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(54) **LIGHT PULSE GENERATOR METHOD AND APPARATUS**

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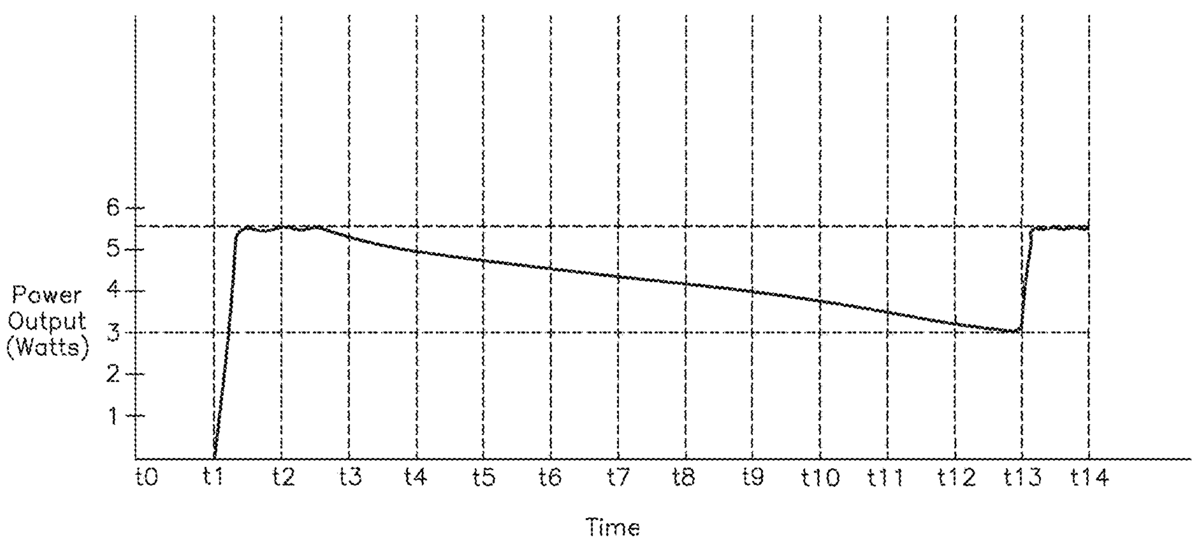
(57) **ABSTRACT**

A solar power generation system includes photovoltaic (PV) material onto which optically concentrated incident sunlight is transmitted from an optical concentrator during a first series of time intervals, thereby inducing and maintaining a state of continuous electron avalanche in the PV material, the PV material continually generating an electrical current that exceeds an electrical current generated by the PV material in the absence of electron avalanche. The system includes a control means that reduces a temperature of the PV material during a second series of time intervals that alternate with the first series of time intervals to maintain integrity of the PV material while electron avalanche is maintained in the PV material, electron avalanche breakdown is avoided in the PV material, and the PV material continues to generate the electrical current. An electrical load receives the electrical current continually generated by the PV material.



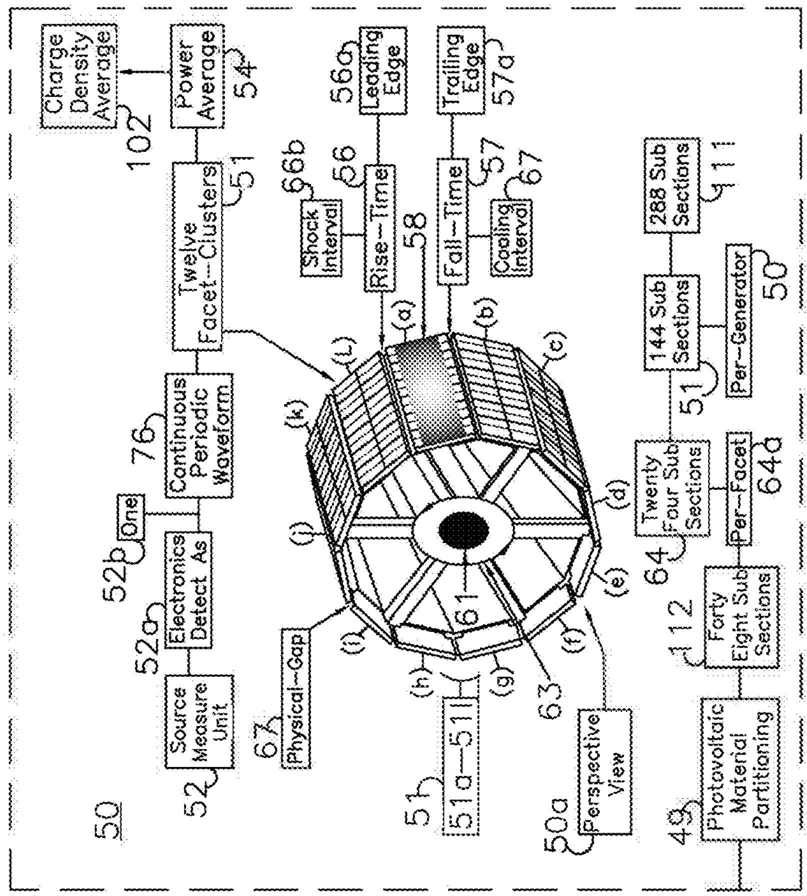

50
Charge Density Average
102
Power Average
54
Twelve Facet-Clusters
51
Continuous Periodic Waveform
76
One
52b
Electronics Detect As
52a
Source Measure Unit
52
Shock Interval
66b
Rise-Time
56
Leading Edge
56a
58
Fall-Time
57
Trailing Edge
57a
Cooling Interval
67
Physical-Gap
67
51
51a-51l
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)
(L)
61
63
Perspective View
50a
Twenty Four Sub Sections
64
Per-Facet
64a
144 Sub Sections
51
Per-Generator
50
288 Sub Sections
111
Forty Eight Sub Sections
112
Photovoltaic Material Partitioning
49

