US008367991B2

(12) **United States Patent**
Bradley

(10) **Patent No.: US 8,367,991 B2**
(45) **Date of Patent: Feb. 5, 2013**

(54) **MODULATION DEVICE FOR A MOBILE TRACKING DEVICE**

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(73) Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 317 days.

(21) Appl. No.: **12/778,870**

(22) Filed: **May 12, 2010**

(65) **Prior Publication Data**

US 2011/0113949 A1 May 19, 2011

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/541,772, filed on Aug. 14, 2009.

(51) **Int. Cl.**
H04K 3/00 (2006.01)
F41G 7/26 (2006.01)
F41G 7/00 (2006.01)

(52) **U.S. Cl.** **244/3.1**; 244/3.15; 244/3.16; 455/1; 342/13; 398/39

(58) **Field of Classification Search** 244/3.1–3.19; 455/1; 398/39, 118, 121, 125; 342/13–20, 342/61, 62; 701/1, 36, 49; 250/493.1, 494.1, 250/495.1; 89/37.01, 41.01, 41.02, 41.06, 89/1.11; 235/435, 439, 454, 462.01, 462.41, 235/462.42; 356/138, 139.04, 140, 141.1, 356/141.2, 141.4
See application file for complete search history.

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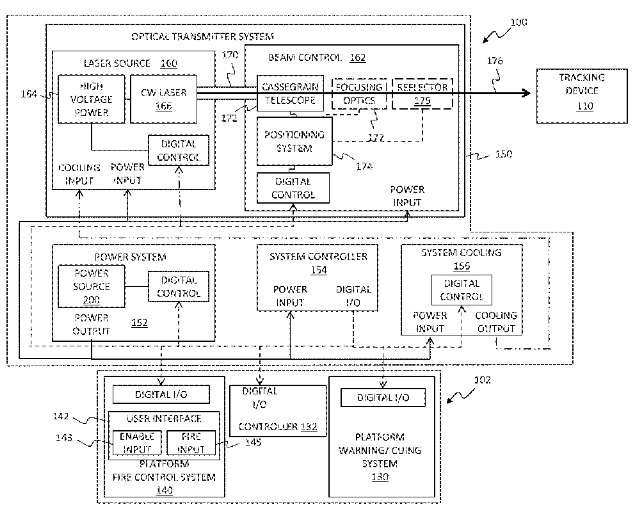
Primary Examiner — Bernarr Gregory
(74) *Attorney, Agent, or Firm* — Christopher A. Monsey

(57) **ABSTRACT**

A modulation device provides optical energy to hamper the operation of a mobile tracking device. The optical energy may include multiple mobile device specific optical codes directed at the mobile tracking device in parallel.

28 Claims, 29 Drawing Sheets



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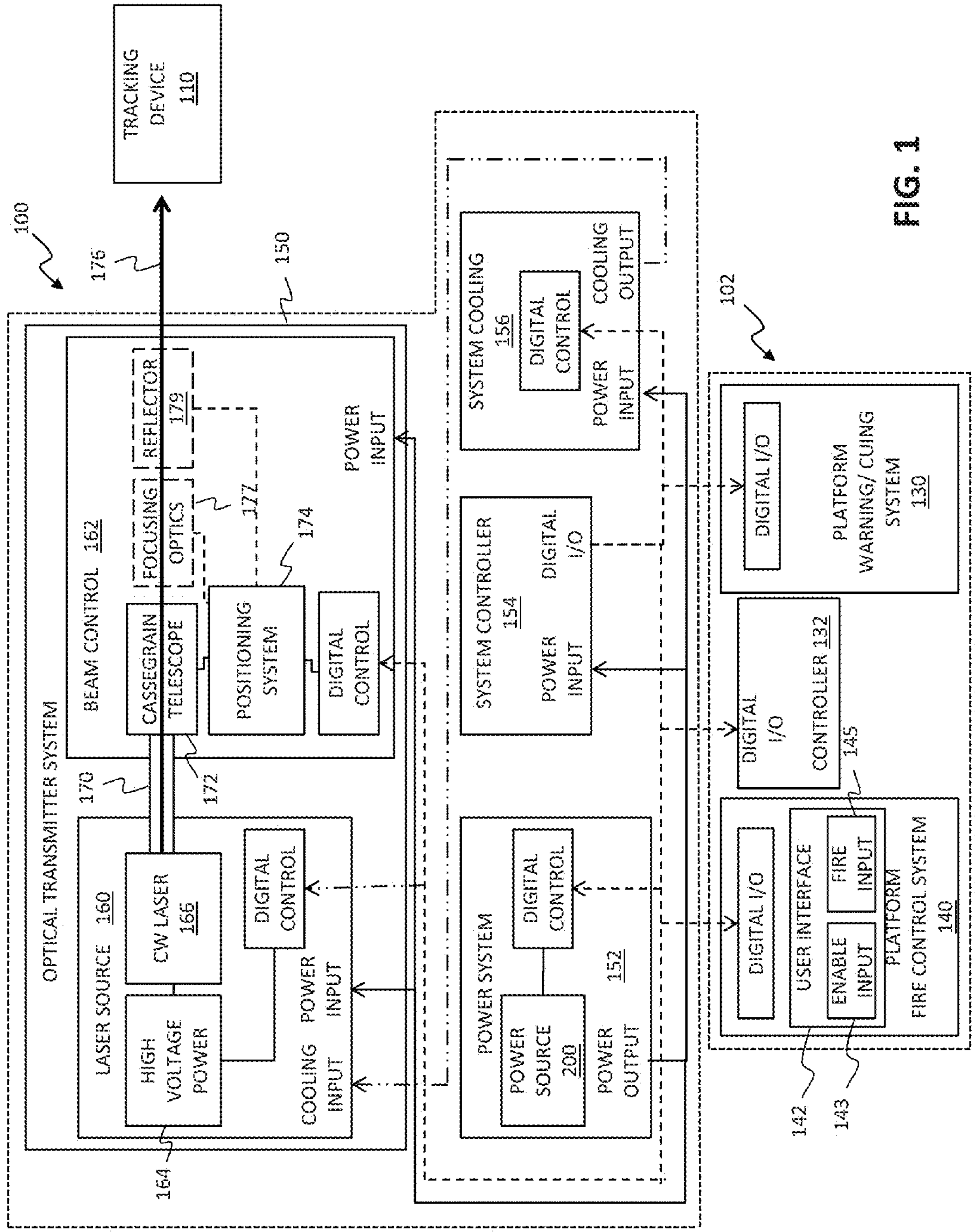

100
TRACKING DEVICE 110
176
150
OPTICAL TRANSMITTER SYSTEM
BEAM CONTROL 162
CASSEGRAIN TELESCOPE
FOCUSING OPTICS
REFLECTOR 179
177
174
POSITIONING SYSTEM
DIGITAL CONTROL
POWER INPUT
170
172
LASER SOURCE 160
HIGH VOLTAGE POWER
CW LASER 166
DIGITAL CONTROL
COOLING INPUT
POWER INPUT
164
SYSTEM COOLING 156
DIGITAL CONTROL
POWER INPUT
COOLING OUTPUT
SYSTEM CONTROLLER 154
POWER INPUT
DIGITAL I/O
POWER SYSTEM 152
POWER SOURCE 200
DIGITAL CONTROL
POWER OUTPUT
102
DIGITAL I/O
PLATFORM WARNING/ CUING SYSTEM 130
DIGITAL I/O
CONTROLLER 132
145
DIGITAL I/O
USER INTERFACE
ENABLE INPUT
FIRE INPUT
PLATFORM FIRE CONTROL SYSTEM 140
142
143

