first platform through said medium to said second platform; and

redirecting said amplified beam from said second platform, said second platform being mobile relative to said first platform.

16. The method of claim **15** wherein the steps of transmitting said beam and transmitting said amplified beam comprise transmitting the beams through the atmosphere.

17. The method of claim **15** wherein the steps of transmitting said beam and transmitting said amplified beam comprise transmitting the beams through at least one fiber optic cable.

18. The method of claim **15** wherein the step of amplifying said beam includes correcting pointing and wavefront errors.

19. The invention of claim **1** wherein said means for correcting aberrations is a phase conjugate mirror.

20. The invention of claim **19** wherein said first means is an amplifier and said phase conjugate mirror is operationally coupled to the output thereof.

21. The invention of claim **15** wherein said step of correcting aberrations is performed with a phase conjugate mirror.

22. A system for directing electromagnetic energy comprising:

a master oscillator for generating a beam of electromagnetic energy;

first means amplifying said beam of electromagnetic energy to form an amplified beam;

second means for redirecting said amplified beam, said first means being mounted on a first platform, and said master oscillator and said second means being mounted on a second platform, said second platform being mobile relative to said first platform; and

an optical fiber for coupling said amplified beam between said first platform and said second platform.

23. A method for directing electromagnetic energy comprising the steps of:

generating a beam of electromagnetic energy on a second platform;

transmitting said beam of electromagnetic energy through a medium to a first platform;

amplifying said beam on said first platform to form an amplified beam;

transmitting said amplified beam from said first platform through said medium to said second platform; and

redirecting said amplified beam from said second platform, said second platform being mobile relative to said first platform, wherein the steps of transmitting said beam and transmitting said amplified beam comprise transmitting the beams through at least one fiber optic cable.

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