Fig. 1A

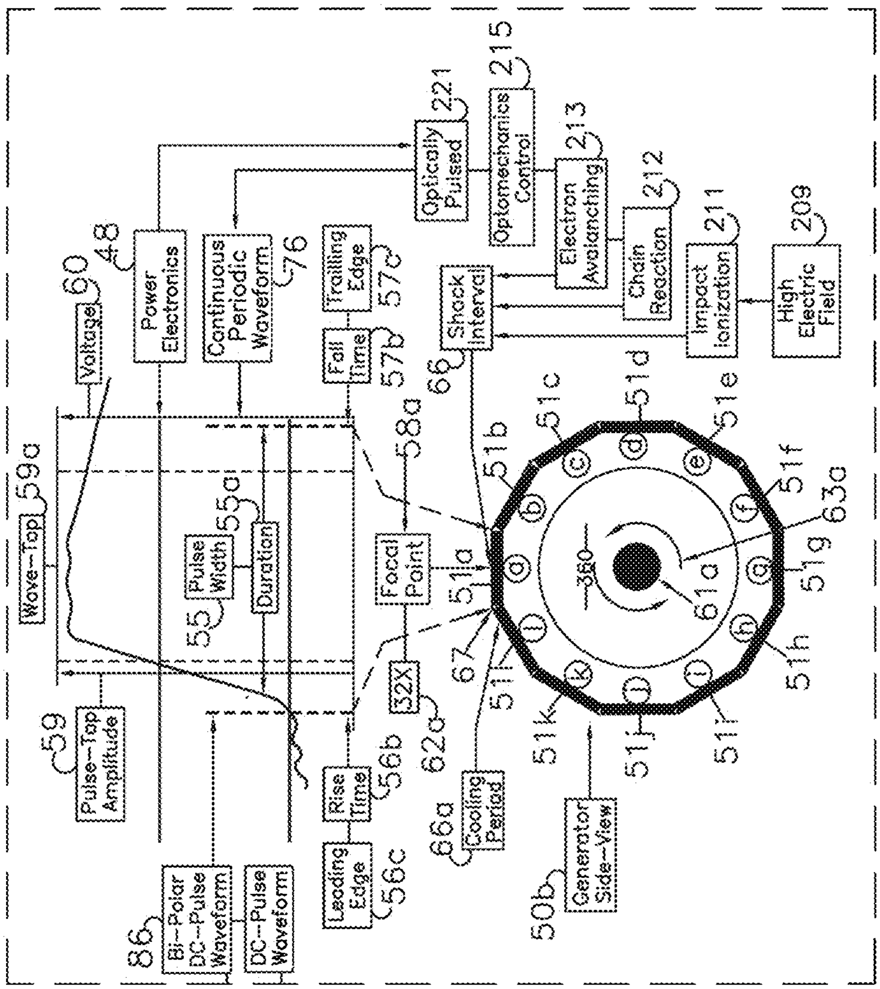
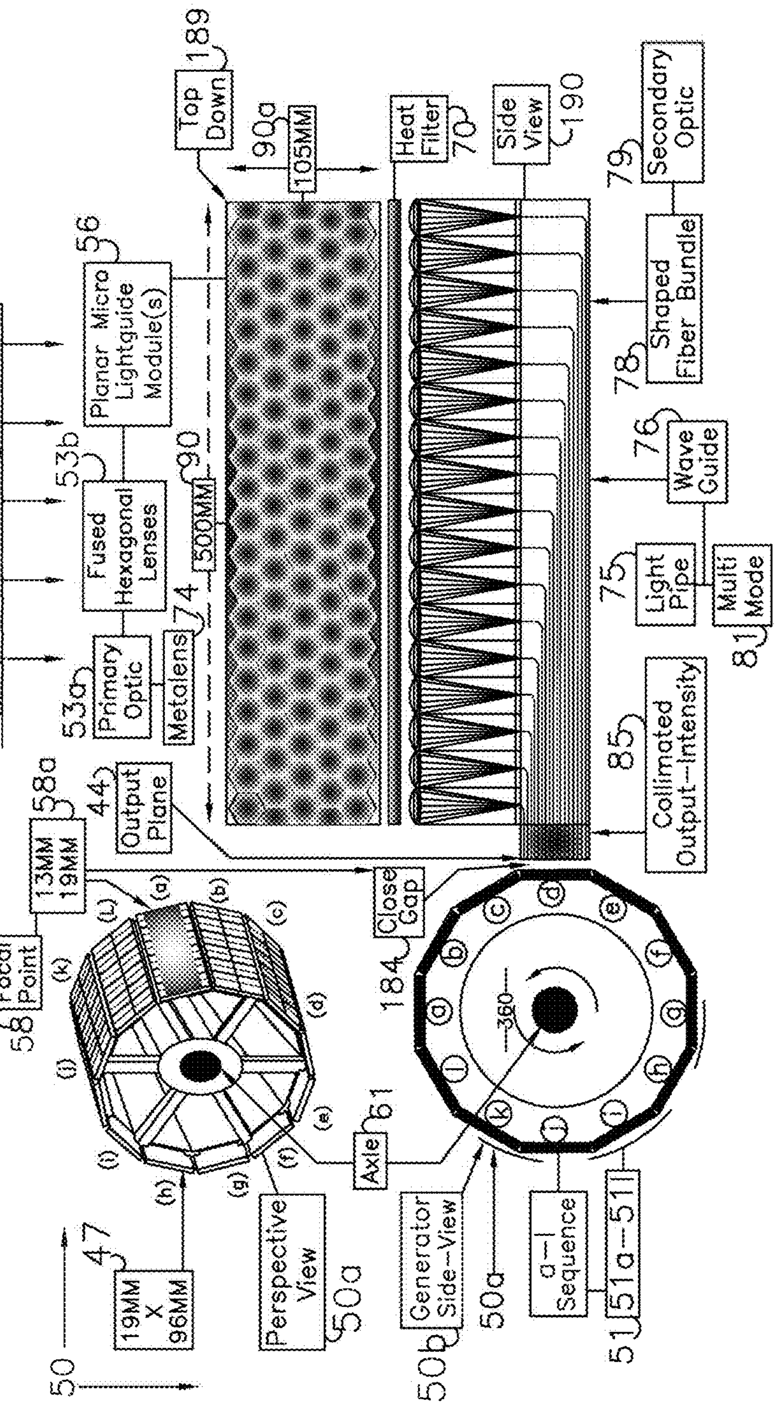