FIG. 1

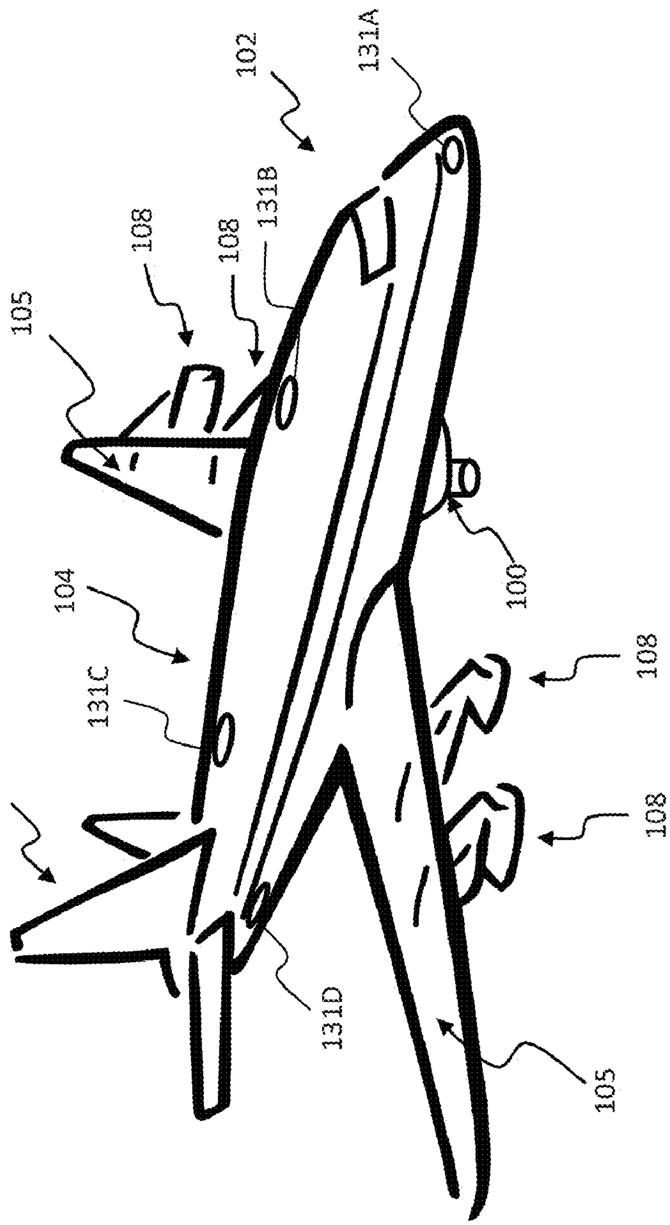


FIG. 2

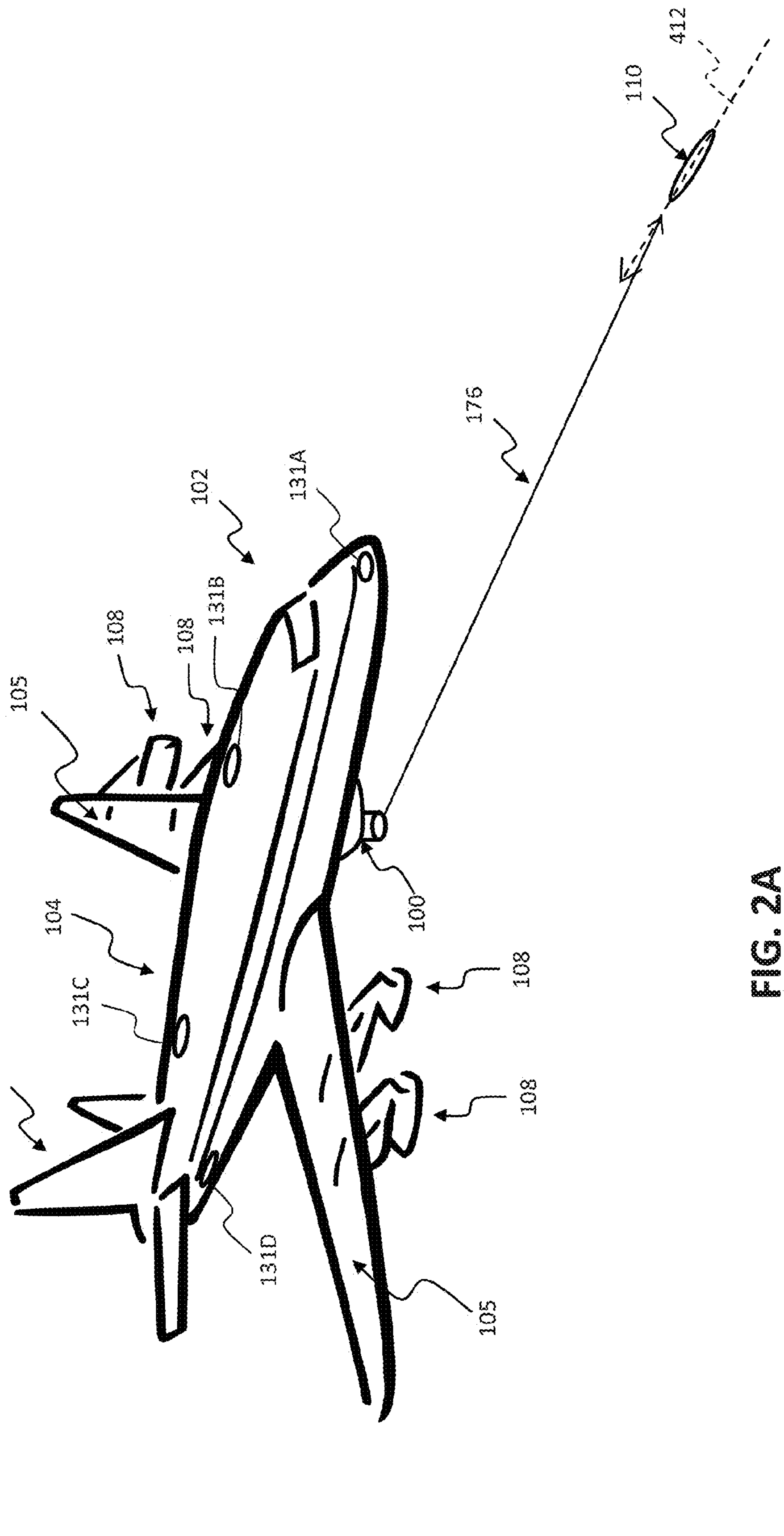

412
110
175
102
131A
131B
108
108
105
104
131C
106
131D
100
108
108
105

FIG. 2A

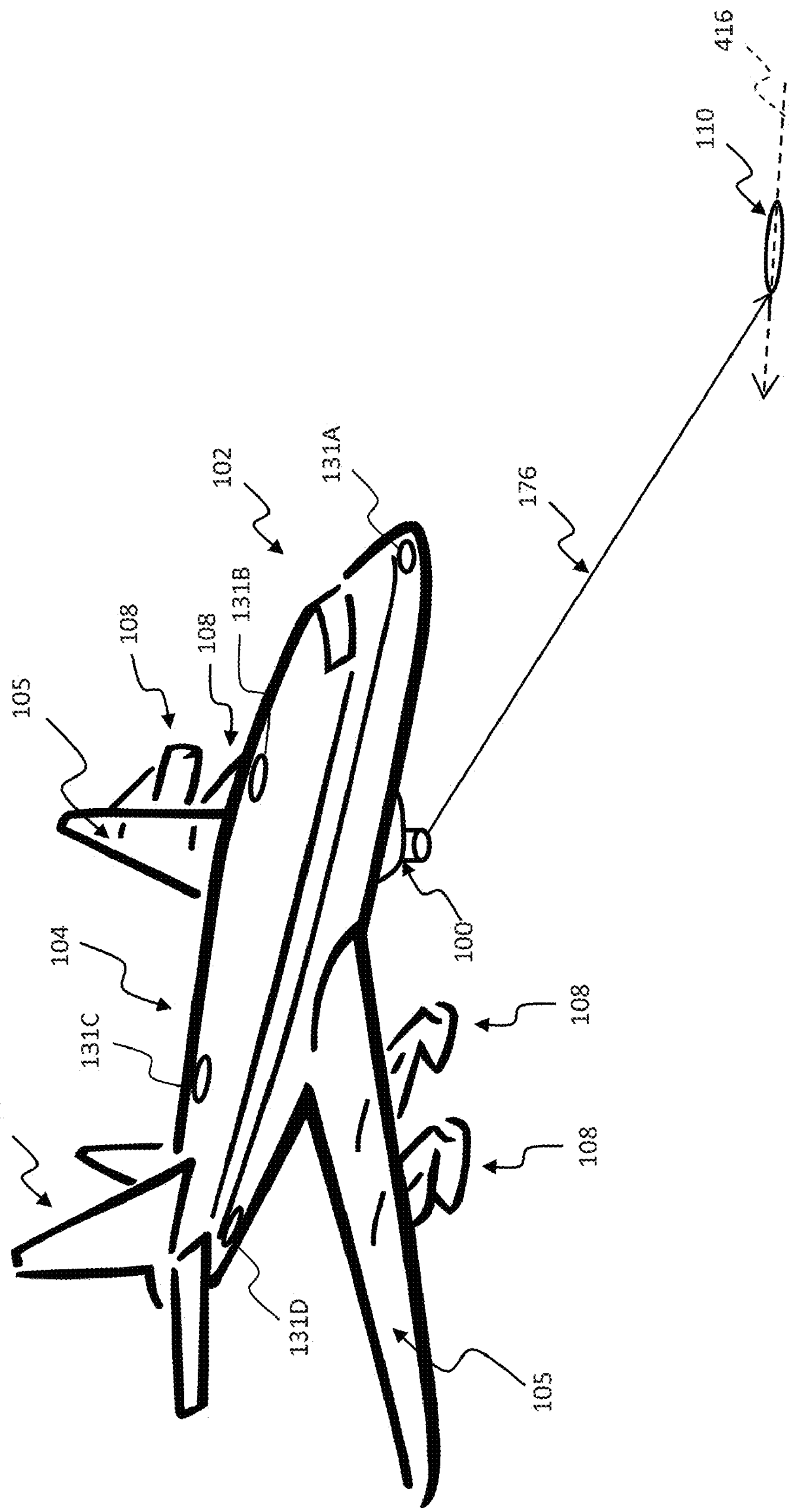

416
110
102
131A
176
131B
108
108
105
100
104
131C
106
108
108
131D
105

FIG. 2B

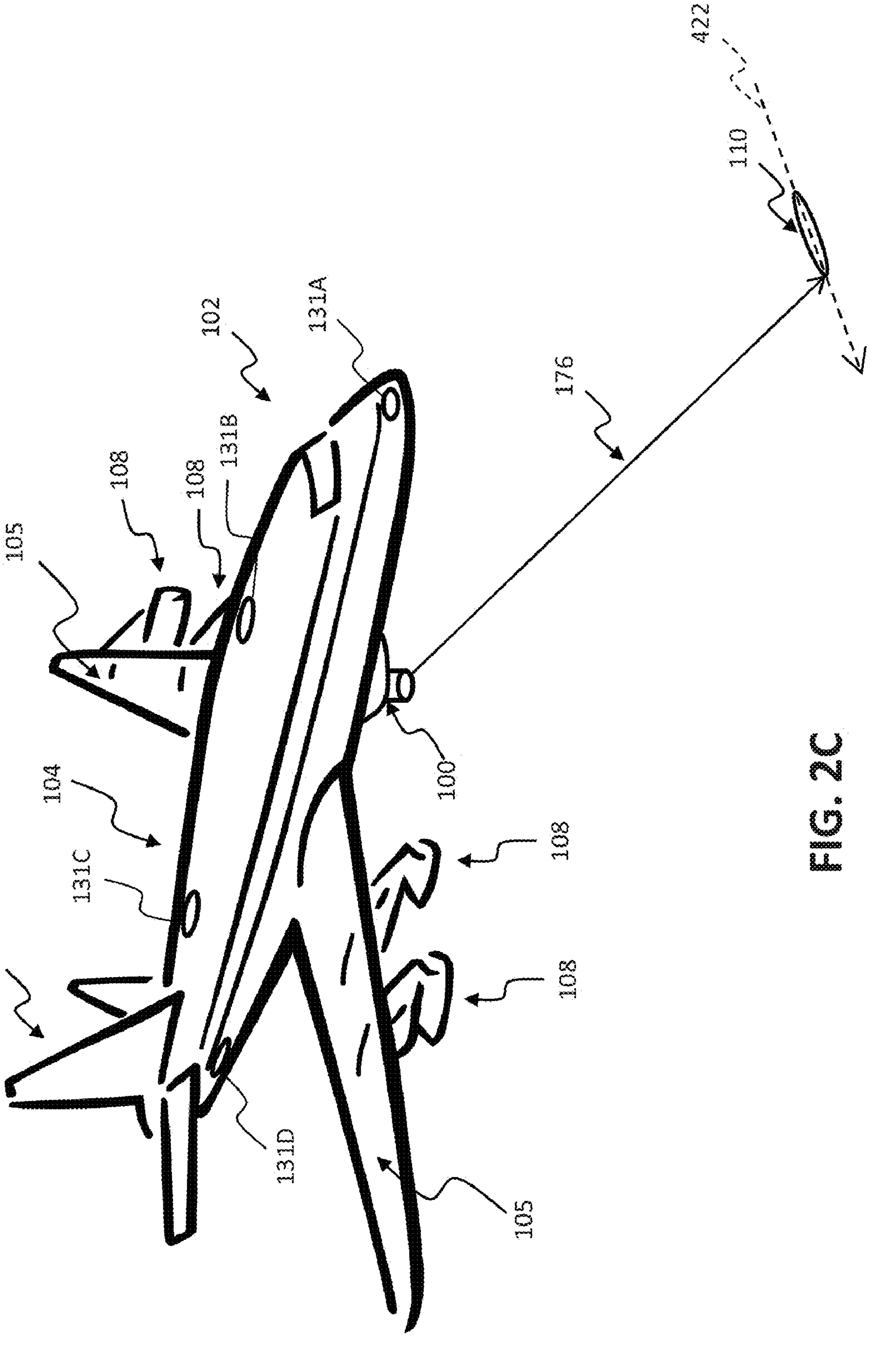

422
110
102
131A
176
131B
108
108
105
100
104
131C
108
108
106
131D
105

FIG. 2C

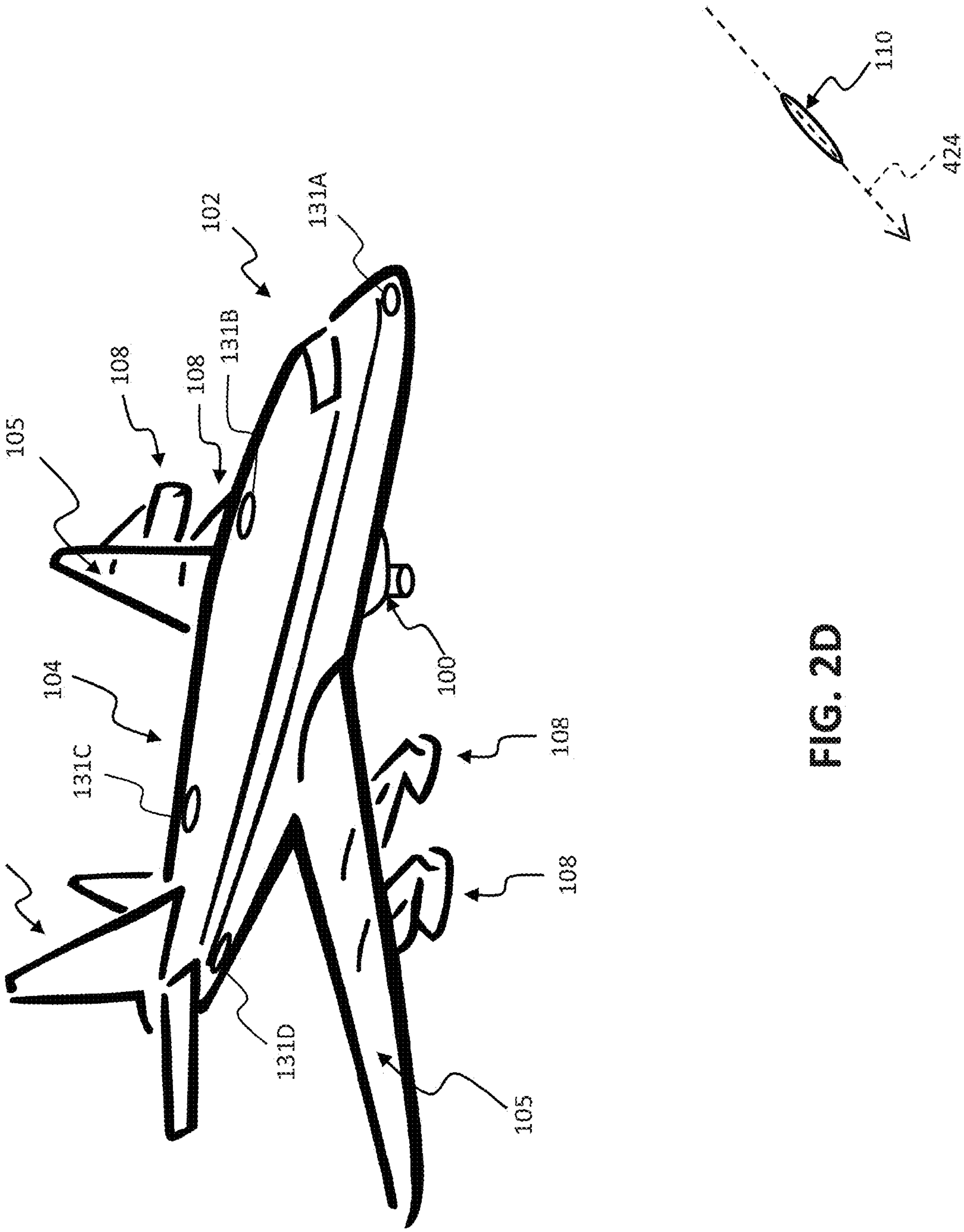

102
131A
131B
108
108
105
104
131C
106
131D
105
100
108
108
110
424

FIG. 2D

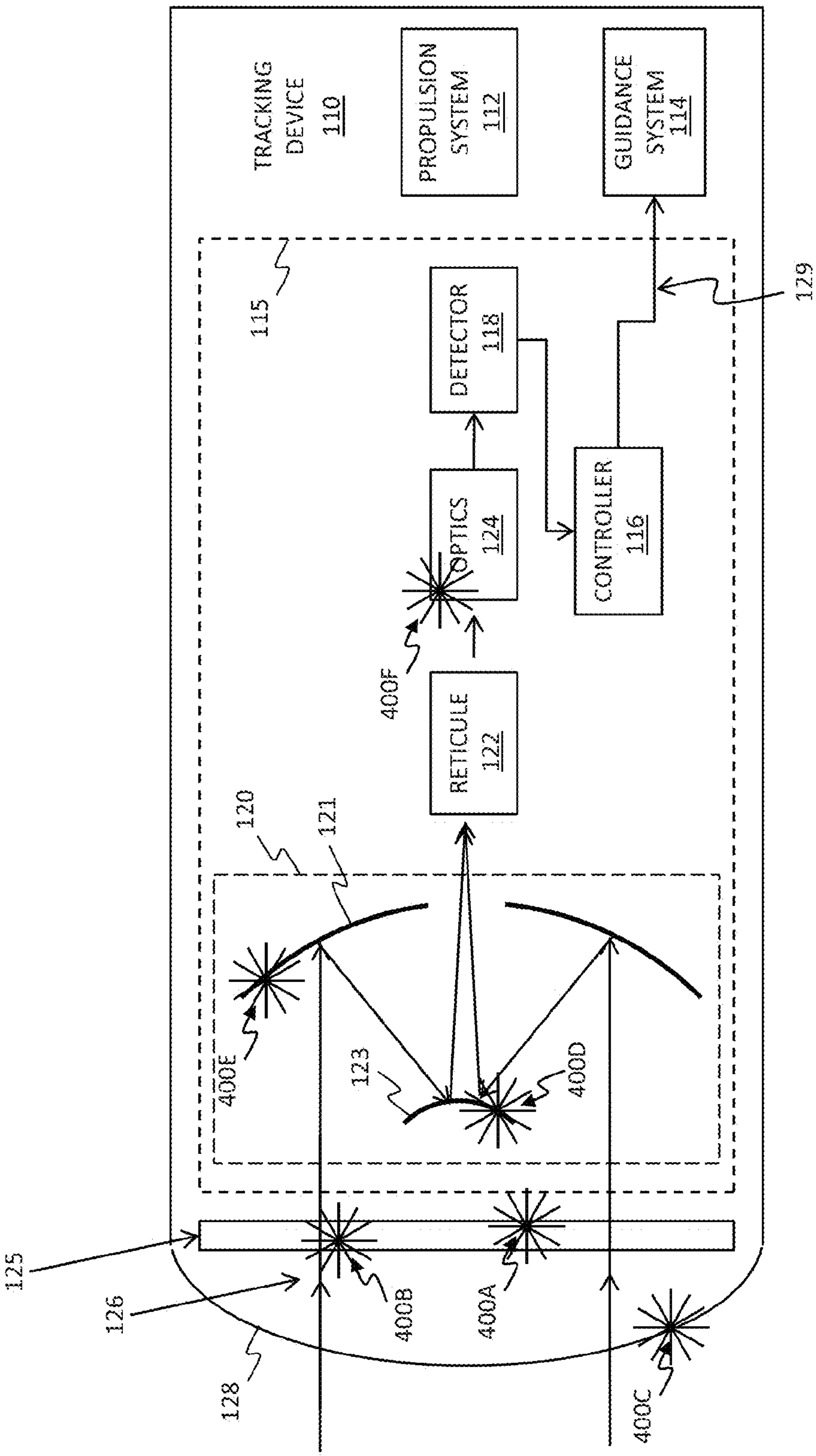

TRACKING DEVICE 110
PROPULSION SYSTEM 112
GUIDANCE SYSTEM 114
115
DETECTOR 118
129
OPTICS 124
CONTROLLER 116
400F
RETICULE 122
120
121
400E
123
400D
125
126
400B
400A
128
400C

FIG. 3

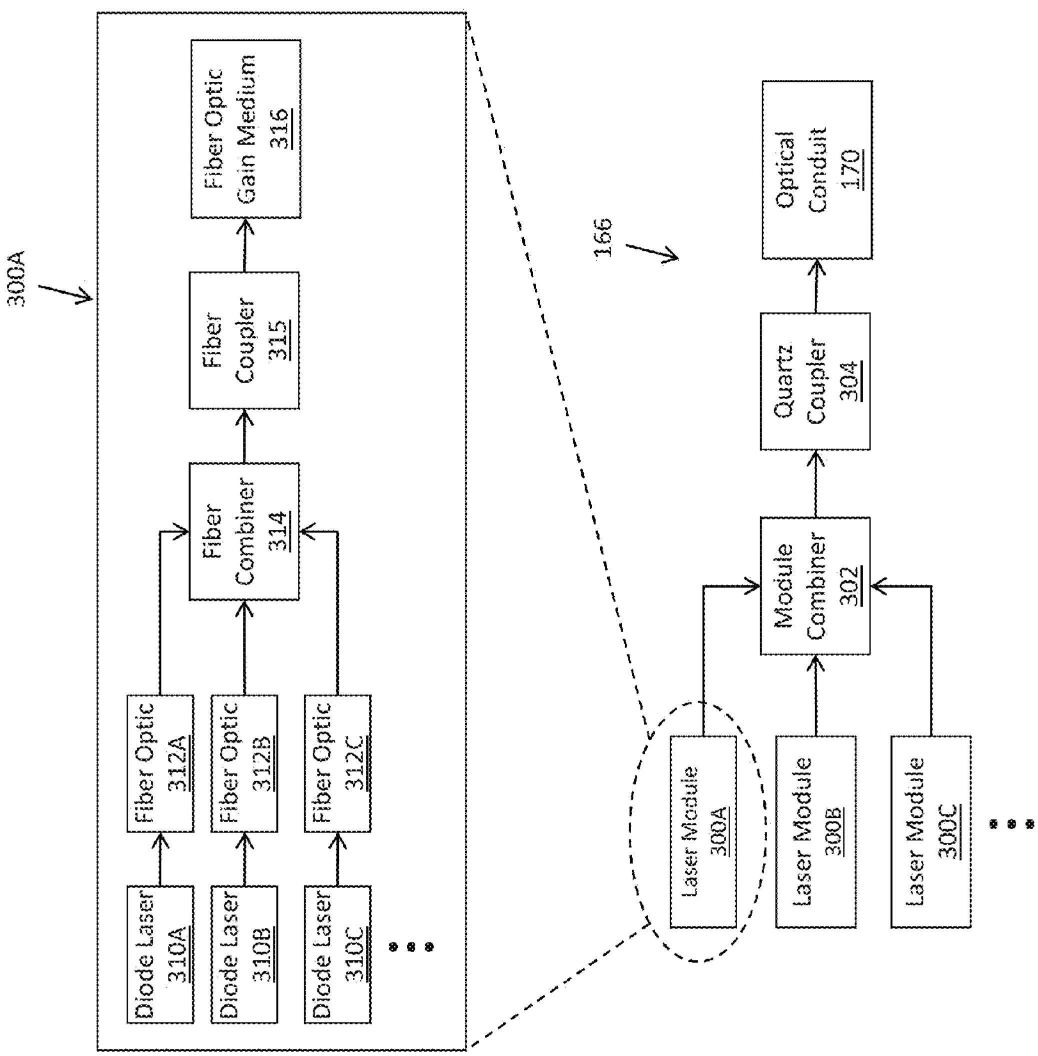

300A
Diode Laser 310A
Diode Laser 310B
Diode Laser 310C
Fiber Optic 312A
Fiber Optic 312B
Fiber Optic 312C
Fiber Combiner 314
Fiber Coupler 315
Fiber Optic Gain Medium 316
166
Laser Module 300A
Laser Module 300B
Laser Module 300C
Module Combiner 302
Quartz Coupler 304
Optical Conduit 170

FIG. 4

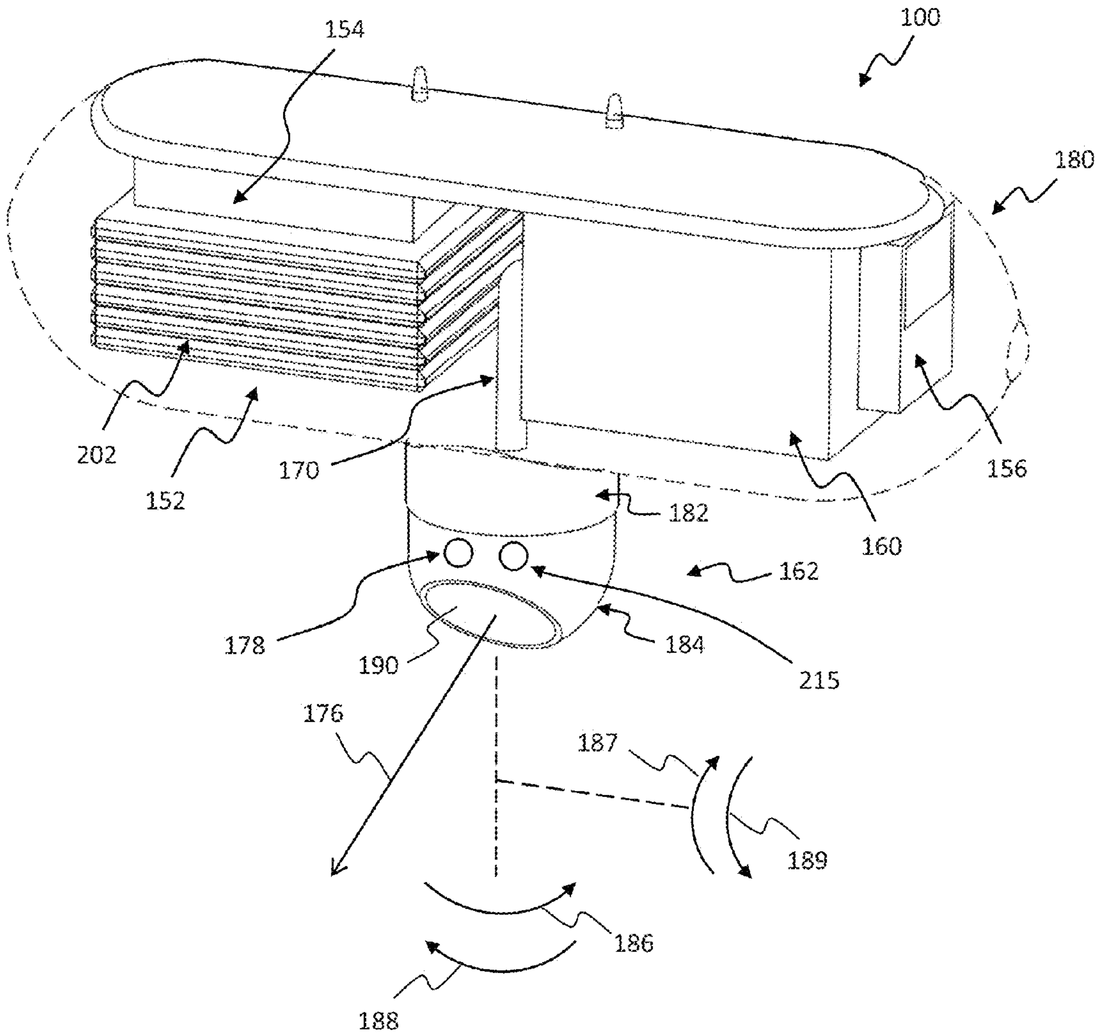

154
100
180
202
152
170
156
160
182
162
178
190
184
215
176
187
189
186
188

FIG. 5

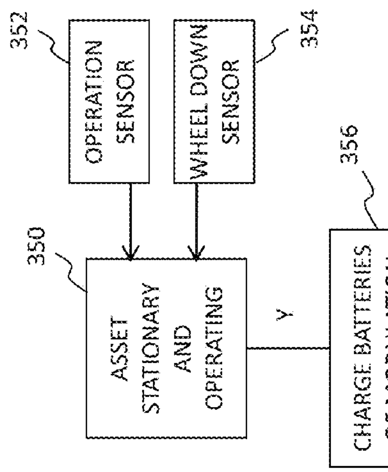

352
OPERATION SENSOR
354
WHEEL DOWN SENSOR
350
ASSET STATIONARY AND OPERATING
Y
356
CHARGE BATTERIES OF MODULATION DEVICE

FIG. 8

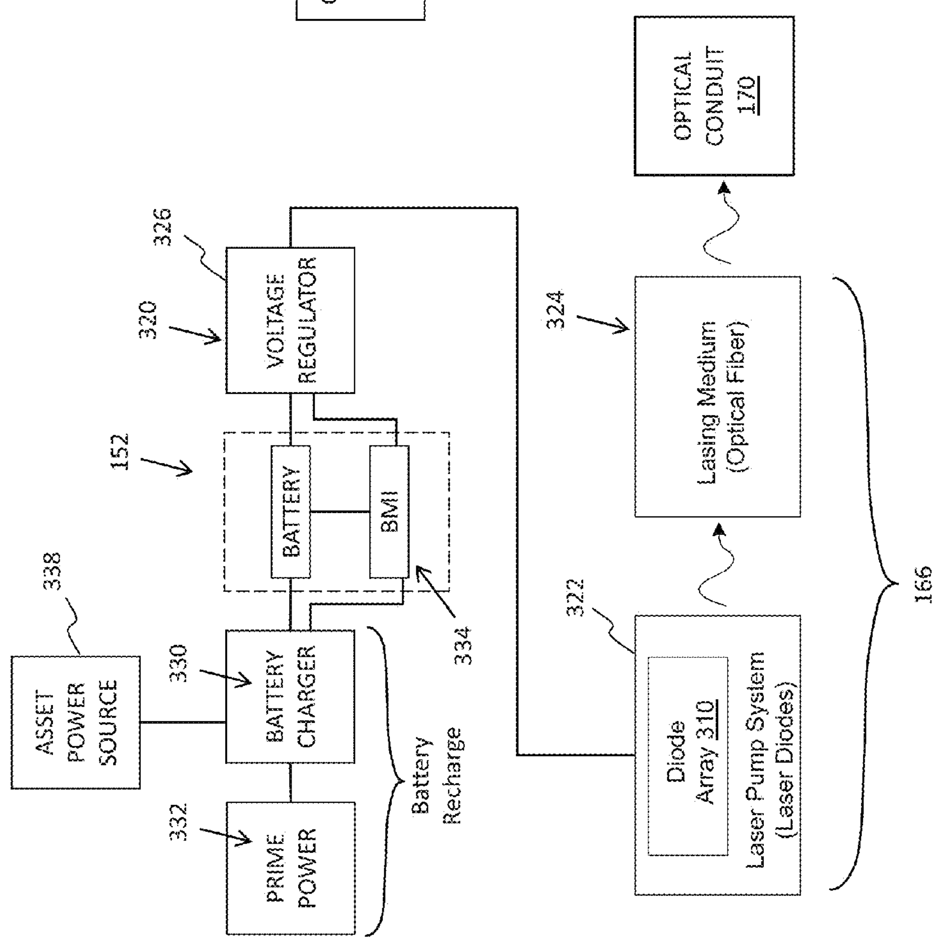

338
ASSET POWER SOURCE
330
BATTERY CHARGER
332
PRIME POWER
Battery Recharge
334
152
BATTERY
BMI
320
326
VOLTAGE REGULATOR
322
Diode Array 310
Laser Pump System (Laser Diodes)
324
Lasing Medium (Optical Fiber)
OPTICAL CONDUIT 170
166

FIG. 6

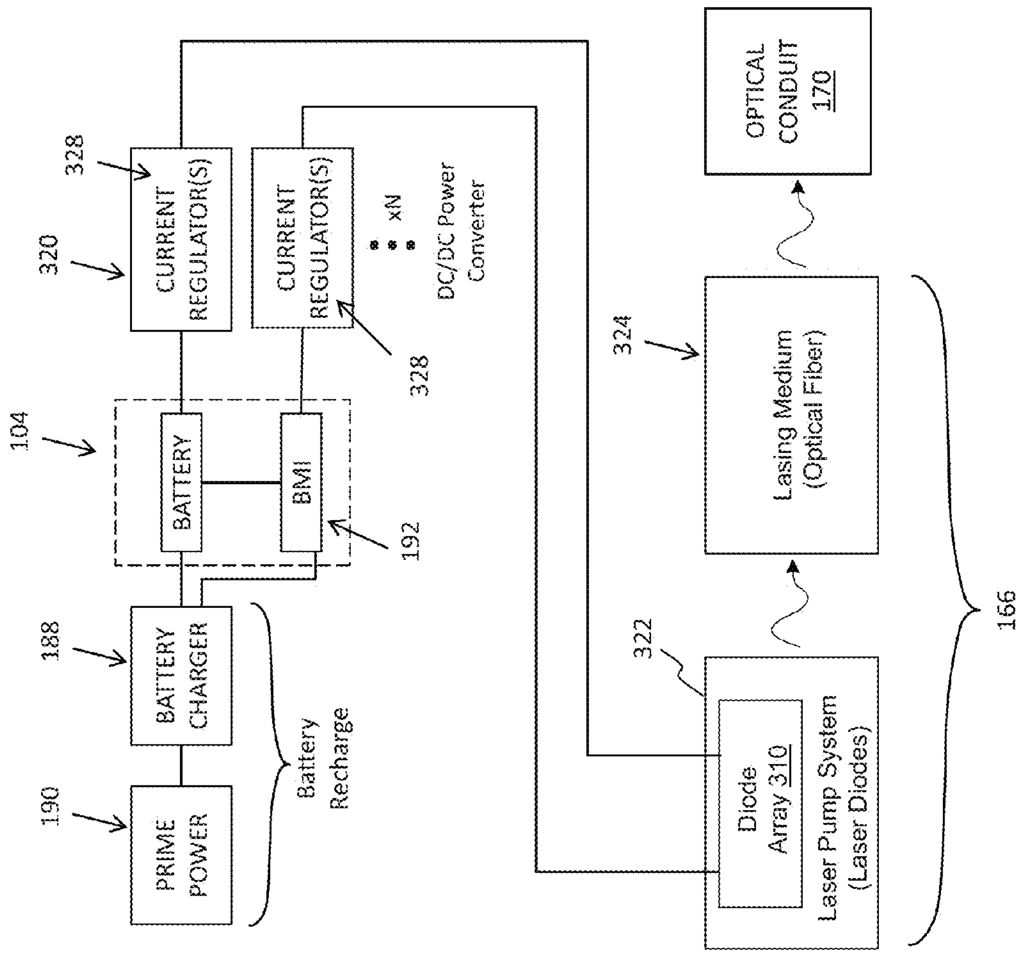

PRIME POWER
190
BATTERY CHARGER
188
Battery Recharge
BATTERY
BMI
104
192
CURRENT REGULATOR(S)
320
328
CURRENT REGULATOR(S)
328
xN
DC/DC Power Converter
Diode Array 310
Laser Pump System (Laser Diodes)
322
Lasing Medium (Optical Fiber)
324
OPTICAL CONDUIT 170
166