Wave-Tap
59a
Pulse-Tap Amplitude
59
Voltage
60
Power Electronics
48
Continuous Periodic Waveform
76
Optically Pulsed
221
Optomechanics Control
215
Electron Avalanching
213
Chain Reaction
212
Impact Ionization
211
High Electric Field
209
Shock Interval
66
Trailing Edge
57c
Fall Time
57b
Pulse Width
55
Duration
55a
Focal Point
58a
32X
62a
Rise Time
56b
Leading Edge
56c
Bi-Polar DC-Pulse Waveform
86
DC-Pulse Waveform
Cooling Period
66a
Generator Side-View
50b
360
61a
63a
67
51a
51b
51c
51d
51e
51f
51g
51h
51i
51j
51k
51l

FIG. 1 B

FIG. 2A


50
19MM X 96MM
47
Perspective View
50a
Axle
61
Generator Side-View
50b
50a
a-l Sequence
51
51a-51l
58
Focal Point
13MM 19MM
58a
184
Close Gap
360
44
Output Plane
45
53a
Primary Optic
Metalens
74
Fused Hexagonal Lenses
53b
500MM
90
Incident Light
Planar Micro Lightguide Module(s)
56
90a
105MM
Top Down
189
Heat Filter
70
Side View
190
85
Collimated Output-Intensity
81
Multi Mode
75
Light Pipe
76
Wave Guide
78
Shaped Fiber Bundle
79
Secondary Optic

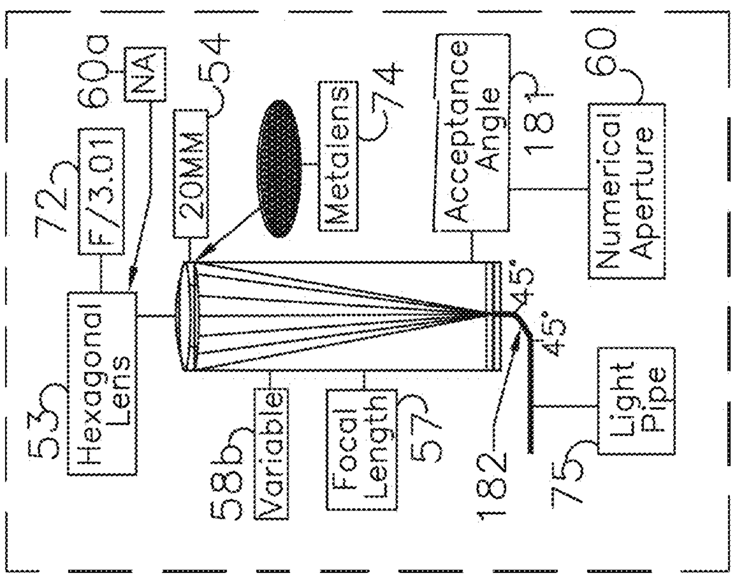

53
Hexagonal Lens
72
F/3.01
60a
NA
20MM
54
Metalens
74
Acceptance Angle
181
Numerical Aperture
60
45°
45°
Light Pipe
75
182
Focal Length
57
Variable
58b

FIG. 2B

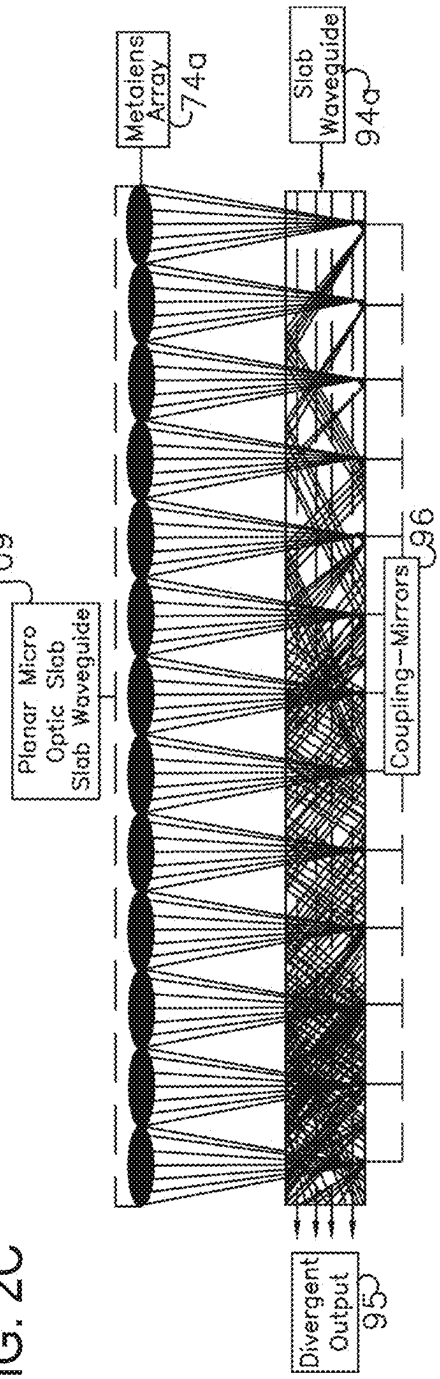

Metalens Array
74a
Slab Waveguide
94a
Planar Micro Optic Slab Slab Waveguide
109
Coupling—Mirrors
96
Divergent Output
95