FIG. 7

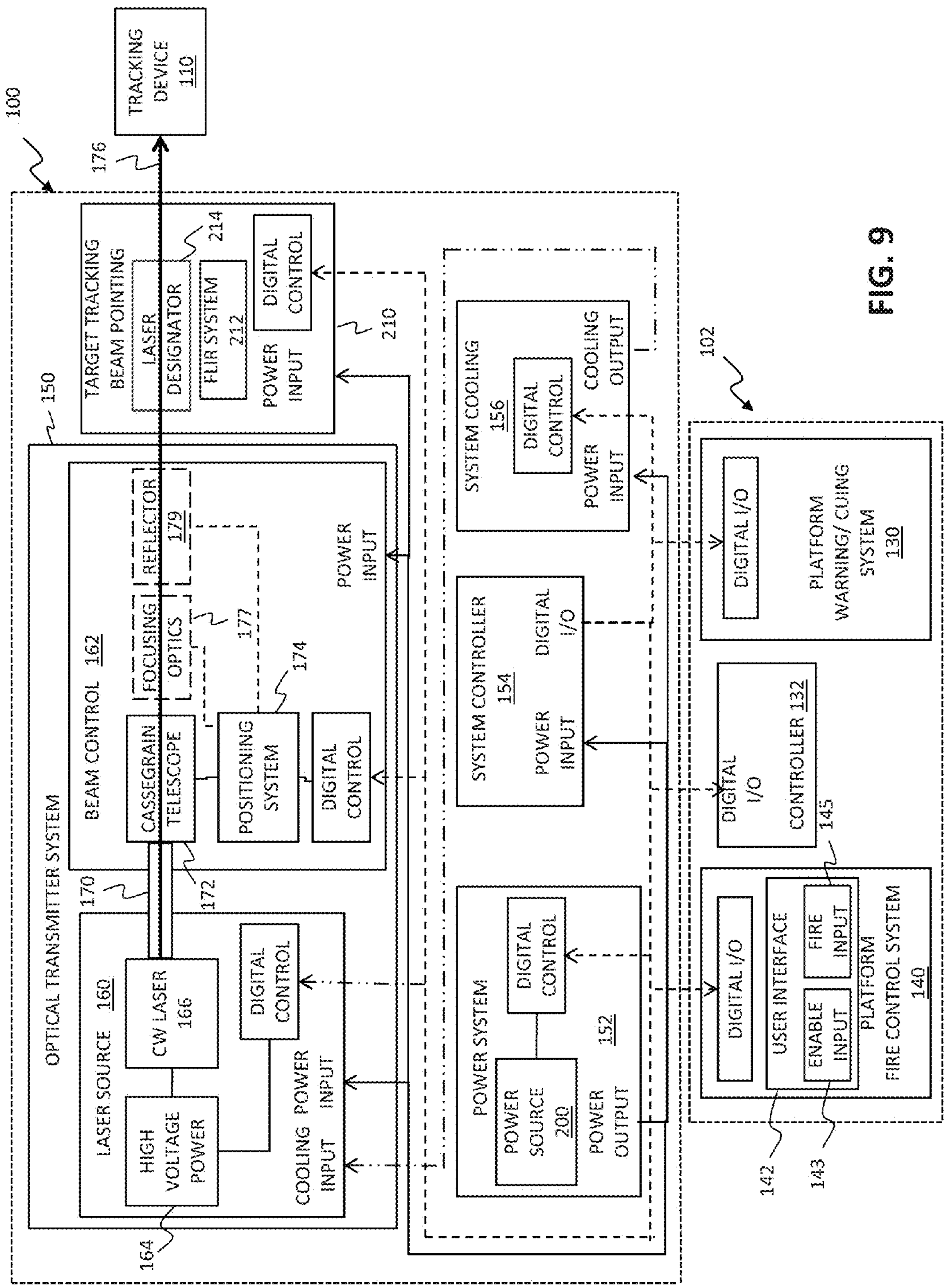

TRACKING DEVICE 110
100
176
OPTICAL TRANSMITTER SYSTEM
150
TARGET TRACKING BEAM POINTING
LASER DESIGNATOR
214
FLIR SYSTEM 212
DIGITAL CONTROL
POWER INPUT
210
BEAM CONTROL 162
REFLECTOR 179
FOCUSING OPTICS
177
CASSEGRAIN TELESCOPE
POSITIONING SYSTEM
174
DIGITAL CONTROL
POWER INPUT
170
172
LASER SOURCE 160
CW LASER 166
HIGH VOLTAGE POWER
DIGITAL CONTROL
COOLING INPUT
POWER INPUT
164
SYSTEM COOLING 156
DIGITAL CONTROL
POWER INPUT
COOLING OUTPUT
SYSTEM CONTROLLER 154
DIGITAL I/O
POWER INPUT
POWER SYSTEM
POWER SOURCE 200
DIGITAL CONTROL
152
POWER OUTPUT
102
DIGITAL I/O
PLATFORM WARNING/ CUING SYSTEM 130
DIGITAL I/O
CONTROLLER 132
145
DIGITAL I/O
USER INTERFACE
FIRE INPUT
ENABLE INPUT
PLATFORM FIRE CONTROL SYSTEM 140
142
143

FIG. 9

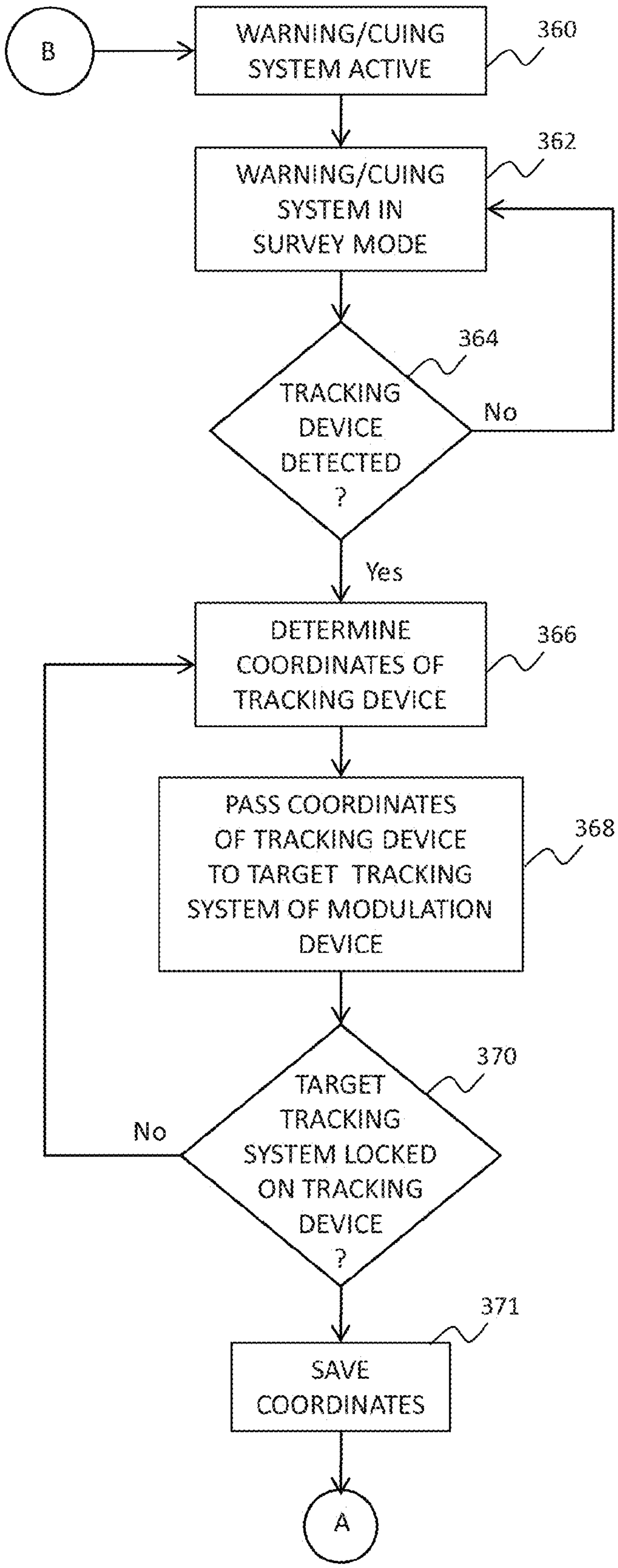

B
WARNING/CUING SYSTEM ACTIVE
360
WARNING/CUING SYSTEM IN SURVEY MODE
362
TRACKING DEVICE DETECTED ?
364
No
Yes
DETERMINE COORDINATES OF TRACKING DEVICE
366
PASS COORDINATES OF TRACKING DEVICE TO TARGET TRACKING SYSTEM OF MODULATION DEVICE
368
TARGET TRACKING SYSTEM LOCKED ON TRACKING DEVICE ?
370
No
SAVE COORDINATES
371
A

FIG. 10A

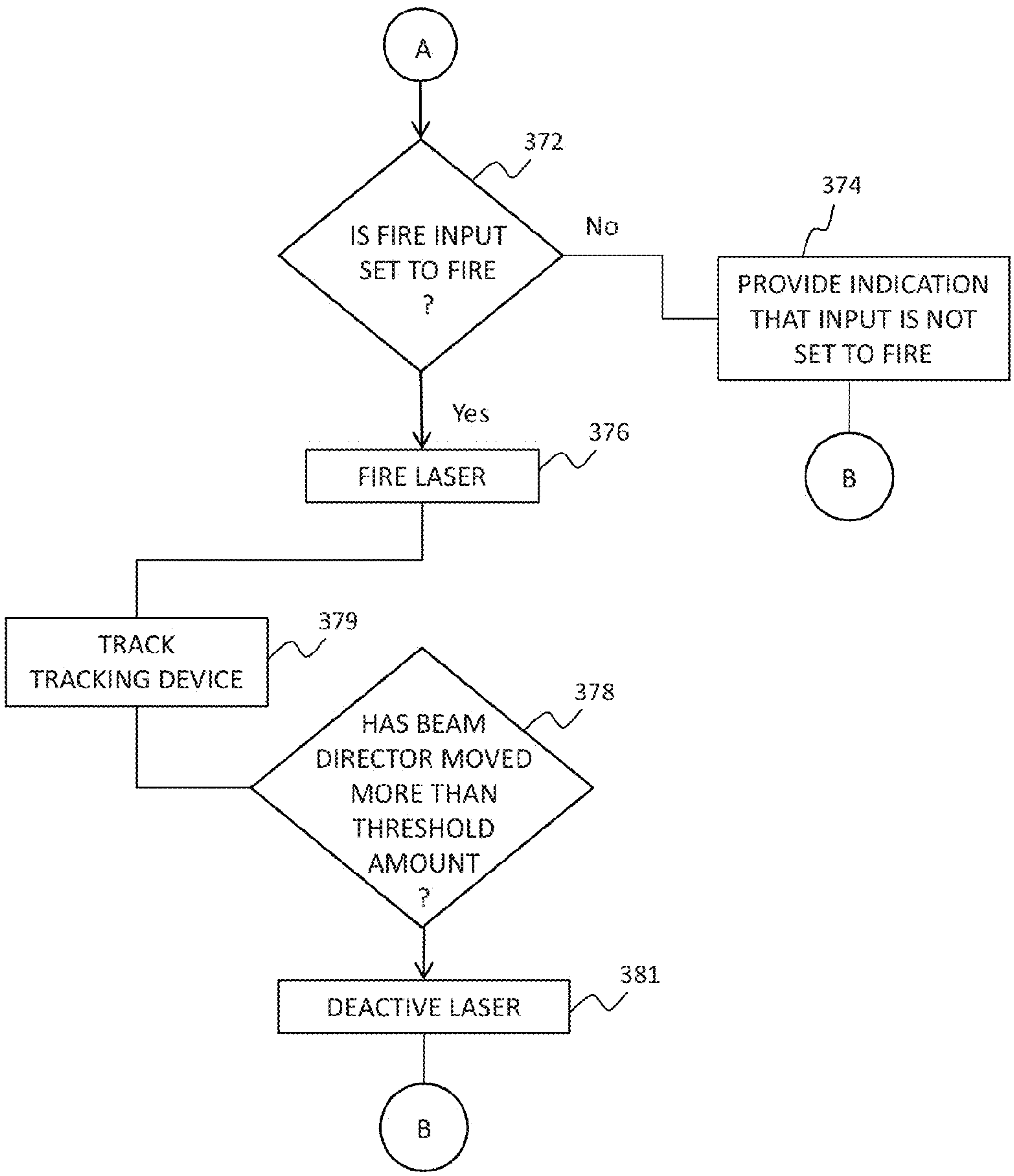

A
372
IS FIRE INPUT SET TO FIRE ?
No
374
PROVIDE INDICATION THAT INPUT IS NOT SET TO FIRE
B
Yes
376
FIRE LASER
379
TRACK TRACKING DEVICE
378
HAS BEAM DIRECTOR MOVED MORE THAN THRESHOLD AMOUNT ?
381
DEACTIVE LASER
B

FIG. 10B

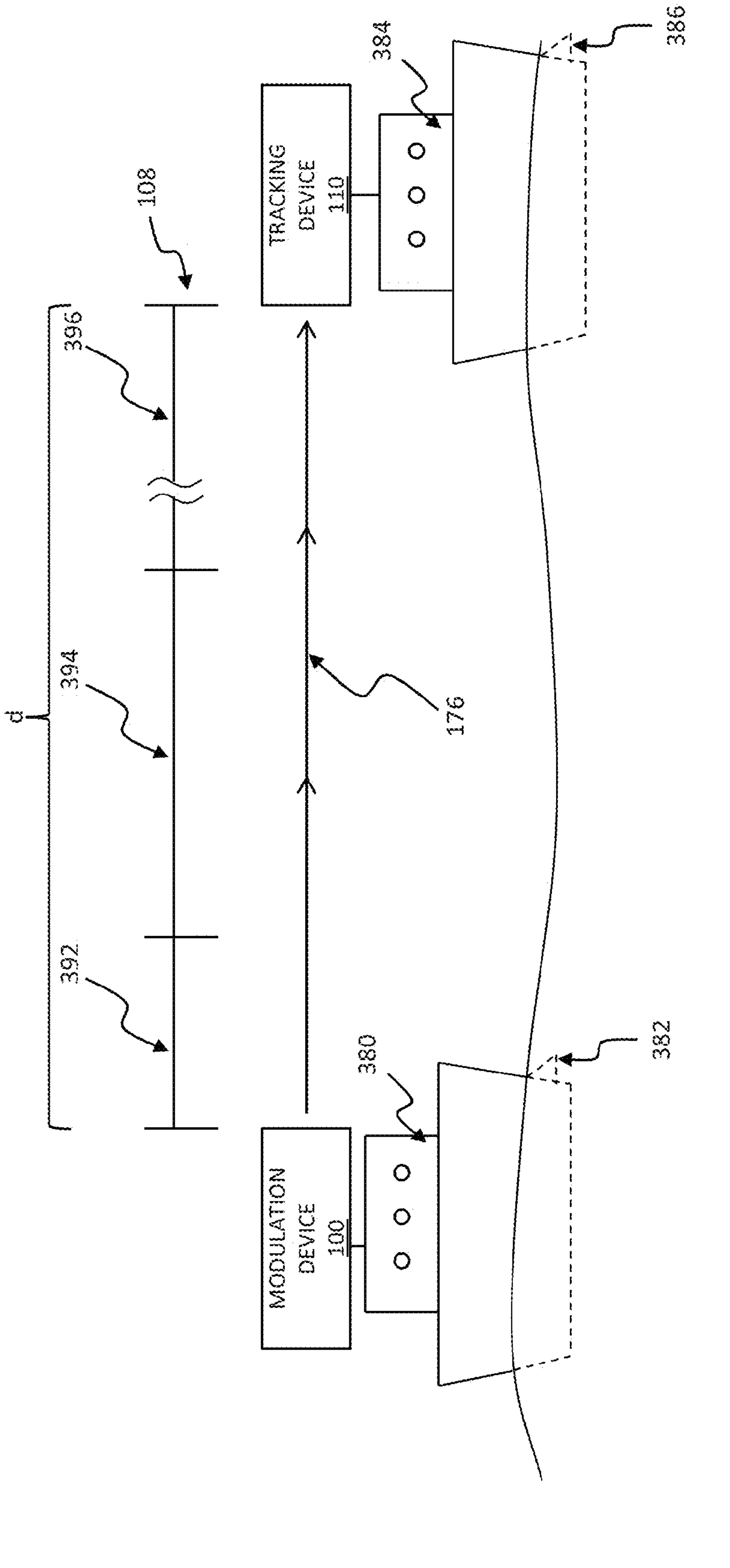

TRACKING DEVICE 110
MODULATION DEVICE 100
108
384
386
396
394
392
d
176
380
382

FIG. 11

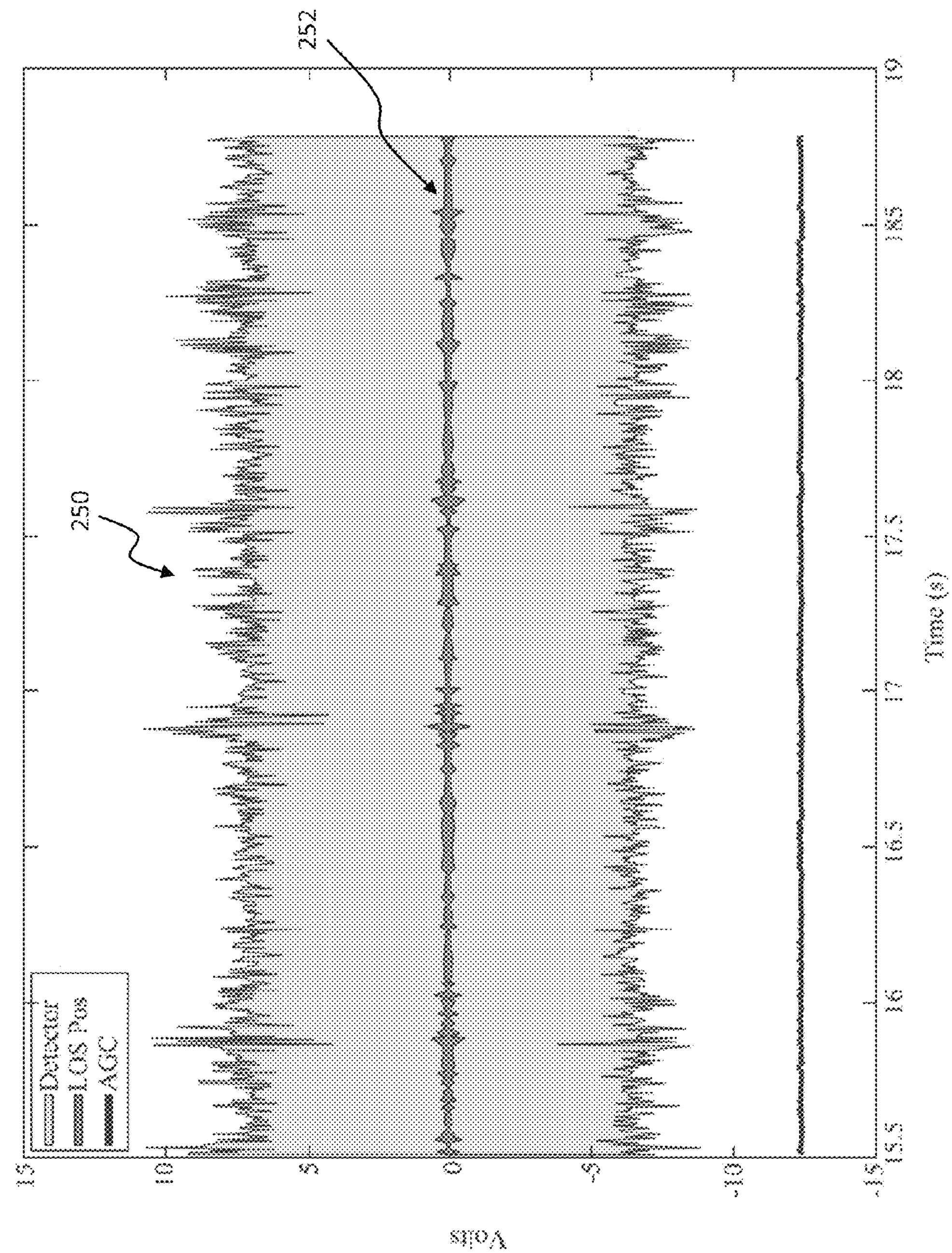

Detector
LOS Pos
AGC
Volts
15
10
5
0
-5
-10
-15
Time (s)
15.5
16
16.5
17
17.5
18
18.5
19
250
252