FIG. 2C

FIG. 3

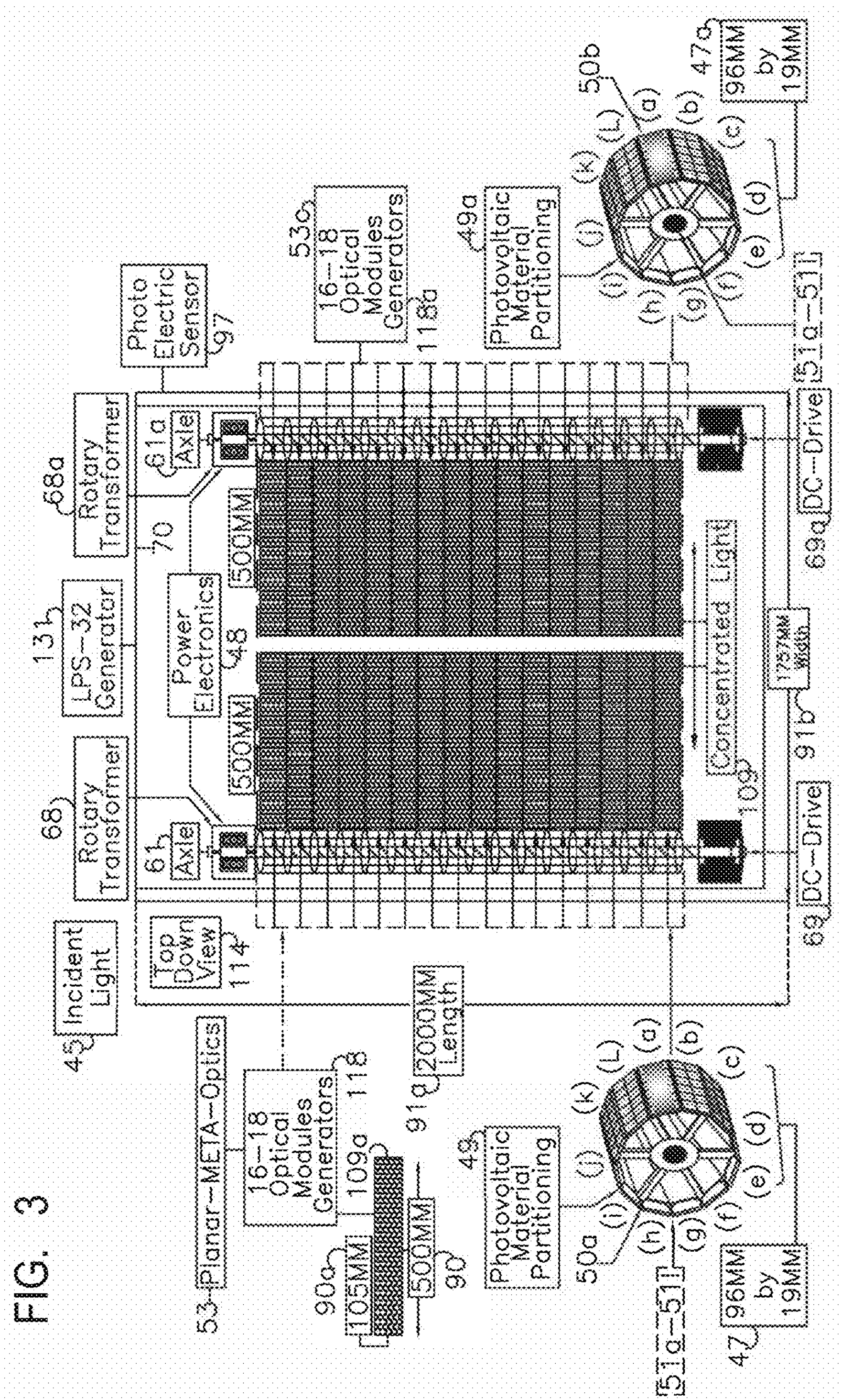

Planar-META-Optics
53
16-18 Optical Modules Generators
118
109a
90a
105MM
500MM
90
91a
2000MM Length
Incident Light
45
Top Down View
114
Photovoltaic Material Partitioning
49
50a
96MM by 19MM
47
51a-51l
Rotary Transformer
68
61
Axle
500MM
Power Electronics
48
LPS-32 Generator
131
Concentrated Light
109
91b
1757MM Width
DC-Drive
69
Rotary Transformer
68a
70
500MM
61a
Axle
DC-Drive
69a
Photo Electric Sensor
97
16-18 Optical Modules Generators
53c
118a
Photovoltaic Material Partitioning
49a
50b
96MM by 19MM
47a
51a-51l

FIG. 4A

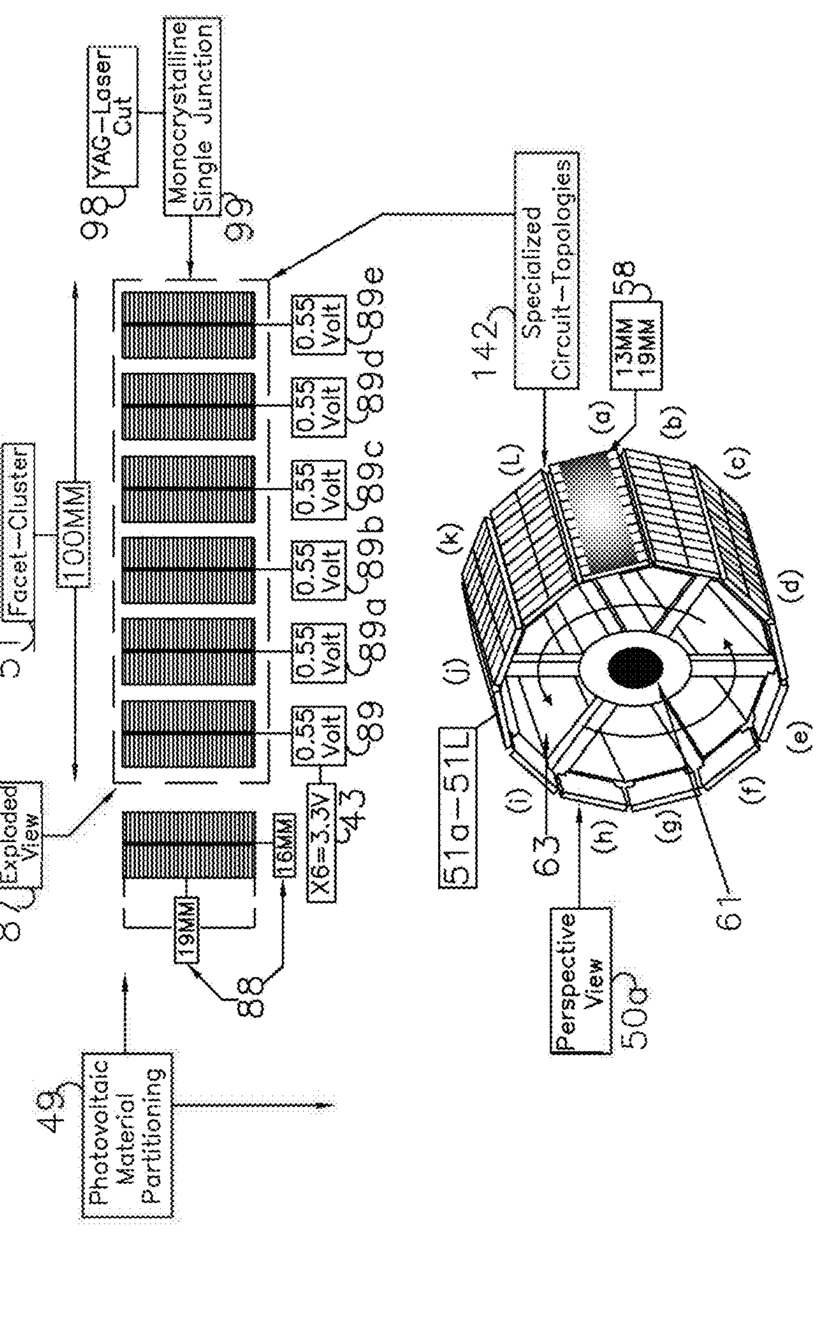
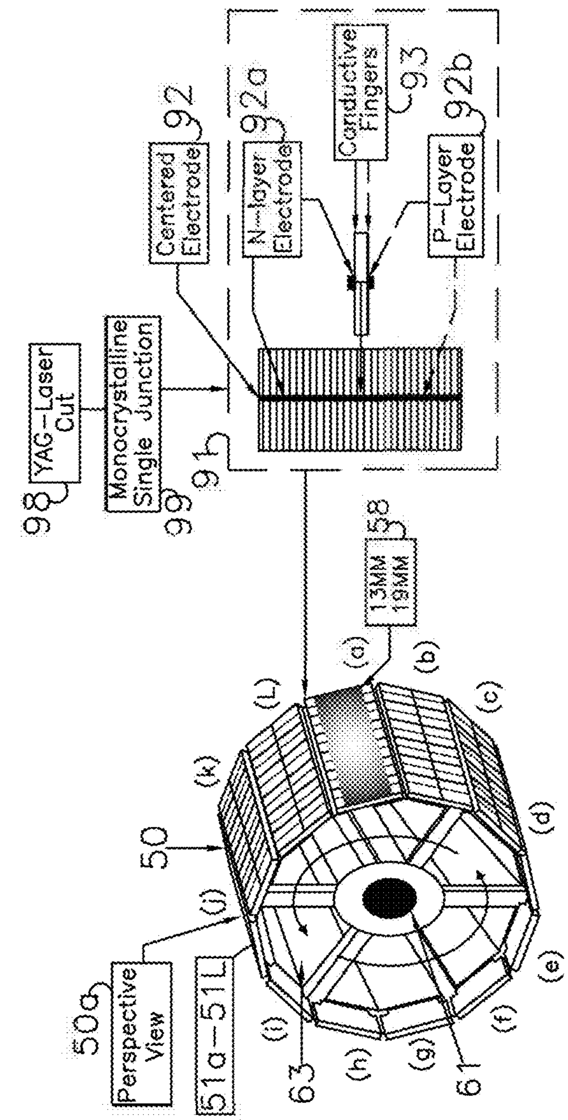
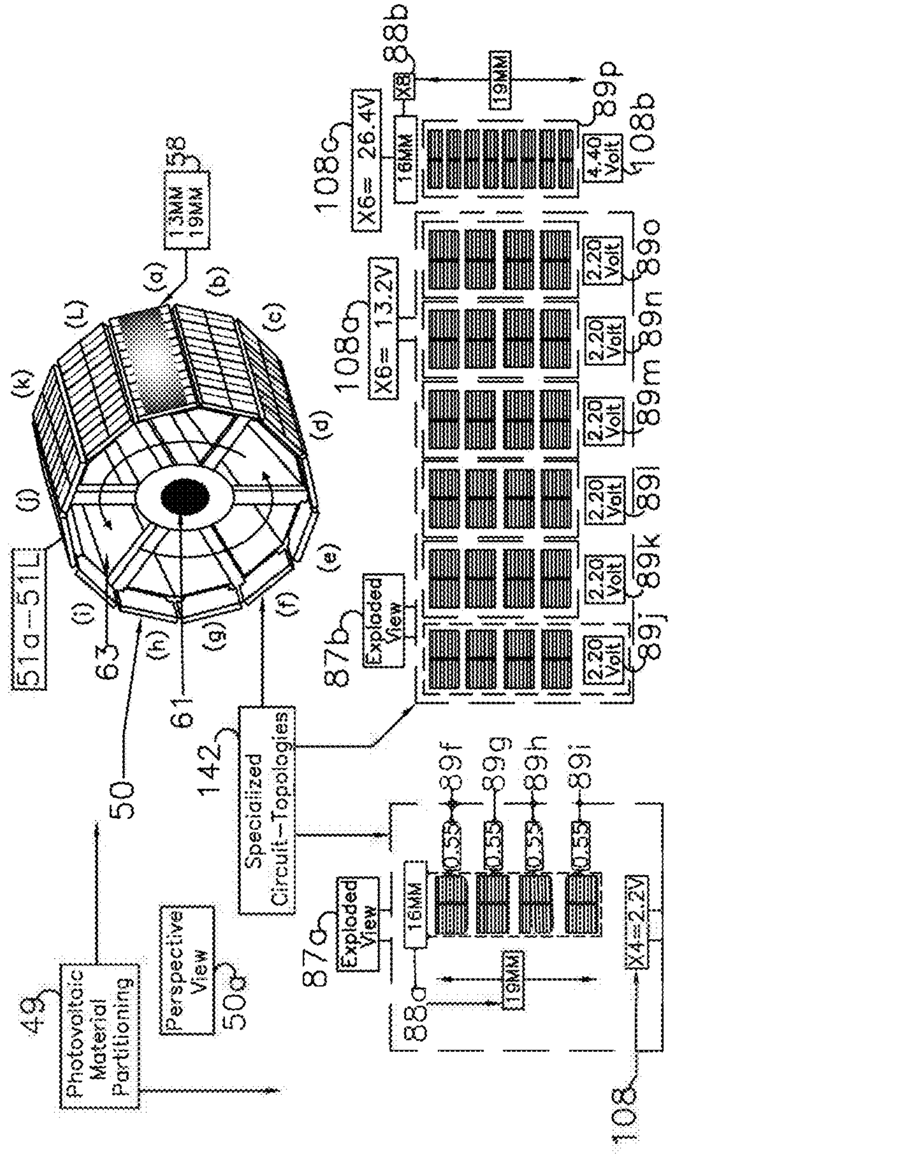