FIG. 12

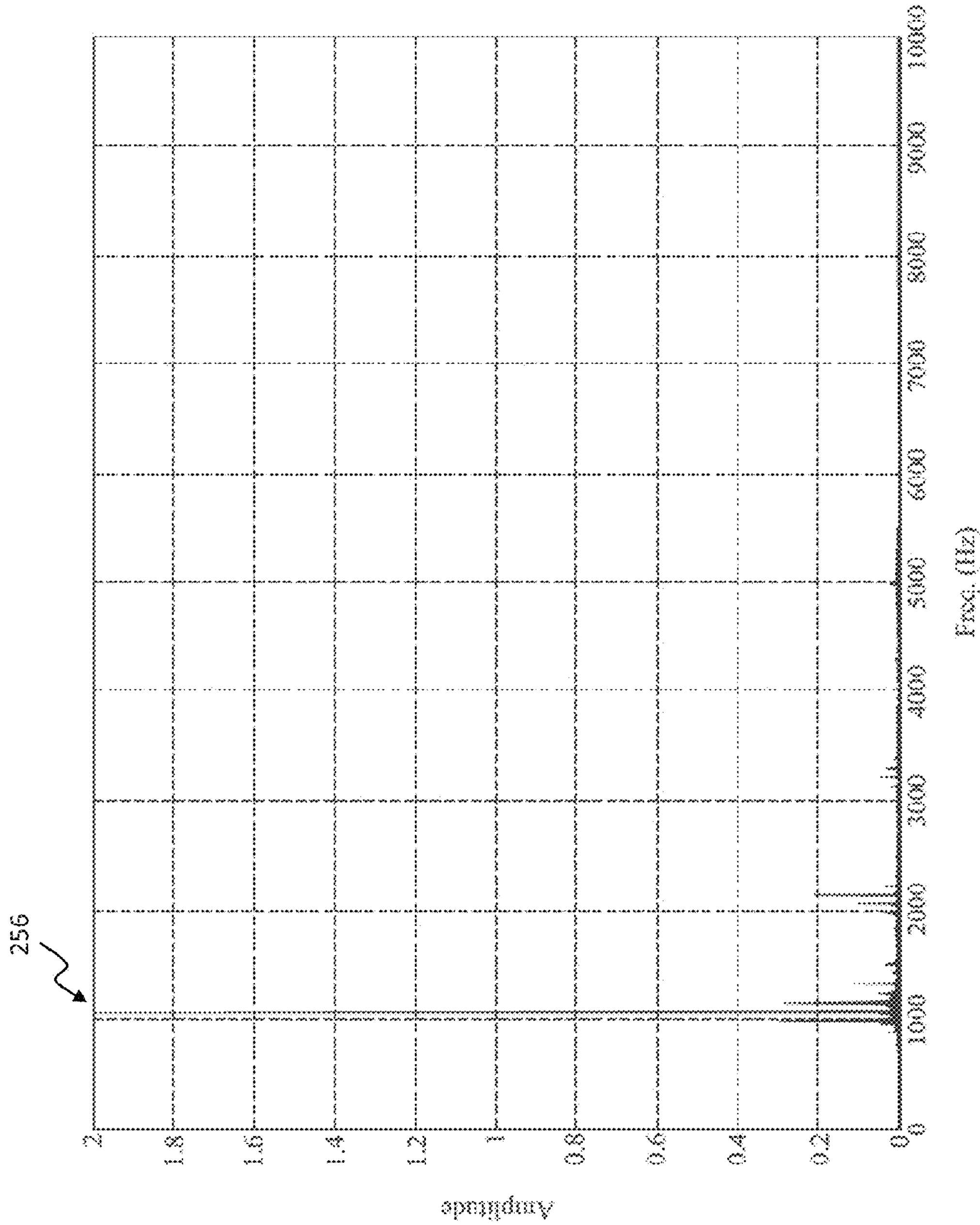
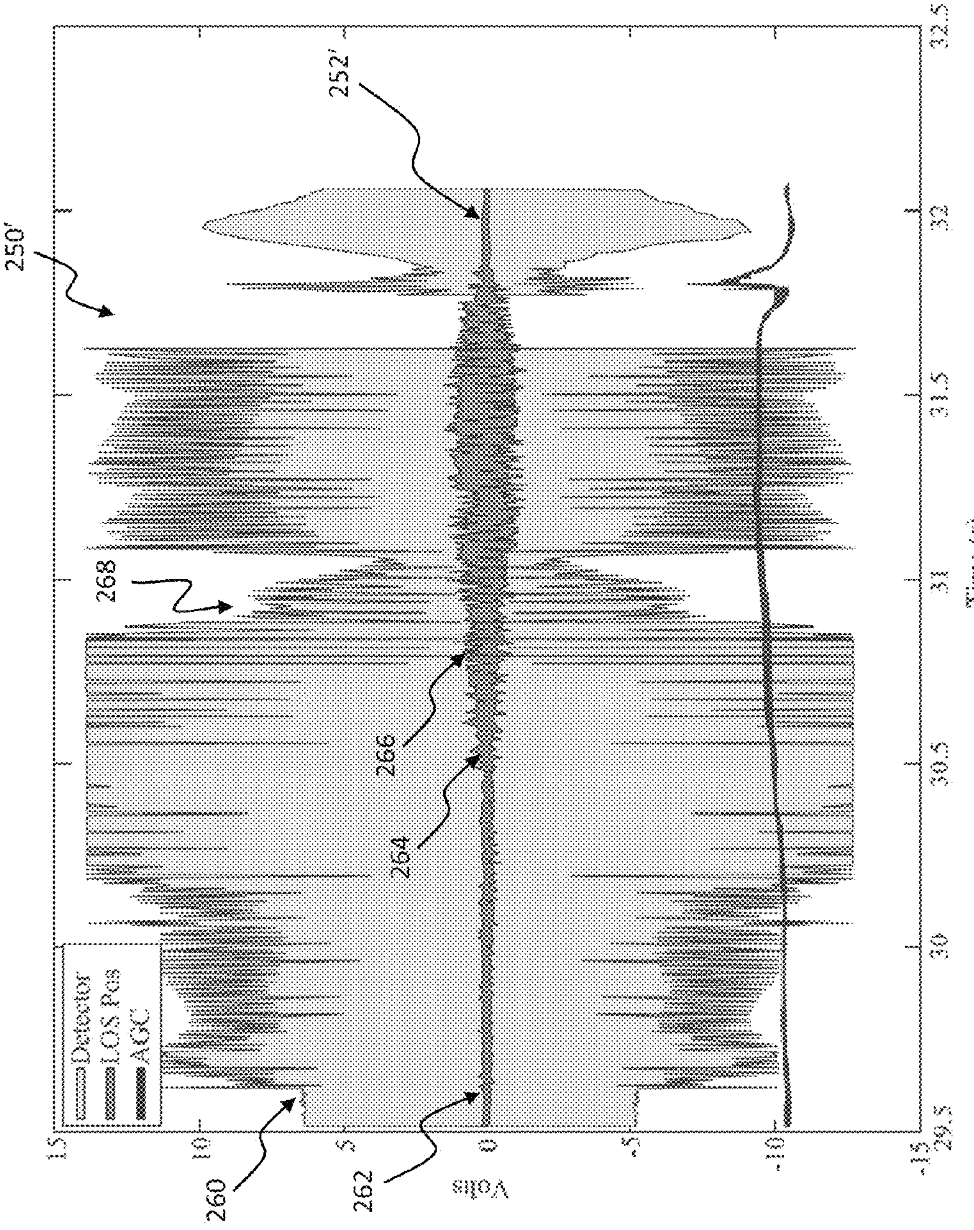

256
Amplitude
Freq. (Hz)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

FIG. 13



250′
252′
260
262
264
266
268
Detector
LOS Pos
AGC
Volts
Time (s)
15
10
5
0
-5
-10
-15
29.5
30
30.5
31
31.5
32
32.5

FIG. 14

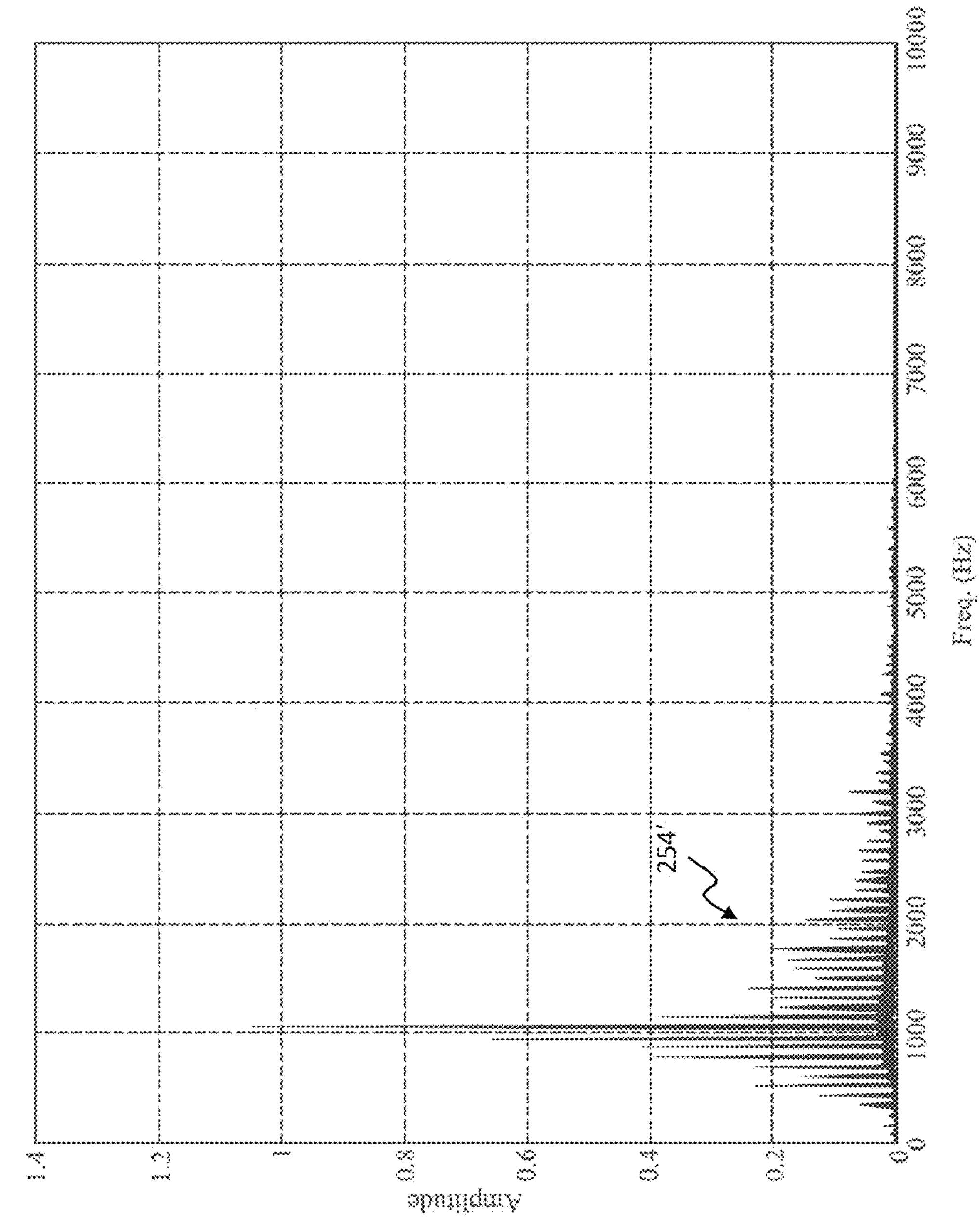

Amplitude
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Freq. (Hz)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
254'

FIG. 15

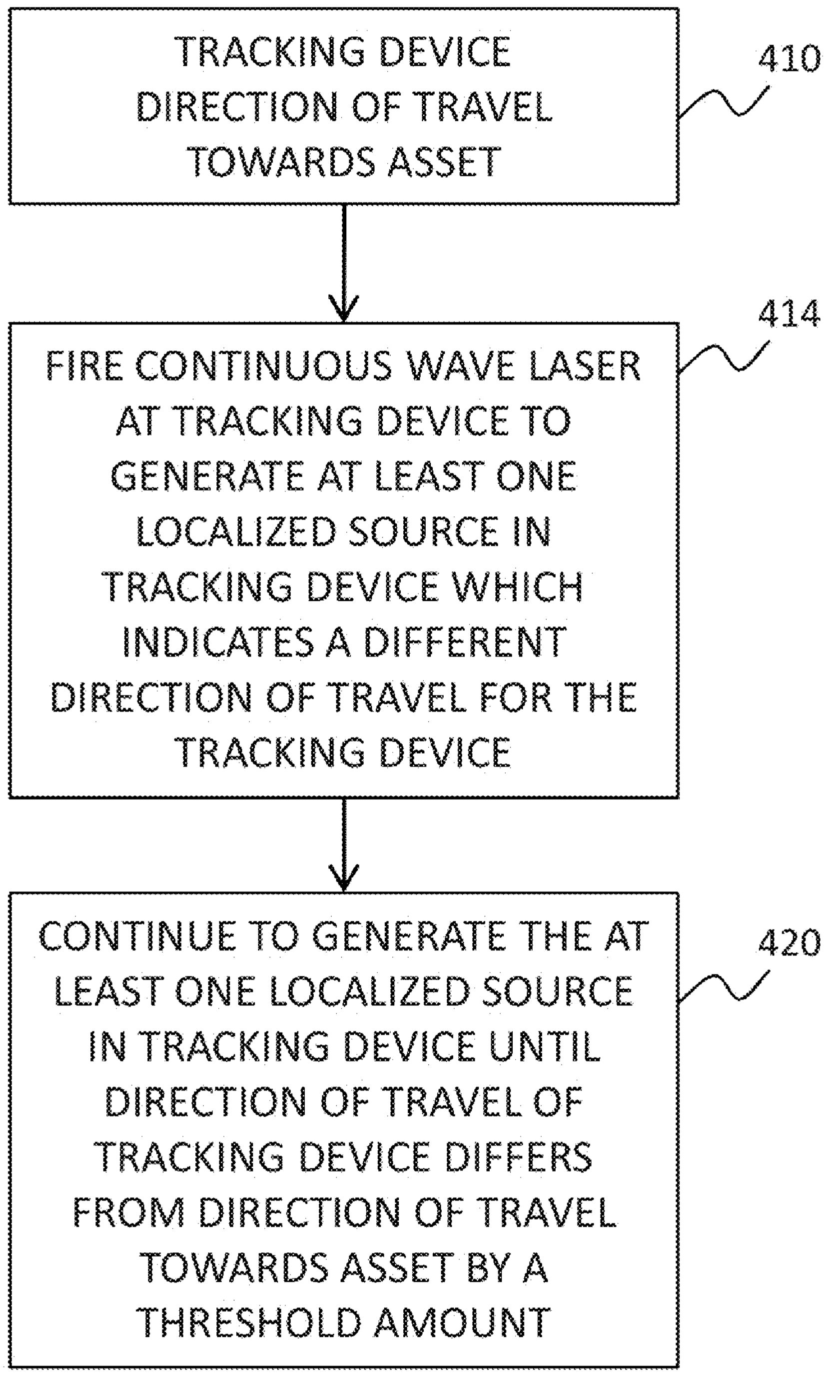
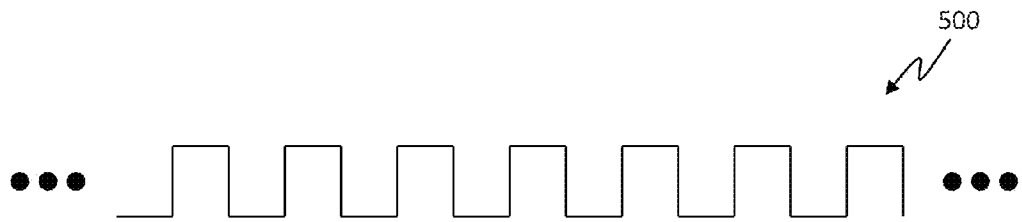
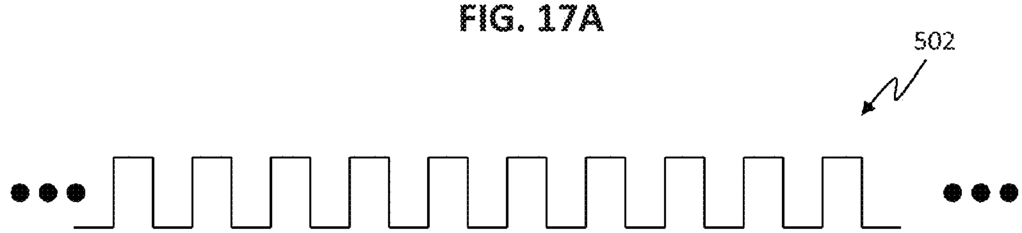

TRACKING DEVICE DIRECTION OF TRAVEL TOWARDS ASSET
410
FIRE CONTINUOUS WAVE LASER AT TRACKING DEVICE TO GENERATE AT LEAST ONE LOCALIZED SOURCE IN TRACKING DEVICE WHICH INDICATES A DIFFERENT DIRECTION OF TRAVEL FOR THE TRACKING DEVICE
414
CONTINUE TO GENERATE THE AT LEAST ONE LOCALIZED SOURCE IN TRACKING DEVICE UNTIL DIRECTION OF TRAVEL OF TRACKING DEVICE DIFFERS FROM DIRECTION OF TRAVEL TOWARDS ASSET BY A THRESHOLD AMOUNT
420

FIG. 16



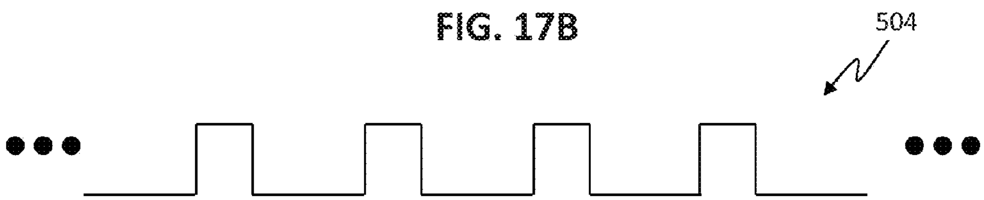
MODULATION CODE 1 (“MC 1”)

FIG. 17A



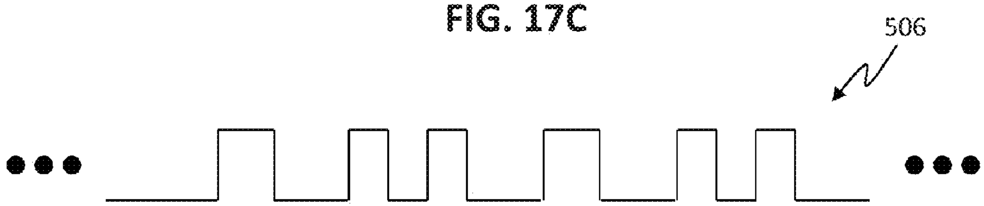
MODULATION CODE 2 (“MC 2”)

FIG. 17B



MODULATION CODE 3 (“MC 3”)

FIG. 17C



MODULATION CODE 4 (“MC 4”)

FIG. 17D

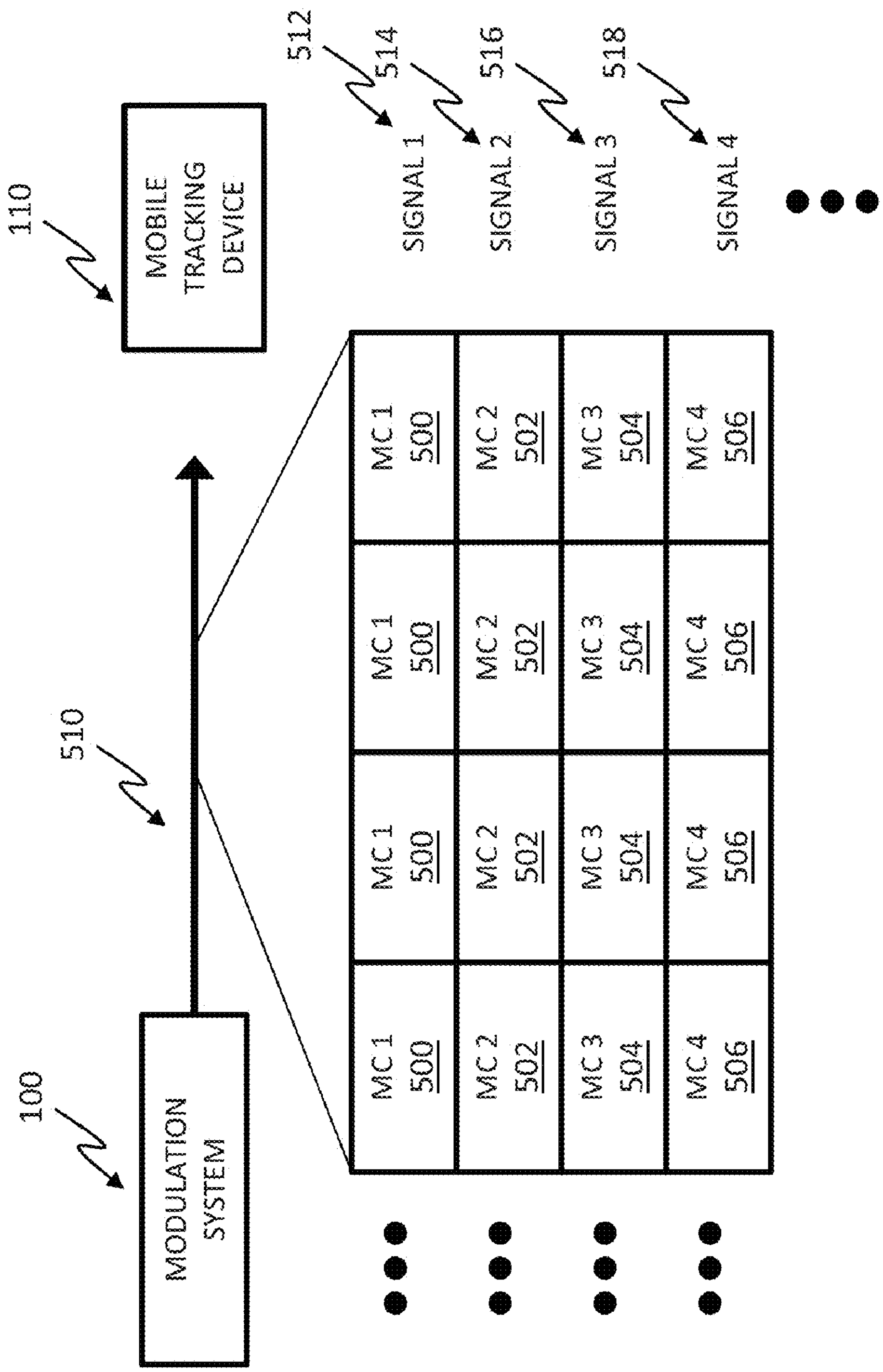

100
MODULATION SYSTEM
510
110
MOBILE TRACKING DEVICE
MC 1 500
MC 2 502
MC 3 504
MC 4 506
512
514
516
518
SIGNAL 1
SIGNAL 2
SIGNAL 3
SIGNAL 4

FIG. 18

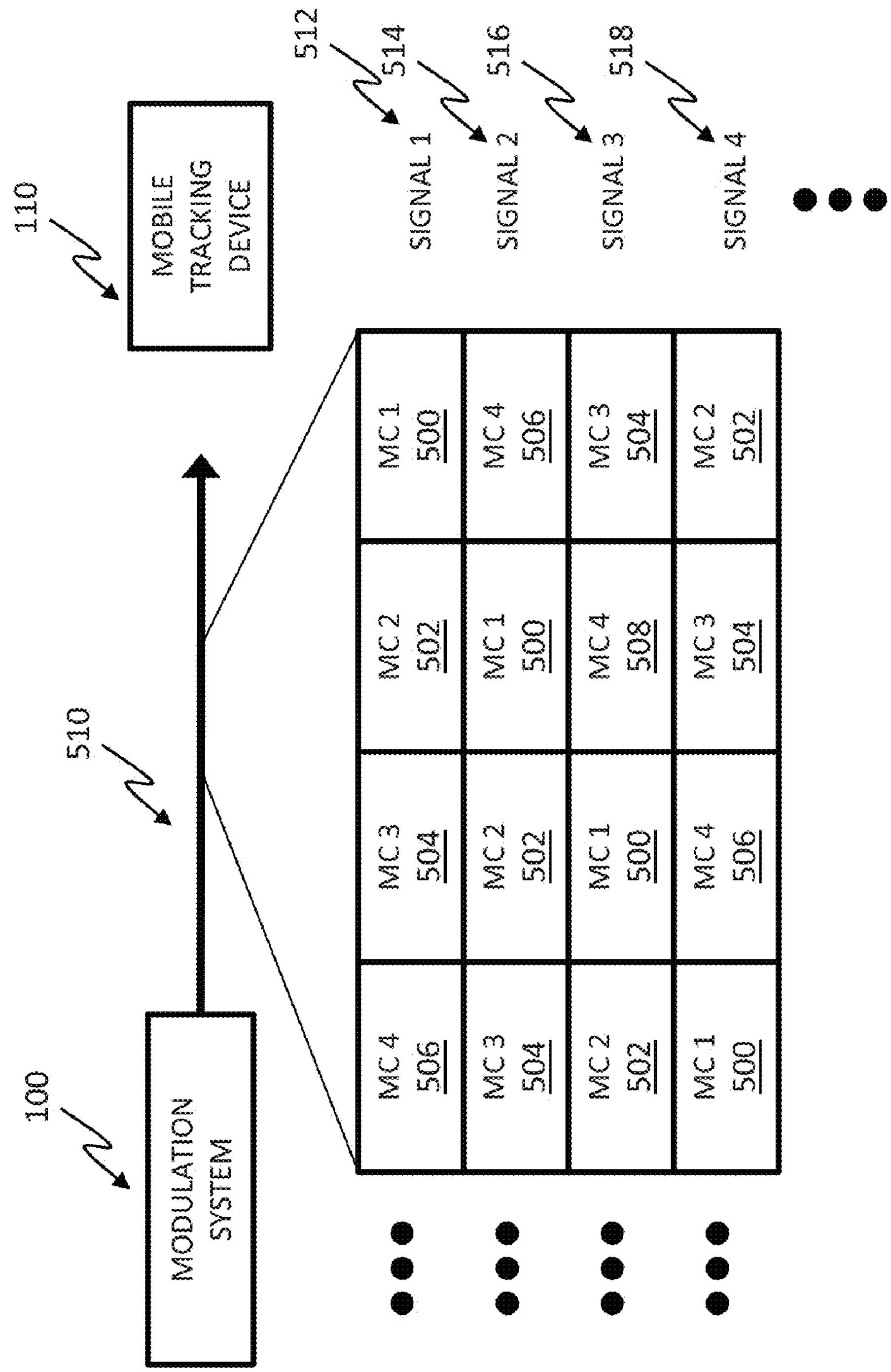

100
MODULATION SYSTEM
110
MOBILE TRACKING DEVICE
510
512
514
516
518
SIGNAL 1
SIGNAL 2
SIGNAL 3
SIGNAL 4
MC 1 500
MC 2 502
MC 3 504
MC 4 506
MC 4 506
MC 1 500
MC 2 502
MC 3 504
MC 3 504
MC 4 508
MC 1 500
MC 2 502
MC 2 502
MC 3 504
MC 4 506
MC 1 500

FIG. 19

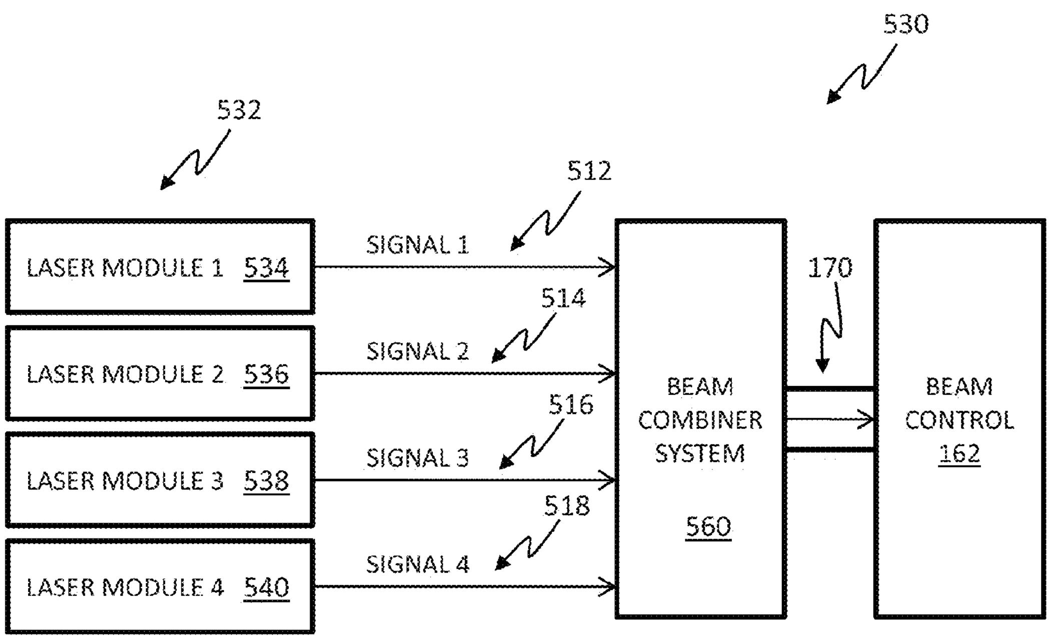

530
532
512
LASER MODULE 1 534
SIGNAL 1
170
514
LASER MODULE 2 536
SIGNAL 2
BEAM COMBINER SYSTEM
560
BEAM CONTROL 162
516
LASER MODULE 3 538
SIGNAL 3
518
LASER MODULE 4 540
SIGNAL 4

FIG. 20

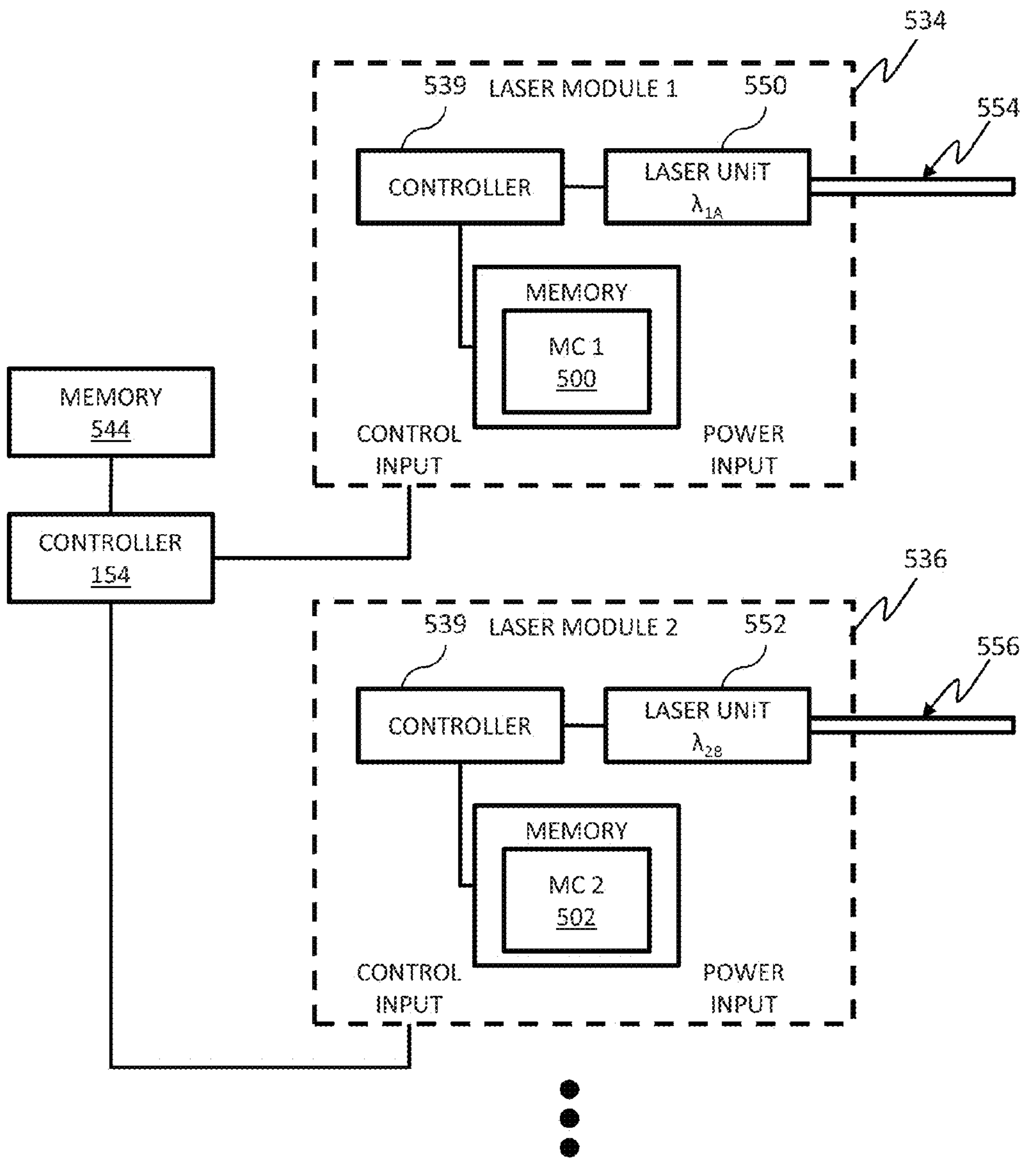

534
539
LASER MODULE 1
550
554
CONTROLLER
LASER UNIT
λ1A
MEMORY
MC 1
500
MEMORY
544
CONTROL
INPUT
POWER
INPUT
CONTROLLER
154
536
539
LASER MODULE 2
552
556
CONTROLLER
LASER UNIT
λ2B
MEMORY
MC 2
502
CONTROL
INPUT
POWER
INPUT

FIG. 21

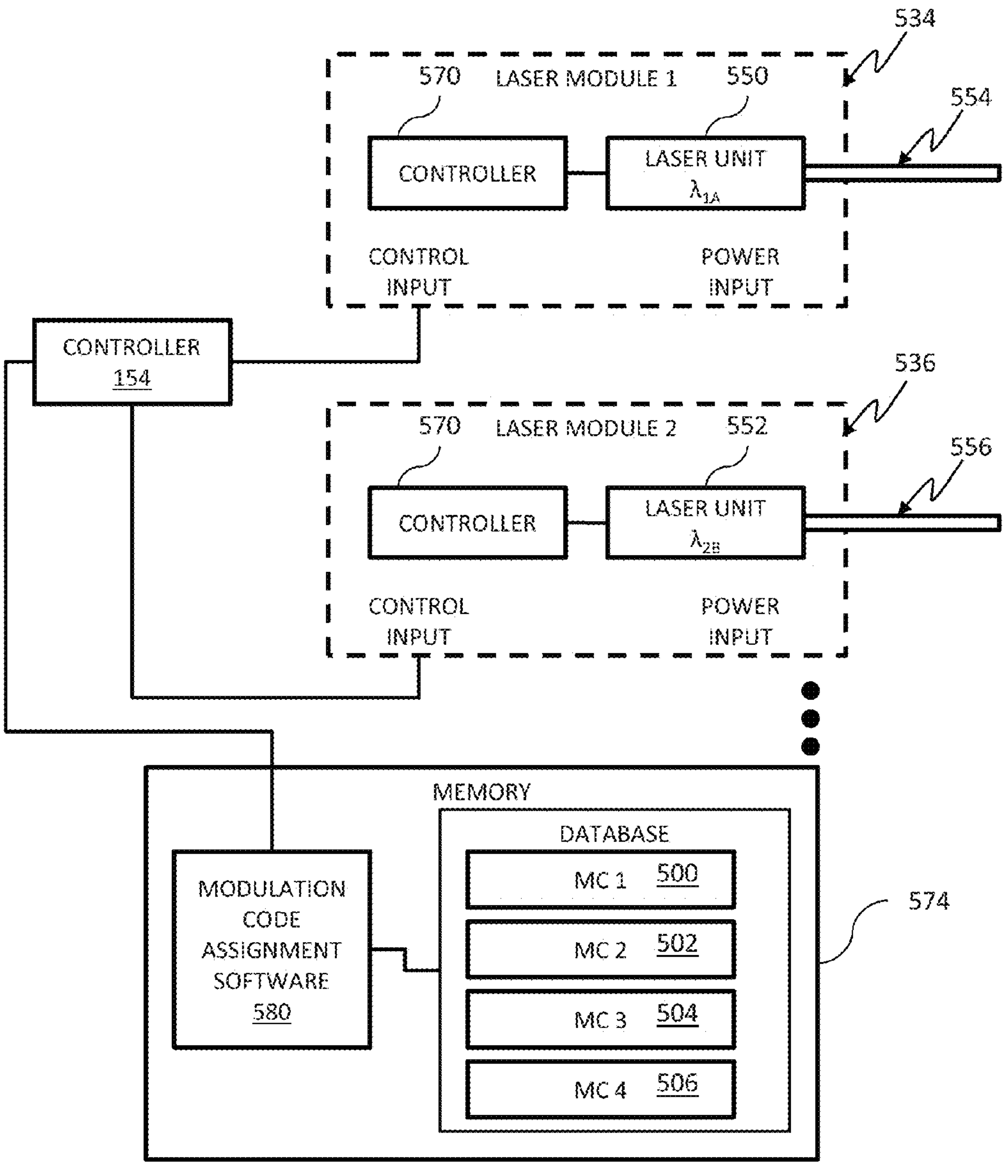

534
570
LASER MODULE 1
550
554
CONTROLLER
LASER UNIT
λ1A
CONTROL INPUT
POWER INPUT
CONTROLLER
154
536
570
LASER MODULE 2
552
556
CONTROLLER
LASER UNIT
λ2B
CONTROL INPUT
POWER INPUT
MEMORY
DATABASE
MC 1 500
MC 2 502
MC 3 504
MC 4 506
MODULATION CODE ASSIGNMENT SOFTWARE
580
574

FIG. 22

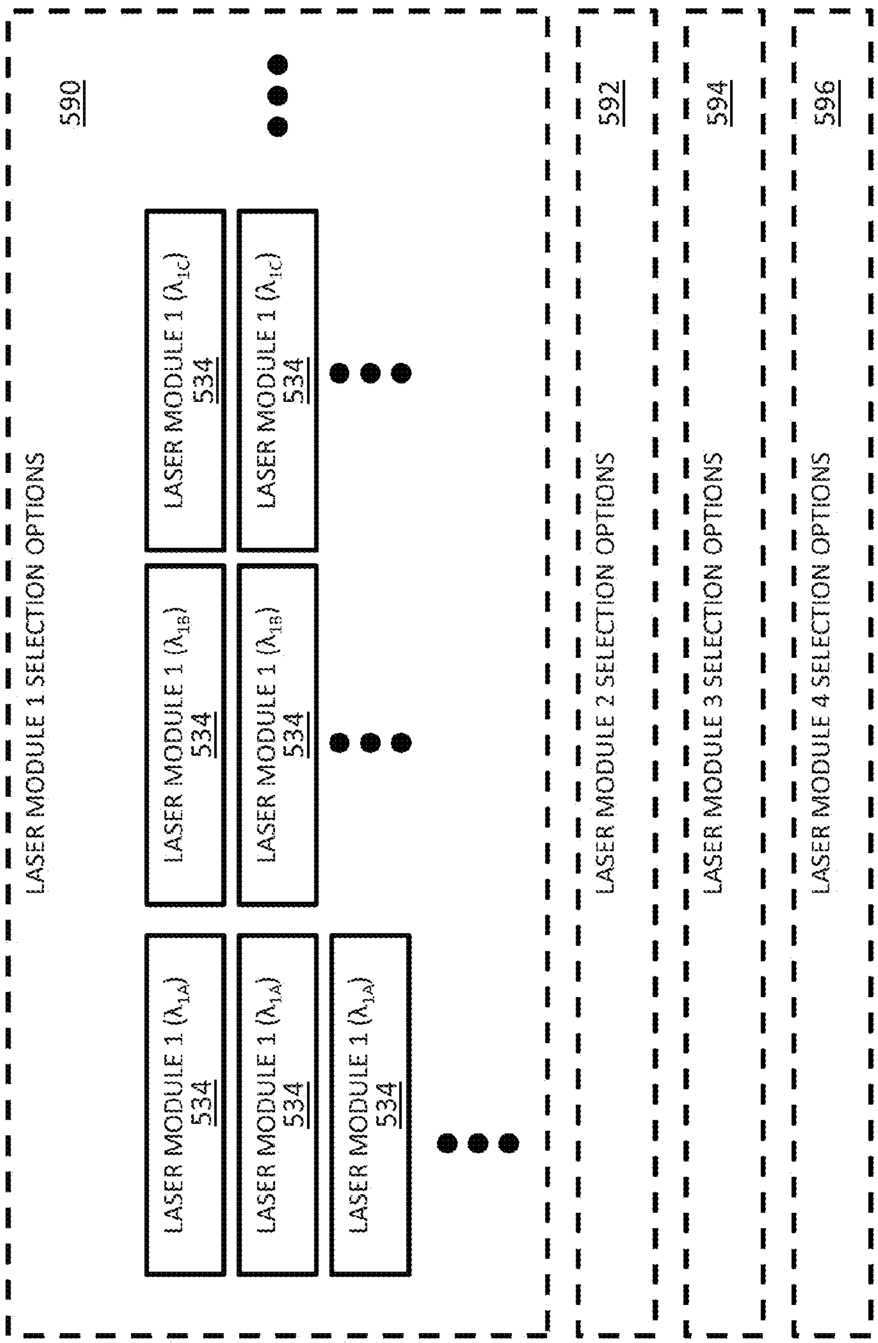

LASER MODULE 1 SELECTION OPTIONS
590
LASER MODULE 1 (λ_{1A}) 534
LASER MODULE 1 (λ_{1A}) 534
LASER MODULE 1 (λ_{1A}) 534
LASER MODULE 1 (λ_{1B}) 534
LASER MODULE 1 (λ_{1B}) 534
LASER MODULE 1 (λ_{1C}) 534
LASER MODULE 1 (λ_{1C}) 534
LASER MODULE 2 SELECTION OPTIONS
592
LASER MODULE 3 SELECTION OPTIONS
594
LASER MODULE 4 SELECTION OPTIONS
596

FIG. 23

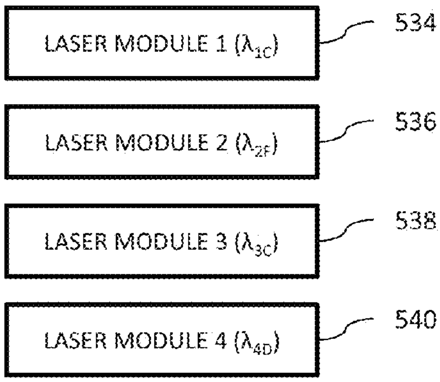


FIG. 24

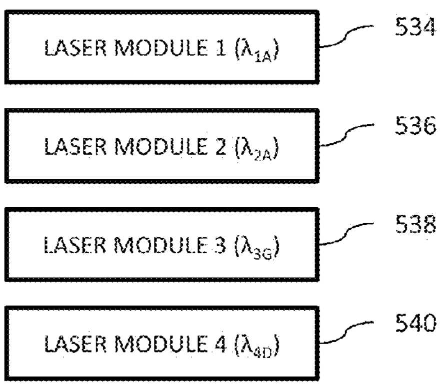


FIG. 25

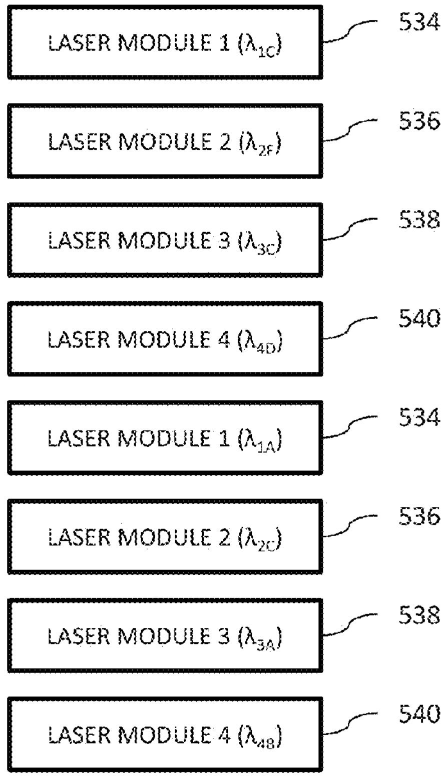


FIG. 26

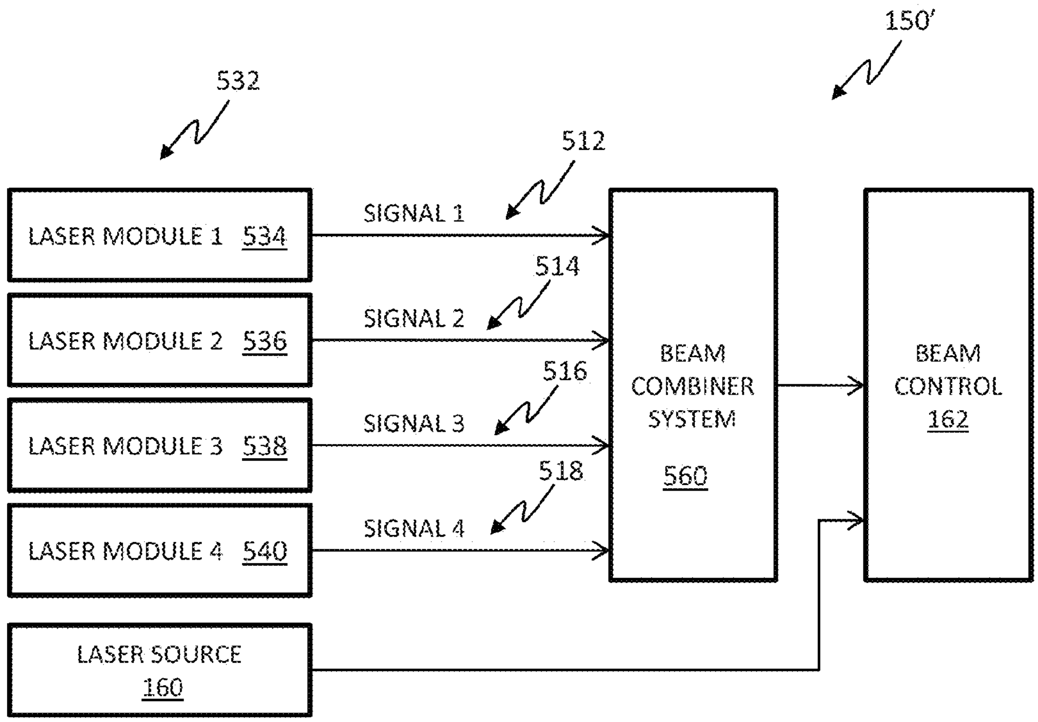

150'
532
512
514
516
518
LASER MODULE 1 534
LASER MODULE 2 536
LASER MODULE 3 538
LASER MODULE 4 540
LASER SOURCE 160
SIGNAL 1
SIGNAL 2
SIGNAL 3
SIGNAL 4
BEAM COMBINER SYSTEM 560
BEAM CONTROL 162

FIG. 27

MODULATION DEVICE FOR A MOBILE TRACKING DEVICE

RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 12/541,772, filed Aug. 14, 2009, the disclosure of which is expressly incorporated by reference herein. U.S. patent application Ser. No. 12/778,892, filed May 12, 2010 now U.S. Pat. No. 8,305,252, titled SCENE ILLUMINATOR, and U.S. patent application Ser. No. 12/778,643, filed May 12, 2010, titled HIGH POWER LASER SYSTEM are expressly incorporated by reference herein.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

The invention described herein was made in the performance of official duties by employees of the Department of the Navy and may be manufactured, used and licensed by or for the United States Government for any governmental purpose without payment of any royalties thereon.