49
Photovoltaic Material Partitioning
87
Exploded View
51
Facet-Cluster
100MM
98
YAG-Laser Cut
99
Monocrystalline Single Junction
88
19MM
16MM
X6=3.3V
43
0.55 Volt
89
89a
89b
89c
89d
89e
142
Specialized Circuit-Topologies
58
13MM
19MM
51a-51L
63
61
Perspective View
50a
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)
(L)

FIG. 4B



YAG-Laser Cut
98
Monocrystalline Single Junction
99
91
Centered Electrode
92
N-layer Electrode
92a
Conductive Fingers
93
P-Layer Electrode
92b
13MM 19MM
58
Perspective View
50a
51a-51L
50
63
61
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)
(L)

FIG. 4C



Photovoltaic Material Partitioning
49
Perspective View
50a
50
51a—51L
63
61
58
13MM 19MM
142
Specialized Circuit-Topologies
87a
Exploded View
88a
16MM
19MM
0.55
89f
89g
89h
89i
X4=2.2V
108
87b
Exploded View
2.20 Volt
89j
89k
89l
89m
89n
89o
108a
X6= 13.2V
108c
X6= 26.4V
16MM
X8
88b
19MM
4.40 Volt
89p
108b

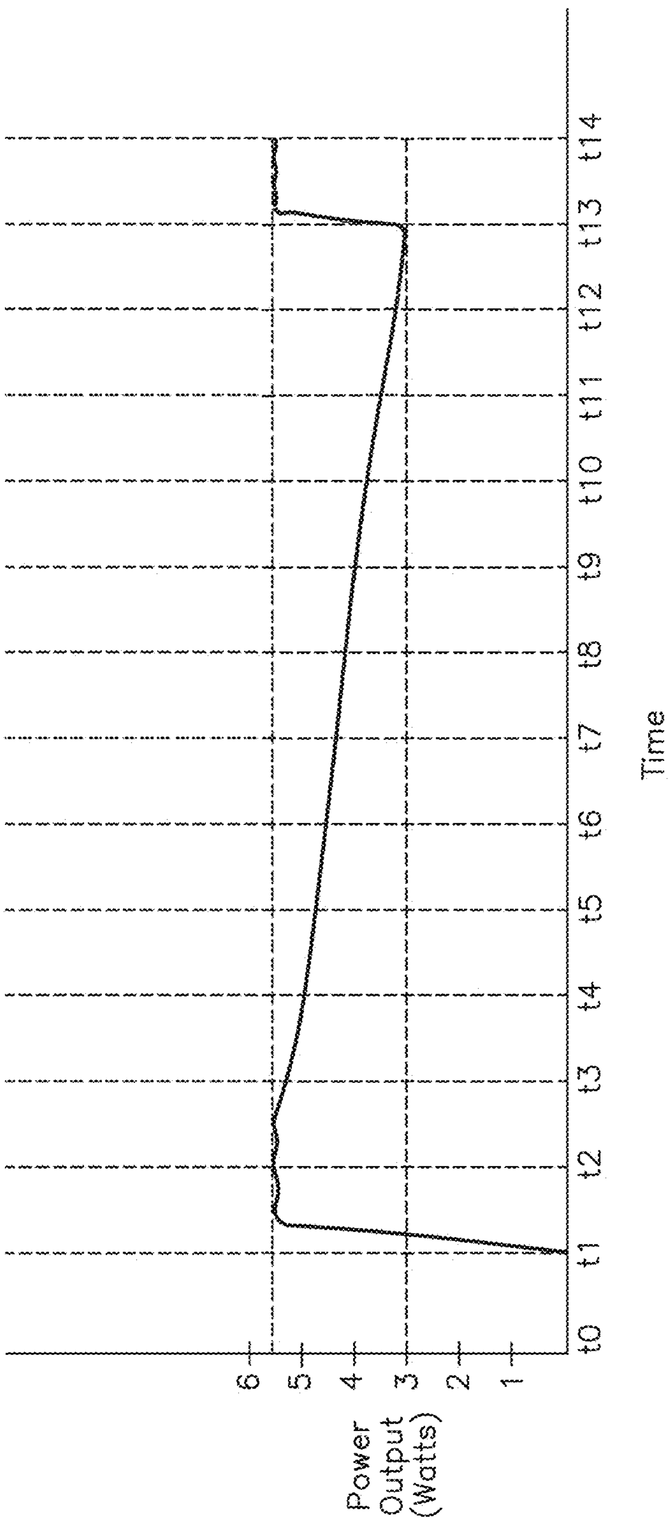

Power Output (Watts)
6
5
4
3
2
1
t0
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
t12
t13
t14
Time

FIG. 5

LIGHT PULSE GENERATOR METHOD AND APPARATUS

CROSS REFERENCE TO RELATED DOCUMENTS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/554,878, filed Feb. 16, 2024, entitled "LIGHT PULSE PHOTOVOLTAIC SYSTEM (LPS) PERIODIC WAVE MECHANICS", the disclosure of which is incorporated by reference herein in its entirety, and claims the benefit of U.S. Provisional Patent Application No. 63/641,877, filed May 2, 2024, entitled "LIGHT PULSE PHOTOVOLTAIC SYSTEM (LPS)", the disclosure of which is incorporated by reference herein in its entirety. This application is related to US patent 10,673,377, issued Jun. 2, 2020, entitled "METHOD AND APPARATUS FOR ALTERNATING CIRCUIT SOLAR POWER GENERATION".

TECHNICAL FIELD

[0002] Photovoltaic solar power generation and, in particular, photovoltaic solar power generation that produces higher power output by maintaining a state of electron avalanche in the PV material.

BACKGROUND

[0003] A goal of conventional operation of a photovoltaic cell is to generate a steady flow of electrical current. Static photovoltaic solar power generators are fundamentally inefficient. The static photovoltaic (PV) material in conventional flat solar panels is inadequately utilized. In other words, a flat solar panel deployed in prior art electrical power generation systems produces only a nominal amount of electrical energy from incident sunlight. The PV material is capable of producing much more electrical energy. Yet, the solar industry continues to focus on minor incremental improvements with new photovoltaic materials and combinations of static single-junction and multijunction materials with different bandgaps, substrate doping schemes, and other methods. What is needed is a system that dramatically increases solar power generation capability beyond present-day one-sun flat panel technology.