BACKGROUND OF THE INVENTION

The present invention relates generally to a modulation device which causes a mobile tracking device to not approach closer to an asset, and more particularly, to a modulation device which directs the mobile tracking device away from the asset or disables the tracking device.

Presently, a multitude of mobile tracking devices are known which identify an asset and attempt to move closer to the asset and potentially contact the asset. Examples of mobile tracking devices include infrared based mobile tracking devices which examine the infrared energy which is emitted by the asset and detected by the mobile tracking device. These infrared mobile tracking devices alter their direction of travel to track the highest infrared energy being detected within their field of view. Such mobile tracking devices may rely on a non-imaging detection system or an imaging detection system.

There are several devices available to misdirect a mobile infrared tracking device away from an asset. One exemplary device is infrared hot bodies which appear brighter to the mobile infrared tracking device than the asset. These infrared hot bodies may be expelled by the asset. The mobile tracking device detects the brighter infrared hot bodies and follows the hot bodies as they become further spaced apart from the asset; thereby directing the mobile infrared tracking device away from the asset. Exemplary infrared hot bodies include flares.

Another type of device is a laser device which directs a pulsed or modulated laser signal at a detection system of the mobile tracking device. The pulsed or modulated laser signal is tailored to the specific characteristics of the mobile tracking device. An example of one device which is tailored to multiple types of tracking devices is disclosed in U.S. Pat. No. 6,359,710.

SUMMARY OF THE INVENTION

In an exemplary embodiment of the present disclosure, a modulation device is disclosed. In another exemplary embodiment, a method of interacting with a mobile tracking device is disclosed.

In yet another exemplary embodiment of the present disclosure, an apparatus for interacting with a mobile tracking device is provided. The apparatus comprising: a body; at least

one propulsion device supported by the body; a plurality of sensor modules supported by the body which monitor the environment surrounding the body; and a controller operatively connected to the plurality of sensor modules. The controller determining a presence of the mobile tracking device in the environment surrounding the body based on information collected by the plurality of sensor modules and a current location of the mobile tracking device. The apparatus further comprising a modulation system which receives the current location of the mobile tracking device from the controller, orients a tracking system of the modulation system based on the current location of the mobile tracking device, detects the mobile tracking device, updates the location of the mobile tracking device, and directs a continuous beam of optical energy at the mobile tracking device.

In a further exemplary embodiment, a method for keeping a mobile tracking device away from an asset is provided. The mobile tracking device having a seeker head which is directed at an asset due to the infrared energy radiated by the asset. The method comprising the steps of: directing an output of a continuous wave laser at the seeker head along a first direction of travel of the mobile tracking device, the output of the continuous wave laser being infrared energy; and propagating the infrared energy from the continuous wave laser into the seeker head of the mobile tracking device to generate at least one localized source within the mobile tracking device and within a field of view of the mobile tracking device which indicates a second direction of travel for the mobile tracking device.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description when taken in conjunction with the accompanying drawings.

FIG. **1** illustrates a representative view of a modulation device and associated asset;

FIG. **2** is a view of a representative asset;

FIG. **2**A illustrates the representative asset of FIG. **2** with a mobile tracking device approaching the representative asset along a first direction and optical energy from the modulation device being directed at the mobile tracking device;

FIG. **2**B illustrates the mobile tracking device changing its direction of travel to a second direction due to the optical energy directed from the modulation device at the mobile tracking device;

FIG. **2**C illustrates the mobile tracking device changing its direction of travel to a third direction due to the optical energy directed from the modulation device at the mobile tracking device;

FIG. **2**D illustrates the mobile tracking device changing its direction of travel to a fourth direction due to the optical energy directed from the modulation device at the mobile tracking device;

FIG. **3** illustrates an exemplary mobile tracking device;

FIG. **4** illustrates an exemplary laser source;

FIG. **5** illustrates a perspective view of a modulation device wherein portions of the housing are shown in phantom;

FIG. **6** illustrates a first arrangement of components of a power supply of the modulation device;

FIG. **7** illustrates a second arrangement of components of a power supply of the modulation device;

FIG. **8** illustrates a processing sequence for charging the battery source of the modulation device;

FIG. **9** illustrates a representative view of a modulation device and associated asset;

FIGS. **10**A and **10**B illustrate a processing sequence for engaging a mobile tracking device;

FIG. **11** illustrates a representative asset being tracked by a representative mobile tracking device;

FIGS. **12** and **13** represent the response characteristics of a mobile tracking device following an asset; and

FIGS. **14** and **15** represent the response characteristics of a mobile tracking device following an asset and being subsequently illuminated by a modulation device;

FIG. **16** illustrates a method of countering a mobile tracking device with a modulation device;

FIGS. **17**A-D illustrate exemplary mobile tracking device specific optical codes for an IR mobile tracking device;

FIG. **18** illustrates the provision of multiple mobile tracking device specific optical codes to a seeker head of an IR mobile tracking device in parallel according to a first method;

FIG. **19** illustrates the provision of multiple mobile tracking device specific optical codes to a seeker head of an IR mobile tracking device in parallel according to a second method;

FIG. **20** illustrates a first arrangement of an optical transmitter system of the modulation device of FIG. **1** for providing parallel mobile tracking device specific optical codes;

FIG. **21** illustrates exemplary laser modules of the optical transmitter system of FIG. **20** wherein the laser modules include their respective mobile tracking device specific optical codes in a memory of the laser modules;

FIG. **22** illustrates exemplary laser modules of the optical transmitter system of FIG. **20** wherein the laser modules receive their respective mobile tracking device specific optical codes from a controller of the modulation system;

FIG. **23** illustrates a plurality of laser modules for inclusion in the optical transmitter system of FIG. **20**, wherein the plurality of laser modules are divided into respective groupings;

FIGS. **24** and **25** illustrate laser modules selected for a first modulation device and a second modulation device, at least one of the laser modules of the first modulation device having different wavelengths from the laser modules of the second modulation device;

FIG. **26** illustrates exemplary laser modules for a respective modulation device wherein at least two laser modules are selected from each grouping to combat filtering of the seeker head of the IR mobile tracking device; and

FIG. **27** illustrates another arrangement of an optical transmitter system of the modulation device of FIG. **1** for providing parallel mobile tracking device specific optical codes and including a separate high power laser.

Corresponding reference characters indicate corresponding parts throughout the several views. Although the drawings represent embodiments of various features and components according to the present disclosure, the drawings are not necessarily to scale and certain features may be exaggerated in order to better illustrate and explain the present disclosure. The exemplification set out herein illustrates embodiments of the invention, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE DRAWINGS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings, which are described below. The embodiments disclosed below are not intended to be exhaustive or limit the invention to the precise form disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art may utilize their teachings. It will be understood that no limitation of the scope of the invention is thereby intended. The invention includes any alterations and further modifications in the illustrated devices and described methods and further applications of the principles of the invention which would normally occur to one skilled in the art to which the invention relates.

The present disclosure is directed to modulation devices which are implemented to protect aircraft, such as commercial airlines and military aircraft. However, the principles discussed herein are applicable to other types of assets. Exemplary assets include moveable assets, such as aircraft, ships, buses, or trucks, or land based assets, such as an airport, factory, building, or facility. Exemplary modulation devices include countermeasure devices.

Referring to FIG. **1**, a modulation device **100** is shown. Modulation device **100** is coupled to an asset **102**. For purposes of discussion, asset **102** is considered to be an airplane, such as the airplane designated **102** in FIG. **2**. However, the present disclosure is contemplated for use with a multitude of different assets. Airplane **102** includes a body or fuselage **104**, a pair of main wings **105**, tail wings **106**, and a plurality of propulsion devices **108**. Exemplary propulsion devices include jet engines, internal combustion engines with associated propellers, and any other suitable engine arrangement.

Referring to FIG. **3**, components of a mobile tracking device **110** are shown. Mobile tracking device **110** includes a propulsion system **112** which provides power to propel mobile tracking device **110**. Exemplary propulsion systems include solid fuel rockets, engines, and any other suitable devices for providing power to mobile tracking device **110**. Mobile tracking device **110** also includes a guidance system **114** which controls the direction of travel of mobile tracking device **110**. Exemplary guidance system components include wings for an airborne mobile tracking device **110**, a rudder for a marine mobile tracking device **110**, and ground engaging members for a land based mobile tracking device **110**. The guidance system **114** steers mobile tracking device **110** to change a direction of travel of mobile tracking device **110**. Exemplary airborne tracking devices include rockets, airplanes, and other flying devices. Exemplary marine tracking devices include boats (see FIG. **11**), submersible devices, and other marine devices. Exemplary land based tracking devices include wheeled devices, tracked devices, and other suitable land based devices.

Mobile tracking device **110** includes a controller **116** which controls the operation of propulsion system **112** and guidance system **114**. Mobile tracking device **110** also includes a gimbaled seeker head **115** which is able to move independent of the remainder of mobile tracking device **110**. Seeker head **115** supports controller **116**, a detector **118**, telescope **120**, a reticule **122**, and optics **124**.

In operation, electromagnetic radiation **126** from the environment enters an optical window **128** of mobile tracking device **110**. Optical window **128** may be a dome. Optical window **128** may be selected to only pass electromagnetic radiation **126** within a certain wavelength band. For instance, in the case of an infrared mobile tracking device **110**, optical window **128** may only pass electromagnetic radiation **126** within the infrared spectrum or a portion of the infrared spectrum. In other embodiments, a separate filter **125** is included somewhere within the optical setup of mobile tracking device **110** to limit the range of wavelengths of electromagnetic radiation **126** passed on to detector **118**. Filter **125** is shown between optical window **128** and telescope **120**.

However, filter **125** may be positioned anywhere between optical window **128** and detector **118**.

The electromagnetic radiation **126** is received by telescope **120**. Telescope **120** includes a primary mirror **121** which focuses the electromagnetic radiation **126** towards a secondary mirror **123**. Secondary mirror **123** in turn focuses the electromagnetic radiation **126** towards reticule **122**. Reticule **122** spins to provide a modulated signal of the electromagnetic radiation. Optics **124** receives and focus the modulated signal of the electromagnetic radiation **126** passing through reticule **122** onto detector **118** which is a non-imaging detector.

Controller **116** receives input from detector **118** which is used by controller **116** to determine the location the brightest object in the environment, typically asset **102**. The modulated signal allows controller **116** to discriminate between background electromagnetic radiation and the radiation of asset **102**, as well as, determine the location of asset **102** relative to a direction of travel of mobile tracking device **110**. Based on this input from detector **118**, controller **116** determines a desired direction of travel for mobile tracking device **110** which corresponds to tracking device **110** heading towards asset **102**. Seeker head **115** is adjusted to center the brightest object in the environment so that seeker head **115** is pointed directly at the brightest object. Controller **116** provides this adjustment of seeker head **115** (from its intended orientation in line with the direction of travel of mobile tracking device **110**) to guidance system **114** as error signal **129**. Guidance system **114** uses this error signal **129** to alter the direction of travel of mobile tracking device **110**. Over time, if mobile tracking device **110** is tracking asset **102** mobile tracking device **110** will be pointed at asset **102** and seeker head **115** generally produces a small error signal which is indicative of mobile tracking device **110** being aligned to intercept asset **102**.

In the embodiment illustrated in FIG. **3**, mobile tracking device **110** includes a spinning reticule **122**. In another embodiment, mobile tracking device **110** does not include reticule **122** but rather secondary mirror **123** is tilted and telescope **120** is spun to produce a signal for controller **116**. In one embodiment, detector **118** is an imaging detector and controller **116** processes the images from detector **118** to determine the location of asset **102**.

Returning to FIG. **2**, airplane **102** includes warning/cuing system **130** which detects when a mobile tracking device **110** has been launched and/or is tracking airplane **102**. Warning/cuing system **130** includes sensor modules **131** which monitor the environment around airplane **102**. Illustratively, four sensor modules **131**A-D are shown. Depending on the asset **102** being protected, fewer or additional sensor modules **131** may be used. In one embodiment, sensor modules **131** include focal plane array sensors with wide field of views that continuously survey the environment for mobile tracking devices **110**. In one embodiment, warning/cuing system **130** looks for a characteristic signal that indicates the launch of an airborne mobile tracking device **110**. In the case of airborne mobile tracking device **110**, the mobile tracking device **110** has a characteristic infrared and ultraviolet signature which warning/cuing system **130** recognizes as an airborne mobile tracking device **110**.

Exemplary warning/cuing systems include Model No. AAR-54 EWS available from Northrup Grumman Corporation located in Los Angeles, Calif. As explained herein, warning/cuing system **130** communicates with modulation device **100**. Modulation device **100**, in turn, provides optical energy from a continuous wave laser to redirect mobile tracking device **110** from tracking the path of asset **102** or to disable mobile tracking device **110**. In one embodiment, warning/cuing system **130** is provided as part of modulation device **100** instead of as a separate component of airplane **102**.

Airplane **102** further includes a fire control system **140**. Fire control system **140** interprets information provided by warning/cuing system **130** and provides a user interface **142** through which the operator of asset **102** activates modulation device **100**. In one embodiment, user interface **142** includes a user input **143** to enable modulation device **100** and a user input **145** to permit modulation device **100** to fire. In one embodiment, modulation device **100** is automatically activated when asset **102** is moving. Exemplary inputs include switches, buttons, and other suitable types of user inputs.

Returning to FIG. **1**, modulation device **100** is represented. Modulation device **100** includes an optical transmitter system **150**, a power system **152**, a system controller **154**, and a cooling system **156**. Each of optical transmitter system **150**, power system **152**, and cooling system **156** are coupled to system controller **154**. System controller **154** receives input from and provides instructions to each of optical transmitter system **150**, power system **152**, and cooling system **156** to control the operation of modulation device **100**. As explained herein, in one embodiment, modulation device **100** is housed in a self-contained pod which may be coupled to asset **102**.

Optical transmitter system **150** includes a laser source module **160** and a beam control module **162**. Laser source module **160** includes a high voltage power supply **164** which receives power from power system **152**. High voltage power supply **164** drives a continuous wave laser **166**. In one embodiment, continuous wave laser **166** is a continuous wave fiber laser. In one embodiment, continuous wave laser **166** is a continuous wave Ytterbium single mode fiber laser. Details regarding an exemplary continuous wave laser **166** are provided in U.S. patent application Ser. No. 11/973,437, filed Oct. 9, 2007 titled POWERFUL FIBER LASER SYSTEM, now U.S. Pat. No. 7,593,435, assigned to IPG Photonics Corporation, the disclosure of which is expressly incorporated by reference herein. Details regarding an exemplary continuous wave laser **166** are provided in U.S. patent application Ser. No. 11/611,247, filed Dec. 15, 2006 titled FIBER LASER WITH LARGE MODE AREA FIBER, now abandoned, assigned to IPG Photonics Corporation, the disclosure of which is expressly incorporated by reference herein. In one embodiment, continuous wave laser **166** is a solid state laser. Other exemplary continuous wave lasers include a 2.0 micrometer (μm) Thulium Fiber Laser (1.96-2.2 (μm) Thulium laser) having an output power of about at least 1 kW and a 1.0 μm, 800 Watt Direct Diode. An exemplary Thulium fiber laser is disclosed in U.S. Pat. No. 6,801,550, the disclosure of which is expressly incorporated by reference herein.

Referring to FIG. **4**, an exemplary configuration of continuous wave laser **166** is shown. Continuous wave laser **166** includes a plurality of individual modules **300** each of which provide a single mode 1.07 μm output beam. The output of each of modules **300** is combined together through a module combiner **302** which brings the energy together in a single beam. This combined beam is coupled to an optical conduit **170** through a quartz coupler **304**. Although three laser modules **300** are illustrated, any number of laser modules **300** may be included.

The components of a given laser module **300** are also shown in FIG. **4**. The laser module **300** includes a plurality of diode lasers **310** each of which are coupled into a respective Ytterbium fiber **312**. The output of the Ytterbium fibers **312** are combined through a fiber combiner **314** which brings the energy together. This energy is fed through a coupler **315** into an Ytterbium fiber optic gain medium **316** which produces therefrom a single mode 1.07 μm output beam. Although three diode laser sets **310** are illustrated any number of diode laser sets **310** may be included.

In one embodiment, the power of continuous wave laser **166** is about 3 kilowatts (kW). In one embodiment, the power level of continuous wave laser **166** is about 5 kW. In one embodiment, the power level of continuous wave laser **166** is about 10 kW. In one embodiment, the power level of continuous wave laser **166** is about 20 kW. In one embodiment, the power level of continuous wave laser **166** is about 50 kW. In one embodiment, the power level of continuous wave laser **166** is between about 3 kW and 20 kW. In one embodiment, the power level of continuous wave laser **166** is at least 3 kW.

Returning to FIG. **1**, the optical energy produced by continuous wave laser **166** is communicated to beam control module **162** through optical conduit **170**. An exemplary optical conduit **170** is a fiber optic cable.

Beam control module **162** includes a beam expander **172** and a positioning system **174**. Beam expander **172** receives the optical energy from optical conduit **170** and provides a generally collimated beam **176** of optical energy which exits modulation device **100**. An exemplary beam expander is a Cassegrain telescope. Optical energy from optical conduit **170** is provided at a focus of the Cassegrain telescope which then generally collimates this optical energy to produce the expanded beam of optical energy **176**. In one embodiment, a path length of beam expander **172** may be automatically adjusted by system controller **154** to change output beam **176** from a generally collimated beam of optical energy to a focused beam of optical energy. In this case, beam expander **172** may serve both as a beam expander (collimator) and focusing optics. In one embodiment, beam control module **162** also includes separate focusing optics **177** which focus the output beam **176** at a given distance from modulation device **100**.

Positioning system **174** alters the direction in which collimated beam **176** is directed. Referring to FIG. **5**, an exemplary configuration of modulation device **100** is shown. Modulation device **100** includes a housing **180** which houses system controller **154**, power system **152**, cooling system **156** and laser source module **160** of optical transmitter system **150**. Provided on a lower side of housing **180** is positioning system **174**. Positioning systems **174** includes a housing **182** coupled to housing **180** and a rotatable head **184** which is rotatable in directions **186** and **188**. In one embodiment, the rotatable head **184** has a pointing accuracy of up to 25 microradians. Rotatable head **184** includes an optical window **190** through which output beam **176** is directed. Output beam **176** is generally a directed beam and is not radiated in all directions. In one embodiment, positioning system **174** also includes at least one reflector **179** which may be controlled to alter the direction output beam **176** in directions **187** and **189**. The reflector **179** may be tilted to alter the elevation of collimated beam **176** by positioning system **174**.

Housing **180**, in the illustrated embodiment, is a pod which is detectably coupled to airplane **102** (see FIG. **2**). Referring to FIG. **5**, housing **180** includes a set of couplers **181** which cooperate with couplers **183** on asset to couple housing **180** to airplane **102**. In one embodiment, housing **180** is coupled to airplane **102** by any suitable conventional mechanism which permits housing **180** to be later detached from airplane **102**. An exemplary system is the coupling system used with the AN/AAQ-28(V) LITENING targeting pod commercially available from Northrop Grumman Corporation located in Los Angeles, Calif.