[0004] One way of improving the electrical generation performance of photovoltaic materials has been using various configurations of optical concentration systems joined with expensive multijunction materials and expensive refrigeration and or heat sink systems. The physics of optical concentration systems does not cause an increase in photon energy; instead, what changes with optical concentration is the number of photons incident in a unit area of photovoltaic material per unit of time, gathered from a larger primary optical surface such as microlens arrays and focused into a smaller optical output aperture through an optical waveguide such as a slab waveguide with coupling prisms, optical dimples, lenticular optics, and other optical means such as fiber optic multimode waveguides, larger scale molded light pipe arrays, that are coupled with microlenses, and or optical metalenses. This increased photon flux density leads to a higher intensity or power density, such as increased or enhanced photochemical reactions in the crystalline substrates that increase photocurrent levels in photovoltaic material. This is one of the reasons why electron avalanching occurs in photovoltaic material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The features and advantages of the disclosed embodiments will become apparent from the details of the subject matter in which:

[0006] FIG. 1A illustrates a perspective view of an LPS 12 gon generator according to the disclosed embodiments.

[0007] FIG. 1B illustrates a side view of an LPS 12 gon generator according to the disclosed embodiments.

[0008] FIG. 2A illustrates the LPS 12 gon generator with planar micro-optics with the fiber optic and slab waveguide version according to the disclosed embodiments.

[0009] FIG. 2B illustrates aspects of the LPS 12 gon generator with planar micro-optics with the fiber optic and slab waveguide version according to the disclosed embodiments.

[0010] FIG. 2C illustrates further aspects of the LPS 12 gon generator with planar micro-optics with the fiber optic and slab waveguide version according to the disclosed embodiments.

[0011] FIG. 3 illustrates an LPS 32 generator according to the disclosed embodiments.

[0012] FIG. 4A illustrates aspects of an LPS generator system with partitioned photovoltaic material according to the disclosed embodiments.

[0013] FIG. 4B illustrates aspects of an LPS generator system with partitioned photovoltaic material according to the disclosed embodiments.

[0014] FIG. 4C illustrates aspects of an LPS generator system with partitioned photovoltaic material according to the disclosed embodiments.

[0015] FIG. 5 illustrates power output of a single facet-cluster of PV sections over a single revolution of the generator according to the disclosed embodiments.

DETAILED DESCRIPTION

[0016] Light Pulse System (LPS) generator optomechanical technology, according to the disclosed embodiments, manages electron avalanching under controlled conditions, avoiding avalanche breakdown and subsequent damage to photovoltaic material while sustaining a high level of electricity generation in a cyclical and rhythmic pattern managed by electronics that govern electro-optical-mechanical functions with effective heat management.

[0017] Embodiments of the invention, also referred to herein as the Light Pulse System (LPS) Generator system, or simply, the LPS generator, is the first solar electrical power generation system that intentionally induces and controls a state of electron avalanching within the crystalline substrate of any photovoltaic (PV) material to yield greater power output than possible in prior art solar power generation systems that avoid the state of electron avalanche. In one embodiment, the state of electron avalanching is continuously maintained in the PV material while the system is operating and receiving concentrated incident light. This is accomplished through systemic periodic pulsing of the PV material with optically concentrated incident light. Periodically pulsing the PV material with optically concentrated incident light creates an on-and-off periodic interval where a burst of photons generates a burst of high-energy electron-hole pair carriers sufficient to induce a state of impact ionization-electron avalanche in the PV material. Each interval is followed by an interval in which no optically concentrated incident light reaches the PV material. This interval in which no optically concentrated incident light reaches the PV material provides time for reducing the temperature of the PV material, which is needed to maintain the state of electron avalanche in the material, while at the same time avoiding the occurrence of electron avalanche breakdown. Alternating between these two different intervals energizes the PV material to improve electrical energy production during systemically controlled impact ionization-electron avalanching, while avoiding electron avalanche breakdown, and reduces heat-induced phonon scattering and collisions with the lattice of the PV material that cause energy loss.

[0018] Phonons represent the collective vibrations of atoms in a crystal lattice. Phonons do not have mass or charge; they are simply disturbances in the regular arrangement of atoms in the lattice that comprises the crystalline substrate of the photovoltaic material. However, phonons play a crucial role in the material's heat conduction, thermal expansion, and other thermal properties. As temperature rises, the atoms in the photovoltaic material vibrate more vigorously, increasing the number and energy of phonons-lattice vibrations. These phonons then collide more frequently with the charge carriers-electrons and holes responsible for generating electricity. This increased scattering disrupts the flow of charge carriers, reducing their mobility and hindering their ability to reach the electrodes and contribute to the electrical current. The LPS generator system minimizes phonon scattering due to effective heat management, thereby avoiding, or minimizing energy loss, and yielding a higher level of electrical current than heretofore produced with PV material in prior art solar power generation systems.

[0019] The electrical energy levels produced according to the disclosed embodiments are novel and unprecedented in the history of the solar power industry. A solar cell photovoltaic material is a semiconductor designed like a diode; a photovoltaic material is considered a wide-area diode. Most other semiconductors used today utilize some form of pulsing mechanism. Diodes, transistors, and MOSFETs all operate with a periodic time-based function. Why not consider a photovoltaic cell that would operate much more efficiently when designed similarly to the other semiconductors? The next stage of advancing the efficiency of photovoltaic cells is through applying an external mechanism, managed by electronic controls, that creates a pulsating dynamic relationship with optically concentrated incident light and internal (crystalline lattice) and external (surface) photovoltaic material temperature control, which further establishes a method of controlling the rate of charge to photovoltaic material for increasing electrical power production, efficiency and sustained system operational integrity. Electron avalanching in photovoltaic material occurs in stages, as discussed below. When an LPS generator facet-cluster of photovoltaic material sections is energized with optically concentrated incident light during an interval, a high electric field is created as a starting condition. The high electric field accelerates charge carrier-electron-hole pairs to high energies. This field is established across the p-n junction in the photovoltaic material within the band gap boundary.