Returning to FIG. **1**, power system **152** includes a power source **200**. In one embodiment, power source **200** is a plurality of batteries. The batteries may be rechargable batteries. Exemplary rechargeable batteries include lithium-ion batteries and lithium polymer batteries. Exemplary lithium-ion batteries include commercially available cells, such as those available from A123 Systems located in Watertown, Mass. In one embodiment, a plurality of lithium-ion cells are assembled into a battery pack **202** (see FIG. **5**). In one embodiment, these cells have a nominal amp-hour rating of 2.3 Ah and a nominal load voltage of 3.3 DCV/cell. Based thereon, battery pack **202** should be able to deliver 52.8 Vat 2.3 amps for 1 hour. Under high load (10 C (10×5×2.3 or 115 Amps)) the voltage will "squat" to approximately 2.8 volts/cell. At this level the battery pack **202** could deliver 45 Vat 115 amps (or 5 kW) for 6 min. Under severe load (20 C (20×5*2.3) or 230 amps)) the voltage would squat to approximately 2.5 volts. At this level the battery pack **202** could deliver 40 V at 230 amps (or 9 kW) for about a half minute. In one embodiment, battery pack **202** provides 28 VDC power for modulation device **100**.

The use of battery pack **202** allows high power to be provided to laser source module **160** without causing a large power spike requirement in the power system of asset **102**. In essence, battery pack **202** acts as a capacitor for laser source module **160**.

In one embodiment, continuous wave laser **166** is a three kilowatt Yterrbium single mode fiber laser such as ones commercially available from IPG Photonics located at IPG Photonics Corporation, 50 Old Webster Road Oxford, Mass. 01540 USA and power supply **152** provides about 28 VDC. In general, commercial laser sources from IPG Photonics include an AC-to-DC converter to convert power from an AC source to DC power for continuous wave laser **166**. Since power supply **152** already provides DC power, when a commercial laser source is being used for continuous wave laser **166** the AC-to-DC converter is removed and replaced with a DC driving circuit **320** (see FIGS. **6** and **7**) which corresponds high voltage power supply **164**. DC driving circuit **320** provides power from power supply **152** to continuous wave laser **166** and regulates the power level provided.

Referring to either FIG. **6** or FIG. **7**, continuous wave laser **166** is represented. Continuous wave laser **166**, as explained in connection with FIG. **4**, includes a laser pump system **322** which includes a plurality of laser diodes **310**. Laser diodes **310** provide the pump energy for the lasing medium **316** of continuous wave laser **166**. The lasing medium **316** is provided as part of a fiber optical cable. The output of the lasing medium **316** is provided to optical conduit **170**.

In FIG. **6**, power supply **152** is coupled to laser diodes **183** through DC driving circuit **320** which includes a single voltage regulator **326** that powers laser diodes **310**. In FIG. **7**, power supply **152** is coupled to laser diodes **310** through DC driving circuit **320** which includes a plurality of current regulators **328**. Each current regulator **328** provides the power to one of the modules **300** (see FIG. **4**) to provide power to the diodes of that module **300**.

Referring to either FIG. **6** or FIG. **7**, power supply **152** may be charged with a battery charger **330** coupled to a prime power source **332**. Battery charger **330** is contained within housing **180**. Exemplary prime power sources include a standard AC wall outlet. Power supply **152** includes a battery management interface **334** which controls the recharging of the batteries with battery charger **330**.

In one embodiment, power system **152** is recharged by a power source **338** of the asset **102**. An exemplary power source **338** is a DC generator of asset **102**. Referring to FIG. **8**, a controller of asset **102** determines if asset **102** is operating and stationary (or otherwise operating at a low power level), as represented by block **350**. The controller checks an operational sensor **352** to determine if asset **102** is operational. Exemplary operational sensors include engine sensors which indicate the operation of propulsion devices **108**. The controller also checks in the case of an airplane **102**, a wheel down sensor **354**, which indicates when the landing gear of airplane **102** is lowered. If the controller determines that airplane **102** is stationary (wheels down) and operational, then the controller provides charging energy to battery charger **330**, as represented by block **356**. In one embodiment, airplane **102** does not need to be stationary, but rather only be operating at a low power level, such as flying at a moderate speed. In this case, the controller monitors a power load of airplane **102** and provides charging energy to battery charger **330** when the power load is below a threshold amount.

Cooling system **156** provides cooling to the other components of modulation device **100**. In one embodiment, cooling system **156** provides cooling to laser source module **160**. In one embodiment, cooling system **156** provides cooling to laser source module **160** and the optical components of beam control module **162**. In one embodiment, cooling system **156** provides cooling fluid to power system **152**, laser source module **160**, and the optical components of beam control module **162**. Cooling system **156** may be either air-cooled or liquid cooled. Exemplary cooling systems are provided from Thermo Tek, Inc. located at 1200 Lakeside Parkway, Suite 200 in Flower Mound, Tex.

As indicated in FIG. **1**, the components of modulation device **100** are coupled to each other and to asset **102** through a digital communication system. In one embodiment, the digital communication system includes a common bus for the components within modulation device **100**. Although a digital communication system is illustrated, any suitable connection is acceptable between the components, such as analog connections. In one embodiment, laser source module **160** is coupled to enable input **143** and fire input **145** through discrete connections outside of the digital communication system. Further, warning/cuing system **130** is coupled to system controller **154** through a separate communication connection. An exemplary communication connection is the MIL-STD-1553 Bus.

Referring to FIG. **9**, in one embodiment, modulation device **100** also includes a target tracking and beam pointing system **210**. Target tracking and beam pointing system **210** monitors the scene surrounding asset **102**. In one embodiment, beam pointing system **210** includes a vision system, illustratively a FLIR system **212**, which provides images of the scene surrounding asset **102**. FLIR system **212**, illustratively, has a separate optical window **178** through which the vision system monitors the location of mobile tracking device **110**. In one embodiment, FLIR system **212** uses the same optical window **190** as output beam **176** and is bore sighted to output beam **176**.

Referring to FIGS. **10**A and **10**B, an operation of modulation device **100** is illustrated. Referring to FIG. **10**A, a check is made by a controller **132** of asset **102** whether warning/cuing system **130** is active, as represented by block **360**. Further, warning/cuing system **130** is set to survey mode, as represented by block **362**. In survey mode, warning/cuing system **130** monitors the environment around asset **102** to determine if a mobile tracking device **110** is approaching asset **102**, as represented by block **364**. If a mobile tracking device **110** is detected by warning/cuing system **130**, then the controller **132** of asset **102** determines the coordinates of mobile tracking device **110**, as represented by block **366**. Warning/cuing system **130** may also sound an alarm or provide another indication of mobile tracking device **110** to the operator of asset **102**. Exemplary coordinates for the case when the asset is airplane **102** are the azimuth and elevation angles of mobile tracking device **110** relative to airplane **102**.

The controller **132** of asset **102** passes the coordinates of mobile tracking device **110** to modulation device **100**, as represented by block **368**. Modulation device **100** moves rotatable head **184** to the specified angular position and FLIR system **212** is directed at the specified coordinates. FLIR system **212** may be gimbaled to move independently within housing **180**. The controller **132** of asset **102** determines if mobile tracking device **110** has acquired mobile tracking device **110** with tracking module **210**, as represented by block **370**. If modulation device **100** has not acquired mobile tracking device **110**, new coordinates of mobile tracking device **110** are determined and passed again to modulation device **100**. As such, modulation device **100** remains slaved to controller **132**. If modulation device **100** has acquired mobile tracking device **110** then the initial coordinates corresponding to the lock on location of mobile tracking device **110** are saved by system controller **154**, as represented by block **371**.

Next, system controller **154** of modulation device **100** checks to see if modulation device **100** is authorized to fire continuous wave laser **166**, as represented by block **372**. Continuous wave laser **166** is authorized to fire when fire input **145** is set to fire. If continuous wave laser **166** is not authorized to fire, then an indication of this is provided to the operator of modulation device **100**, as represented by block **374**. Exemplary indications include visual alarms, audio alarms, tactile alarms, and combinations thereof. If continuous wave laser **166** is authorized to fire, then continuous wave laser **166** is fired at mobile tracking device **110**. Beam control module **162** has already adjusted the output direction of collimated beam **176** to coincide with the direction to modulation device **100**.

After modulation device **100** has acquired mobile tracking device **110**, beam pointing system **210** tracks the location of mobile tracking device **110** and updates the coordinates for mobile tracking device **110**, as represented by block **379**. Beam control module **162** rotates and reflector **179** tilts, as necessary, to maintain collimated beam **176** on mobile tracking device **110**.

The position of beam control module **162** is monitored to determine when it has moved a threshold amount, as represented by block **378**. Once mobile tracking device **110** has changed direction by a threshold amount, it no longer is locked on asset **102** and the threat to asset **102** is neutralized. This change in direction of mobile tracking device **110** is indicated by the change in direction of beam control module **162** to keep collimated beam **176** on mobile tracking device **110**. Once the threshold amount is reached, continuous wave laser **166** is deactivated as represented by block **381**. Control is again passed back to warning/cuing system **130** to monitor for additional mobile tracking devices **110**.

In one embodiment, the threshold amount is about 10 degrees in either the azimuth or elevation directions. In one embodiment, the threshold amount is about 5 degrees in either the azimuth or elevation directions. In one embodiment, the threshold amount is about 3 degrees in either the azimuth or elevation directions. In one embodiment, system controller **154** monitors the time since mobile tracking device **110** was acquired by modulation device **100** and deactivates continuous wave laser **166** once a threshold amount of time has passed.

In one embodiment, beam pointing system **210** has a narrower field of view than sensor modules **131** of warning/cuing system **130**. As such, sensor modules **131** are able to survey the surrounding environment for mobile tracking device **110** approaching from various directions, while beam pointing system **210** is fixed on the narrow portion of the environment surrounding a detected mobile tracking device **110**.

In one embodiment, warning/cuing system **130** is integrated into modulation device **100** and system controller **154** detects the launch of a mobile tracking device **110** based on the images captured by warning/cuing system **130**. Although various tasks are discussed as being carried out by one of warning/cuing system **130**, controller **132**, and system controller **154**, these may be carried out by a common controller.

As mentioned herein output beam **176** is produced by a continuous wave laser **166**. Output beam **176** is able to defeat mobile tracking devices **110** which modulate the incoming electromagnetic radiation even though output beam **176** is not pulsed and contains no mobile tracking device specific optical codes. Output beam **176** is also effective against imaging detection systems of more advanced mobile tracking device **110**. Exemplary mobile tracking device specific optical codes include jamming codes.

Referring to FIG. **11**, a ship **380** is shown having a rudder **382** and modulation device **100**. Also shown is a second ship **384** having a rudder **386** which directs the direction of travel of second ship **384**. Second ship **384** also incorporates a mobile tracking device **110**. Second ship **384** is attempting to track first ship **380** and close the distance between first ship **380** and second ship **384**. Mobile tracking device **110** generates course correction signals for second ship **384** so that second ship **384** continues to close on first ship **380**. In this example, mobile tracking device **110** does not include a separate propulsion system **112** and guidance system **114**. Rather, second ship **384** has its own propulsion system, such as an engine, and rudder **386** directs the travel path of second ship **384** based on input from controller **116**.

As illustrated in FIG. **3**, telescope **120** of mobile tracking device **110** attempts to collect a large amount of electromagnetic radiation to extend the viewing range of the modulation device **100**. The distance d indicated in FIG. **11**, corresponds to a viewing distance of mobile tracking device **110** which is the distance at which mobile tracking device **110** is first able to detect first ship **380**. At distances beyond distance d, mobile tracking device **110** is not able to see first ship **380**. Of course, mobile tracking device **110** may be closer to first ship **380** than the distance d and in fact over time mobile tracking device **110** tracks first ship **380** so that second ship **384** closes the distance between second ship **384** and first ship **380**.

Modulation device **100**, upon locking on the position of mobile tracking device **110**, fires continuous wave laser **166** such that output beam **176** is received by telescope **120** of mobile tracking device **110**. Output beam **176** has different effects on mobile tracking device **110** depending on the separation of mobile tracking device **110** from modulation device **100**. Distance d is illustratively divided into three bands, a near distance band **392**, a mid distance band **394**, and a far distance band **396**. At distances in near distance band **392**, the energy of output beam **176** explodes seeker head **115** and destroys mobile tracking device **110**. At distances in mid distance band **394**, the energy of output beam **176** destroys the functionality of detector **118**. In one example, a modulation device **100** including a 3 kW Yterrbium continuous fiber laser as continuous wave laser **166** destroyed a focal plane array detector of a mobile tracking device **110** at a distance of about 3 kilometers.

At distances in far distance band **396**, the energy of output beam **176** produces a plurality of internal localized sources within mobile tracking device **110**. These internal localized sources are produced by the energy of output beam **176** being absorbed by the optical components of mobile tracking device **110** which then reradiate the absorbed energy in multiple wavelengths, similar to a blackbody source. Referring to FIG. **3**, six internal localized sources **400** are illustrated. Sources **400**A and **400**B correspond to filter **125**. Source **400**C corresponds to optical window **128**. Source **400**D corresponds to secondary mirror **123**. Source **400**E corresponds to primary mirror **121**. Source **400**F corresponds to optics **124**. The sources **400** may be produced based on the absorption characteristics of the material of each component or the presence of an imperfection in a component. For instance, optical window **128** may become scratched during travel resulting in an imperfection that produces source **400**C. Although six sources **400** are illustrated, a single source **400** or other number of sources **400** may be produced at various times.

The source **400** produces infrared energy which is brighter than the infrared signature of asset **102** being tracked by mobile tracking device **110**. As such, controller **116** of mobile tracking device **110** interprets the respective source **400** as asset **102** instead of asset **102** itself. If source **400** is off-axis, this will cause controller **116** to try to center source **400** resulting in error signal **129** being increased. Guidance system **114** will then turn mobile tracking device **110** in an attempt to center source **400**. This results in mobile tracking device **110** turning away from the location of asset **102**. Since source **400** is radiating from a portion of mobile tracking device **110**, it cannot be centered. Output beam **176** does not require a mobile tracking device specific optical code to defeat mobile tracking device **110**. Therefore, no knowledge of the modulation scheme of mobile tracking device **110** is required to defeat mobile tracking device **110**. In one embodiment, the power level of continuous wave laser **166** is about 3 kW exiting modulation device **100**.

Source **400** do not explode mobile tracking device **110**, such as what happens in near distance band **392**, nor is detector **118** of mobile tracking device **110** destroyed, such as what happens in mid distance band **394**. Rather, source **400** confuses controller **116** to believe that one or more (if multiple sources) additional objects are present in the field of view of mobile tracking device **110** with a higher intensity than asset **102**. Controller **116** tracks the brightest object in its field of view and thus attempts to track one of sources **400**, instead of asset **102**.

In far distance band **396**, mobile tracking device **110** is not destroyed, but rather sent off course. As mobile tracking device **110** approaches modulation device **100** the power level of output beam **176** increases exponentially resulting in detector **118** being destroyed in mid distance band **394** and/or mobile tracking device **110** exploding in near distance band **392**. Of course, if mobile tracking device **110** is engaged in far distance band **396** mobile tracking device **110** likely will not enter mid distance band **394** because mobile tracking device **110** will be directed in a different direction due to output beam **176**.

The effects of sources **400** are shown through a comparison of FIGS. **14** and **15** with FIGS. **12** and **13**. Referring to FIG. **12**, a typical response of a mobile tracking device **110** in far distance band **396** is shown. The degree of turn being carried out by a mobile tracking device **110** is proportional to a voltage associated with a gyroscope of the seeker head **115**. In FIG. **12**, a raw voltage of detector **118** is shown as curve **250**. Also shown is the voltage associated with the gyroscope of the seeker head **115** as curve **252**. The amplitude of curve **252** corresponds to error signal **129**. The curve **252** shown in FIG. **12**, represents a mobile tracking device **110** which has locked onto an asset **102** and is following directly behind the asset

102. The Fourier transform of curve 250 is shown in FIG. 13. As shown in FIG. 13, the spectrum 254 for curve 250 is generally tightly defined around 1000 Hz. This is generally consistent with the modulation scheme of the mobile tracking device 110 when it is inline with asset 102.

Referring to FIG. 14, a 3 kilowatt, continuous wave, infrared, Ytterbium single mode fiber laser with an m^2 of 1 was used as continuous wave laser 166 of modulation device 100 associated with an asset 102. In tests, a mobile tracking device 110 was fired at asset 102. Modulation device 100 directed a continuous beam of optical energy 176 at the optical window 128 of mobile tracking device 110. The continuous beam of optical energy causes the generation of sources 400 which are falsely recognized by mobile tracking device 110 as asset 102.

Referring to FIG. 14, the corresponding curves 250' and 252' for the above example are shown. A first portion 260 of curve 250' (and corresponding portion 262 of curve 252') are shown prior to activation of continuous wave laser 166. As shown by portion 262, the travel of mobile tracking device 110 is fairly straight. Continuous wave laser 166 is activated at point 264. This results in detector 118 being flooded with IR energy as represented by the increase in amplitude of curve 250' and the generation of sources 400. The generation of sources 400 appears to be later in time potentially indicating the need for the components of mobile tracking device 110 to heat up to cause sources 400. At portion 264 of curve 252' controller 116 is instructing guidance system 114 to turn mobile tracking device 110 more aggressively. This increase in turning of mobile tracking device 110 increases in portion 266 even as the intensity of curve 250' falls in portion 268. This fall in intensity is indicative of mobile tracking device 110 moving far off course so that not as much of collimated beam 176 enters optical window 128. As shown in FIG. 15, the spectrum 254' for curve 250' is considerably broadened compared to spectrum 254 of FIG. 12.

Referring to FIG. 16, mobile tracking device 110 is traveling in a direction towards asset 102, as represented by block 410. This is illustrated in FIG. 2A wherein an airborne mobile tracking device 110 is shown traveling in direction 412 towards asset 102. As explained herein, modulation device 100 fires continuous wave laser 166 to direct output beam 176 towards mobile tracking device 110. This causes the generation of at least one localized source 400 within mobile tracking device 110 which is within a field of view of mobile tracking device 110. These one or more localized sources 400 are brighter than the infrared energy radiated from asset 102 and are generated at locations which do not correspond with the current direction 412 of mobile tracking device 110, as represented by block 414 in FIG. 16. As such, controller 116 attempts to point mobile tracking device 110 at the brighter source 400 and in doing so changes the direction of mobile tracking device 110 to direction 416 as shown in FIG. 2B. Beam control module 162 alters the direction of output beam 176 to coincide with the new direction of mobile tracking device 110, as represented by block 420 in FIG. 16. This again causes the generation of the localized sources 400 within mobile tracking device 110 which are within a field of view of mobile tracking device 110. As such, controller 116 attempts to point mobile tracking device 110 at the brighter source 400 and in doing so changes the direction of mobile tracking device 110 to direction 422 as shown in FIG. 2C. Beam control module 162 alters the direction of output beam 176 to coincide with the new direction of mobile tracking device 110. Once again this causes the generation of the localized sources 400 within mobile tracking device 110 which are within a field of view of mobile tracking device 110. As such, controller 116 attempts to point mobile tracking device 110 at the brighter source 400 and in doing so changes the direction of mobile tracking device 110 to direction 424 as shown in FIG. 2D. In moving beam control module 162 to track mobile tracking device 110 along the direction 424, rotatable head 184 exceeds the threshold rotation amount and continuous wave laser 166 is deactivated, as shown in FIG. 2D.

Unlike prior art devices, modulation device 100 is not mobile tracking device 110 specific. Rather, modulation device 100 is effective against both imaging and non-imaging mobile tracking devices 110. Further, modulation device 100 does not require a mobile tracking device specific optical codes to be known in advance. Rather, modulation device 100 relies on the continuous provision of optical energy into mobile tracking device 110 to produce localized sources 400 within the field of view of mobile tracking device 110 such that detector 118 is confused as to the location of asset 102.

In another example of the use of modulation device 100, a 3 kW, continuous wave, infrared, Ytterbium single mode fiber laser was used as continuous wave laser 166 of modulation device 100 associated with an asset 102. In tests, a plurality of different mobile infrared mobile tracking devices 110 were fired at asset 102 while asset 102 was at ground level. Modulation device 100 each time directed output beam 176 at the optical window of the respective mobile tracking device 110. The modulation device 100 was effective against all of the plurality of different mobile tracking device 110 at a range of up to about 1250 meters from modulation device 100. A computer model was made wherein asset 102 was at ground level, a wavelength of continuous wave laser 166 was set to 1.07 μm, and values for additional parameters modulation device 100 and mobile tracking device 110 were set. The computer model provided a predicted range of up to 1290 meters for a plurality of different mobile tracking device 110. This computer model demonstrated good agreement with the experimentally obtained range of up to 1250 meters.

In a further example of the use of modulation device 100, a 3 kilowatt, continuous wave, infrared, Ytterbium single mode fiber laser was used as continuous wave laser 166 of modulation device 100 associated with an asset 102. In tests, a specific mobile tracking device 110 was fired at asset 102 while asset 102 was at ground level. Modulation device 100 directed output beam 176 at the optical window of mobile tracking device 110. The modulation device 100 was effective against the specific mobile tracking device 110 at a range of up to about 2650 meters from modulation device 100. The above-mentioned computer model provided a predicted range of up to 2440 meters for the specific mobile tracking device 110. This demonstrates good agreement with the experimentally obtained range of up to 2650 meters.

Returning to FIG. 9, in one embodiment, beam pointing system 210 further includes a laser designator system 214. Laser designator system 214 includes a pulsed laser which is directed at mobile tracking device 110 and reflected therefrom. Based on the reflected signal, laser designator system 214 is able to determine a distance from modulation device 100 to mobile tracking device 110. In the case wherein modulation device 100 includes focusing optics 177 or wherein beam expander 172 may be focused, one of system controller 154 and beam pointing system 210 adjusts a focal length of focusing optics 177 to focus output beam 176 at the location of mobile tracking device 110. In one embodiment, output beam 176 is focused at a distance shorter than the determined range to mobile tracking device 110, the distance being chosen based on an estimated speed of mobile tracking device 110. In one embodiment, this distance corresponds to the expected position of mobile tracking device 110 based on assumptions regarding the relative difference in speed between asset **102** and mobile tracking device **110**. In one embodiment, the estimated speed of mobile tracking device **110** is selected based on the type of mobile tracking device **110** which is identified based on a retro-reflection received from mobile tracking device **110**.

Laser designator system **214**, illustratively, has a separate optical window **215** through which the laser beam of laser designator system **214** is sent out of modulation device **100** and the reflection from mobile tracking device **110** is received to determine the distance to mobile tracking device **110**. In one embodiment, laser designator system **214** uses the same optical window **190** as output beam **176** and is bore sighted to output beam **176**.

In one embodiment, once warning/cueing system **130** detects a mobile tracking device **110**, modulation device **100**, in turn, provides optical energy from a plurality of optical sources to hamper the tracking ability of the mobile tracking device **110**. As is known in the art, mobile tracking device specific optical codes are designed to confuse the guidance system **114** of mobile tracking device **110**. Mobile tracking device specific optical codes are developed based on knowledge of the operation of mobile tracking device **110**. By way of example, a spin rate and pattern of reticule **122** may be used to generate a mobile tracking device specific optical code that confuses mobile tracking device **110**.

Referring to FIGS. **17**A-D, four exemplary mobile tracking device specific optical codes are shown. Each of the mobile tracking device specific optical codes is shown as an on/off signal of a repeatable pattern. Referring to FIG. **17**A, mobile tracking device specific optical code **500** is a series of equal duration on/off regions having a first frequency. Referring to FIG. **17**B, mobile tracking device specific optical code **502** is a series of equal duration on/off regions having a second frequency greater than the first frequency of mobile tracking device specific optical code **500**. Referring to FIG. **17**C, mobile tracking device specific optical code **504** is a series of on/off regions having a third frequency and wherein the duration of each off region is twice the duration of each on region. Referring to FIG. **17**D, mobile tracking device specific optical code **506** is a series of on/off regions with on regions of at least two different durations. In each of mobile tracking device specific optical codes **500-508**, the on regions correspond to when optical energy from an optical source of a first intensity is transmitted by modulation device **100** into the environment and the off regions correspond to when optical energy from the optical source of a second, lower intensity is transmitted by modulation device **100** into the environment or when no optical energy from the optical source is transmitted by modulation device **100** into the environment. The patterns between different mobile tracking device specific optical codes may differ based on the duration of various on regions or off regions; the number of on regions or off regions; the intensities of the on regions and off regions; the inclusion of on regions or off regions having differing intensity values; and other parameters which would result in a different shape of the respective mobile tracking device specific optical codes.

In one embodiment, one or more of the mobile tracking device specific optical codes are generated from a respective laser source by directly controlling at least one of the voltage or current supplied to the respective laser source. In one embodiment, one or more of the mobile tracking device specific optical codes are generated from a respective laser source by indirectly controlling the propagation of optical energy from the respective laser source into the environment. An exemplary way of indirect control is with a shutter that can block the transmission of optical energy or a spinning reticule.

Referring to FIG. **18**, in one embodiment, modulation device **100** sends a beam of optical energy **510** towards mobile tracking device **110** wherein mobile tracking device specific optical codes **500-506** are sent in parallel. As such, each of mobile tracking device specific optical codes **500-506** are impinging on mobile tracking device **110** at generally the same time. There is no delay in intercepting the mobile tracking device **110** with the appropriate mobile tracking device specific optical code.

Each of mobile tracking device specific optical codes **500-506** are provided as part of respective signals **512-518** which are propagated towards mobile tracking device **110**. Each signal **512-518** includes only one of mobile tracking device specific optical codes **500-506**. In one embodiment, each of signals **512-518** has a respective wavelength which differs from the wavelength of the remainder of the signals. In one embodiment, the wavelength of each of signals **512-518** is within the range of about 1 um to about 5 um. In one embodiment, the wavelength of each of signals **512-518** is within the range of about 1 um to about 3 um. In one embodiment, the wavelength of each of signals **512-518** is within the range of about 1.8 um to about 2.8 um.

Referring to FIG. **19**, in one embodiment, modulation device **100** sends a beam of optical energy **520** towards mobile tracking device **110** wherein mobile tracking device specific optical codes **500-506** are sent in parallel. As such, each of mobile tracking device specific optical code **500-506** are impinging on mobile tracking device **110** at generally the same time. There is no delay in intercepting the mobile tracking device **110** with the appropriate mobile tracking device specific optical code.

Each of mobile tracking device specific optical codes **500-506** are provided as part of respective signals **512-518** which are propagated towards mobile tracking device **110**. In contrast to signals **512-518** of FIG. **18**, each of signals **512-518** contains multiple mobile tracking device specific optical codes. However, the content of signals **512-518** are arranged so that a respective one of mobile tracking device specific optical codes **500-506** is always presented to mobile tracking device **110**, but by different signals **512-518** at different times. In one embodiment, each of signals **512-518** has a respective wavelength which differs from the wavelength of the remainder of the signals. As such, although a respective mobile tracking device specific optical code is always being presented to mobile tracking device **110**, the wavelength of the signal presenting the mobile tracking device specific optical code changes. This arrangement is beneficial when one of filter **125** or optical window **128** of mobile tracking device **110** is configured to only pass optical energy within a narrow wavelength band. If the wavelengths of signals **512-518** are selected to cover the general spectrum of wavelengths that are passed by differing mobile tracking device **110**, then at least one of signals **512-518** should provide the appropriate code for the respective mobile tracking device **110** at a wavelength that is passed by filter **125** and optical window **128** of mobile tracking device **110**. In one embodiment, the wavelength of each of signals **512-518** is within the range of about 1 um to about 5 um. In one embodiment, the wavelength of each of signals **512-518** is within the range of about 1 um to about 3 um. In one embodiment, the wavelength of each of signals **512-518** is within the range of about 1.8 um to about 2.8 um. In one embodiment, one or more of the wavelengths are in the infrared band of the spectrum. In one embodiment, one or more of the wavelengths are in the visible band of the spectrum. In one embodiment, one or more of the wavelengths are in the ultraviolet band of the spectrum.

Referring to FIG. **20**, another embodiment of **530** of optical transmitter system **150** is shown. In optical transmitter system **530**, a plurality of laser modules **532** are used to generate signals **512-518**. The plurality of laser modules **532** includes laser modules **534-540**. In one embodiment, each of laser modules **534-540** is a semiconductor laser. In one embodiment, each of laser modules **534-540** is a quantum cascade laser. Exemplary quantum cascade lasers include External Cavity Quantum Cascade Lasers available from Daylight Solutions located at 13029 Danielson Street, Suite 130 in Poway, Calif. and Pranalytica located at 1101 Colorado Avenue in Santa Monica, Calif.

Referring to FIG. **21**, a first exemplary embodiment of a laser module **534** and laser module **536** are shown. Each of laser module **534** and laser module **536** includes a controller **539** and an associated memory **542**. The memory **542** includes the instructions to generate the respective modulation code, the mobile tracking device specific optical code, for the laser module. Controller **539** executes the instructions to generate the respective modulation code or codes with the respective laser unit. In one embodiment, controller **539** regulates one or both of the voltage and current provided to the respective laser unit to generate the respective modulation code or codes. In one embodiment, controller **539** controls one or more optical components, such as spinning reticules or shutters, to generate the respective modulation code or codes.

Laser module **534** is shown having mobile tracking device specific optical code **500** associated therewith while laser module **536** is shown having mobile tracking device specific optical code **502** associated therewith. In one embodiment, the respective modulation codes are persistent in memory **542**.

In one embodiment, the respective modulation codes are not persistent, but rather are erased when power is not provided to the respective laser module. In one example, thereof the respective modulation codes are assigned by system controller **154** and are stored on a memory **544** which is associated with controller **154**. In one embodiment, memory **544** is a removable memory. In one example thereof, memory **544** is operatively coupled to system controller **154** to permit the operation of modulation device **100**.

Each of laser module **534** and laser module **536** includes a respective semiconductor laser **550** and **552**. Lasers **550** and **552** are configured to provide optical energy at a respective wavelength, wavelength (λ_{1A}) for laser module **534** and wavelength (λ_{2B}) for laser module **536**. In one embodiment, the output of the lasers **550** and **552** are provided to respective optical conduits **554** and **556**. Exemplary optical conduits include optical fibers.

Referring to FIG. **20**, these optical conduits **554** and **556** (and the respective ones for the remaining laser modules) are combined into optical conduit **170** through a beam combiner system **560** which provides the optical energy to beam control module **162**. In one embodiment, the outputs of optical conduit **554** and **556** are combined through one or more optical components, such as mirrors. In one embodiment, the outputs of optical conduit **554** and optical conduit **556** are combined through an optical fiber.

Referring to FIG. **22**, another exemplary embodiment of a laser module **534** and laser module **536** are shown. Each of laser module **534** and laser module **536** includes a controller **570** and a respective semiconductor laser **550** and **552**. Lasers **550** and **552** are configured to provide optical energy at a respective wavelength, wavelength (λ_{1A}) for laser module **534** and wavelength (λ_{2B}) for laser module **536**. In one embodiment, the output of the lasers **550** and **552** are provided to respective optical conduits **554** and **556**. Exemplary optical conduits include optical fibers. The output of optical conduits **554** and **556** (and the respective ones for the remaining laser modules) are combined into optical conduit **170** through a beam combiner system **560** which provides the optical energy to beam control module **162**.

The respective modulation code for each of laser module **534** and laser module **536** are stored on a memory **574** associated with system controller **154**. System controller **154** executes software **580** stored on memory **574**. The software **580** associates a given modulation code with each of laser module **534** and laser module **536** and the remaining laser modules.

Referring to FIG. **23**, in one embodiment, optical transmitter system **530** is manufactured in the following manner. One or more of laser module **534** are selected from a grouping of **590** of laser module **534**, one or more of laser module **536** are selected from a grouping **592** of laser module **536**, one or more of laser modules are selected from a grouping **594** of laser modules, and one or more of laser modules **540** are selected from a grouping **596** of laser modules **540**. A portion of grouping **590** is represented in FIG. **23**. Grouping **590** includes a plurality of laser module **534** whose output are at a wavelength (λ_{1A}), a plurality of laser module **534** whose output are at a wavelength (λ_{1B}), a plurality of laser module **534** whose output are at a wavelength (λ_{1C}), and so on. The wavelengths (λ_{1A}), (λ_{1B}), and (λ_{1C}) are spaced apart. In one embodiment, the spacing of wavelengths (λ_{1A}), (λ_{1B}), and (λ_{1C}) is about 100 nanometers between (λ_{1A}) and (λ_{1B}) and between (λ_{1B}) and (λ_{1C}).

By selecting one or more of laser module **534** in the manufacture of optical transmitter system **530**, a given instance of optical transmitter system **530** may include a laser module **534** having a wavelength (λ_{1B}), while another instance of optical transmitter system **530** includes a laser module **534** having a wavelength (λ_{1A}), and so on. This randomization of the wavelength of laser module **534** for a given instance of optical transmitter system **530** results in mobile tracking device **110** not having a high confidence that a configuration of filter **125** and/or optical window **128** will adequately block the modulation code of laser module **534**.

Referring to FIG. **24**, one example of four selected laser modules for a first instance of optical transmitter system **530** are shown. The selected laser module **534** has a wavelength (λ_{1C}). The selected laser module **536** has a wavelength (λ_{2F}). The selected laser module **538** has a wavelength (λ_{3C}). The selected laser module **540** has a wavelength (λ_{4D}). This is contrasted with FIG. **25**, wherein four selected laser modules for a second instance of optical transmitter system **530** are shown. In FIG. **25**, the selected laser module **534** has a wavelength (λ_{1A}). The selected laser module **536** has a wavelength (λ_{2A}). The selected laser module **538** has a wavelength (λ_{3G}). The selected laser module **540** has a wavelength (λ_{4D}).

Based on the two instances of FIGS. **24** and **25**, the laser modules **530** have different wavelengths for laser modules **534-538** and the same laser module **540**. As stated above, this randomization of the wavelength of laser modules **534-540** for a given instance of optical transmitter system **530** results in mobile tracking device **110** not having a high confidence that a configuration of filter **125** and/or optical window **128** will adequately block the modulation codes of laser module **534-540**. Optical transmitter system **530** is both not predictable due to the randomization and pseudo-broadband due to the multiple wavelengths.

Referring to FIG. **26**, in another example in one instance optical transmitter system **530** includes eight laser modules.

Optical transmitter system **530** includes a laser module **534** which has a wavelength (λ_{1C}) and a laser module **534** which has a wavelength (λ_{1A}). Optical transmitter system **530** includes a laser module **536** which has a wavelength (λ_{2F}) and a laser module **536** which has a wavelength (λ_{2C}). Optical transmitter system **530** includes a laser module **538** which has a wavelength (λ_{3C}) and a laser module **538** which has a wavelength (λ_{3A}). Optical transmitter system **530** includes a laser module **540** which has a wavelength (λ_{4D}) and a laser module **540** which has a wavelength (λ_{4B}). By having multiple instances of each of laser modules **534-540** at different wavelengths, optical transmitter system **530** is effective against a mobile tracking device **110** even if the mobile tracking device **110** has a filter **125** and/or optical window **128** configured to block one of the wavelengths.

In the illustrated embodiments, either four or eight laser modules **532** are shown. The number of laser modules **532** for a given optical transmitter system **530** may be increased or decreased. In one embodiment, the number of laser modules **532** for a given optical transmitter system **530** is up to eight.

In one embodiment, if the hampering of mobile tracking device **110** fails or if otherwise desired, one or more of the plurality of laser module **532** may provide continuous optical energy to disable mobile tracking device **110**, such as by producing localized sources in the seeker head of the mobile tracking device. In one example, all of the laser modules **532** provide continuous optical energy.

In one embodiment, as illustrated in FIG. **27**, continuous wave laser **166** is included in the optical transmitter system **150'** and is activated to disable or destroy mobile tracking device **110** with continuous optical energy. In one embodiment, the output of continuous wave laser **166** and the output of laser modules **532** are both presented to the primary mirror of telescope **172** such that the directions of their outputs are aligned. In one embodiment, continuous wave laser **166** is activated based on mobile tracking device **110** still tracking the asset subsequent to a first threshold. In one example, the first threshold is time based and corresponds to a given timeframe that the laser modules **532** have been directed at mobile tracking device **110** and the output of the laser modules has been directed at the mobile tracking device. In one example, the first threshold is distance based and corresponds to a given distance from the asset to the mobile tracking device **110**. The distance between asset **102** and mobile tracking device **110** being determined with laser designator system **214**.

The modulation device **100** based on FIG. **27** is not mobile tracking device **110** specific. Rather, modulation device **100** is effective against both imaging and non-imaging mobile tracking devices **110**. Further, modulation device **100** does not require a mobile tracking device specific optical code to be known in advance. Rather, in the absence of a mobile tracking device specific optical code working, modulation device **100** relies on the continuous provision of optical energy into mobile tracking device **110** to produce localized sources **400** within the field of view of mobile tracking device **110** such that detector **118** is confused as to the location of asset **102**.

While this invention has been described as having an exemplary design, the present invention may be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

The invention claimed is:

1. A method of hampering the tracking ability of a mobile tracking device approaching an asset, the method comprising the steps of:

generating a plurality of mobile tracking device specific optical codes, each mobile tracking device specific optical code including a series of pulses of optical energy; and

propagating the plurality of mobile tracking device specific optical codes towards the mobile tracking device, at least two of the plurality of mobile tracking device specific optical codes being propagated in parallel towards the mobile tracking device.

2. The method of claim **1**, wherein at least one of the plurality of mobile tracking device specific optical codes is configured such that when received by the mobile tracking device it causes the mobile tracking device to alter its direction of travel away from the asset.

3. The method of claim **2**, wherein the plurality of mobile tracking device specific optical codes includes a first mobile tracking device specific optical code and a second mobile tracking device specific optical code, the second mobile tracking device specific optical code being different from the first mobile tracking device specific optical code and the second mobile tracking device specific optical code being propagated in parallel towards the mobile tracking device.

4. The method of claim **3**, wherein the first mobile tracking device specific optical code is generated with a first semiconductor laser module at a first wavelength and the second mobile tracking device specific optical code is generated with a second semiconductor laser at a second wavelength, the second wavelength being different from the first wavelength.

5. The method of claim **2**, wherein the plurality of mobile tracking device specific optical codes includes a first mobile tracking device specific optical code and a second mobile tracking device specific optical code which are propagated in parallel towards the mobile tracking device, the first mobile tracking device specific optical code is generated with a first semiconductor laser module at a first wavelength and the second mobile tracking device specific optical code is generated with a second semiconductor laser at a second wavelength, the second wavelength being different from the first wavelength.

6. The method of claim **5**, wherein the second mobile tracking device specific optical code has a different pattern than the first mobile tracking device specific optical code.

7. The method of claim **2**, further comprising the steps of:

providing a plurality of laser modules;

associating at least one of the plurality of mobile tracking device specific optical codes with each of the plurality of laser modules; and

for each of the plurality of laser modules, generating the at least one of the plurality of mobile tracking device specific optical codes.

8. The method of claim **7**, wherein for each of the plurality of laser modules the at least one of the plurality of mobile tracking device specific optical codes is stored on a memory of the laser module.

9. The method of claim **8**, further comprising the step of for each of the plurality of laser modules, erasing the at least one of the plurality of mobile tracking device specific optical codes when power is cut to the laser module.

10. The method of claim **7**, wherein for each of the plurality of laser modules the at least one of the plurality of mobile tracking device specific optical codes is stored on a memory external to the laser module and accessible by a controller of the laser module.

11. The method of claim **1**, further comprising the steps of:

propagating a continuous wave of optical energy at the mobile tracking device to generate at least one localized source within the mobile tracking device and within a field of view of the mobile tracking device which indicates a direction of travel for the mobile tracking device away from the asset.

12. A method of manufacture of an optical transmitter system of a modulation device which interacts with a mobile tracking device, the method comprising the steps of:

selecting a first laser module from a first plurality of laser modules, the first plurality of laser modules including at least a first set of laser modules which output optical energy at a first wavelength and a second set of laser modules which output optical energy at a second wavelength, the first laser module being part of one of the first set of laser modules and the second set of laser modules;

selecting a second laser module from a second plurality of laser modules, the second plurality of laser modules including at least a third set of laser modules which output optical energy at a third wavelength and a fourth set of laser modules which output optical energy at a fourth wavelength, the second laser module being part of one of the third set of laser modules and the fourth set of laser modules; and

coupling the first laser module and the second laser module to a beam control system which directs an output of the first laser module and an output of the second laser module along a first direction, the first laser module intended to generate at least a first mobile tracking device specific optical code and the second laser module intended to generate at least a second mobile tracking device specific optical code.

13. The method of claim 12, wherein each of the first plurality of laser modules when selected is intended to generate at least the first mobile tracking device specific optical code and each of the second plurality of laser modules when selected is intended to generate at least the second mobile tracking device specific optical code.

14. An apparatus for interacting with a mobile tracking device, the apparatus comprising:

a body;

at least one propulsion device supported by the body;

a plurality of sensor modules supported by the body which monitor the environment surrounding the body;

a controller operatively connected to the plurality of sensor modules, the controller determining a presence of the mobile tracking device in the environment surrounding the body based on information collected by the plurality of sensor modules and a current location of the mobile tracking device;

a modulation system which receives the current location of the mobile tracking device from the controller, orients a tracking system of the modulation system based on the current location of the mobile tracking device, detects the mobile tracking device, updates the location of the mobile tracking device, and directs a plurality of mobile tracking device specific optical codes at the mobile tracking device, each mobile tracking device specific optical code including a series of pulses of optical energy and at least two of the plurality of mobile tracking device specific optical codes being propagated in parallel towards the mobile tracking device.

15. The apparatus of claim 14, wherein the plurality of mobile tracking device specific optical codes are generated by at least two lasers, a first laser generating a first mobile tracking specific code and a second laser generating a second mobile tracking specific code, the first mobile tracking specific code and the second mobile tracking specific code being propagated in parallel towards the mobile tracking device.

16. The apparatus of claim 15, wherein the first laser produces optical energy of a first wavelength and the second laser produces optical energy of a second wavelength, the second wavelength being different than the first wavelength.

17. The apparatus of claim 15, wherein the modulation system includes a beam control module which controls a direction of the plurality of mobile tracking device specific optical codes based on the updated location of the mobile tracking device, the beam control module being coupled to the plurality of lasers through an optical conduit.

18. The apparatus of claim 14, wherein the controller continues to update the current location of the mobile tracking device until the modulation system detects the mobile tracking device, the modulation system using the updated current location to orient the tracking system.

19. The apparatus of claim 18, wherein the plurality of sensor modules have a wide field of view to survey the environment around the body and the modulation system has a narrower field of view to focus on the location of the mobile tracking device.

20. The apparatus of claim 19, wherein a continuous wave laser is directed at the mobile tracking device after a first threshold, if the mobile tracking device is still tracking the asset.

21. The apparatus of claim 20, wherein the first threshold is a time value.

22. The apparatus of claim 20, wherein the first threshold is a distance value.

23. The apparatus of claim 14, wherein the modulation system includes a beam control module which controls a direction of the plurality of mobile tracking device specific optical codes based on the updated location of the mobile tracking device.

24. The apparatus of claim 23, wherein the plurality of mobile tracking device specific optical codes are provided until the beam control module has caused the direction of the continuous beam of optical energy to move by a predetermined threshold amount.

25. The apparatus of claim 24, wherein the predetermined threshold amount is three degrees.

26. An apparatus for use with an asset and for interacting with a mobile tracking device, the apparatus comprising:

a pod configured to be attached to the asset, the pod including an optical window;

a plurality of lasers positioned within the pod; and

a battery source operatively coupled to the plurality of lasers and positioned within the pod, the battery source providing power to the plurality of lasers to produce a plurality of mobile tracking device specific optical codes, each mobile tracking device specific optical code including a series of pulses of optical energy and at least two of the plurality of mobile tracking device specific optical codes being propagated in parallel towards the mobile tracking device.

27. The apparatus of claim 26, wherein the pod includes a rotatable head having an optical window through which the plurality of mobile tracking device specific optical codes exits the pod.

28. The apparatus of claim 26, further comprising a battery charger positioned within the pod and coupled to a power source of the asset, the battery charger charging the battery source when the asset is operating in a low power mode.

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