[0020] The high electric field accelerates the initial charge carriers, giving them kinetic energy. Once the charge carriers gain energy, they collide with atoms in the material's crystal lattice. The collision knocks out a bound electron from the valence band to the conductance band within the band gap of the photovoltaic material, creating an additional electron-hole pair. This is the impact ionization process. The newly freed electrons and original electrons are also accelerated by the electric field and cause further impact ionization events. This leads to a chain reaction rapidly multiplying the number of charge carriers-electron hole pairs, increasing the electron avalanching process. As the number of charge carriers multiplies, the charge density in the material increases. The high electric field is the driver; it provides the energy for impact ionization and sustains the electron avalanching process. Impact ionization is the mechanism, for it's the process that multiplies the charge carrier-electron hole pairs.

[0021] Electron avalanching is the outcome; it's the rapid increase in the number of charge carriers due to repeated impact events as a chain reaction. Charge density is a consequence, for it increases as the electron avalanche progresses and influences the electric field, and charge density is increased. This is the core cascading phenomenon. This cascading process is like an ever-increasing energetic spiral in the PV material. The spiral shape visually represents the multiplying effect of impact ionization. Each loop symbolizes a generation of charge carriers, and the spiral grows larger and larger as more carriers are created. The term "energetic" emphasizes the crucial role of the high electric field in accelerating the electrons and providing the energy for impact ionization. This is directly affected by the optically concentrated incident light level, for example, with a concentration ratio sufficient to induce and maintain a state of electron avalanche in the PV material, even for a period of time following the absence of light directed to the PV material, whether optically concentrated light or otherwise. The level of optically concentrated incident light may be, for example, two to one hundred times "one-Sun", where "one-Sun" is a measure of solar irradiance of direct sunlight and can also be expressed in watts per meters squared (W/m^2), where one Sun equals 1000 W/m^2 in many cases. The amount of optically concentrated light incident on the PV material depends on other factors, such as the time each facet cluster of PV material is subject to/under the optically concentrated light, the time interval for cooling the temperature of the PV material while it is not subject to incident light, etc. The point is to induce and maintain electron avalanche in the PV material, and avoid electron avalanche breakdown, by alternating between intervals where the PV material is subject to the optically concentrated light and followed by a period where the PV material is not subject to the optically concentrated light, allowing for cooling the temperature of the PV material, so that continuous energy is output by the PV material, even when the PV material is not subject to incident light.

[0022] The spiral is a conceptual model that can be imagined as gaining momentum and energy as it expands. This highlights the exponential growth of charge carriers in the avalanche process. The spiral expands outward, symbolizing the rapid multiplication of electrons and holes. Another way of visualizing the process is to imagine a bowling ball-hot carrier rolling down a lane-electric field. Without impact ionization, the bowling ball might hit some pins-lattice atoms, losing energy with each collision until it slows down and stops. With impact ionization, the bowling ball hits a pin and knocks it into multiple pins, creating additional electron-hole pairs. These pins also start moving down the lane, potentially hitting more pins and creating a cascading effect. When specific electromechanical and optomechanical characteristics are optimized for photovoltaic material efficiency, improved electrode conductor capacity, and efficient heat protection variables, there is no theoretical limit to what level of electrical power is generated with LPS generator-controlled impact ionization-electrical avalanching technology.

[0023] FIGS. **1**A and **1**B depict a solar power generator rotor design **50**, or simply, a solar generator or generator **50**, according to the disclosed embodiments, in two different views: **50***a*—perspective view; and **50***b*—side view. In this disclosed embodiment, the generator is mechanical in function and dodecagon (12 gon) in shape, comprised of twelve panels or facets, e.g., 3D printed carbon fiber composite panels or facets **51***a* to **51**L, each configured with a cluster or a plurality of sections of photovoltaic (PV) material. According to one embodiment, the cluster of sections of PV material on a single facet are electrically coupled or wired together in series, so that the cluster produces a single power output value that is the combination of the power output of each section of PV material on the facet. This power output by the one cluster can be combined with the power output from one or more of the other clusters so that the generator produces continuous power output, not only for each facet-cluster, but for the generator as a whole, as described in further detail below. While the embodiment illustrated in FIGS. **1**A and **1**B has twelve panels or facets arranged in a dodecagon, it is appreciated an embodiment may have more or less panels or facets similarly arranged. For example, an embodiment may have six panels or facets concentrically arranged on a chassis around an axle in a hexagon, or eight or 24 panels or facets arranged in an octagon. Similarly, while the disclosed embodiments comprise panels or facets populated with a plurality of photovoltaic sections mounted on facet frames fabricated from 3D printed carbon fiber composites, other methods of manufacture and/or materials may be used in other embodiments.

[0024] The generator is attached via a frame or chassis to a common axle **61**, **61***a*. In particular, each facet-cluster is attached via the frame or chassis to axle **61**, **61***a*. A motor or energy source (not shown) is coupled to the axle to cause the axle to turn at a selected number of rotations or revolutions per minute (RPM), which, in turn, causes the generator to rotate the selected number of RPM. Alternatively, or additionally, the generator is powered by the solar energy that energizes the photovoltaic material. In one case, the generator rotates about the axle at 200 RPM, which produces 2400 continuous waveform pulses per minute (PPM), in an embodiment with 12 facets each comprising a cluster of PV material sections, wherein each facet produces a single pulse, or portion, of the continuous waveform each full rotation of the generator. As the generator rotates, a fixed focal point **58**, **58***a* of optically concentrated incident light, focused by a lens (e.g., a Fresnel lens) and/or an optical concentrator, is projected on to each facet-cluster, one after the other as the PV sections rotate under the fixed focal point, contributing to the PV sections in the facet-cluster producing continuous electrical current. In this case, the focal point is an area with a dimension varying from 13 MM (in length) to 19 MM (in length) depending on the optical concentrator components in an embodiment. The total facet-cluster is 20 MM in length by 96 MM in width. Thus, if the width of the focal point is less than the width of the facet-cluster, the focal point will still cover the entire width of the facet-cluster as the generator rotates the facet-cluster under the focal point. Generating 2400 pulses per minute does not mean 2400 PPM produces 2400 complete electrical cycles like a full sinusoidal alternating current (AC) cycle that embodies a positive and negative waveform, for it takes two mirrored pulses to create a full AC electrical cycle. A core example states that a Bi-polar DC pulse comprises a positive pulse, followed by a negative pulse, which equates to a complete electrical cycle. At 2400 PPM, the LPS generator produces 1200 complete positive-negative electrical cycles, or 2400 pulses if the generator system is configured for DC pulse. This is important to understand when converting LPS electrical signals to other standard electrical waveform signaling. In another configuration, a continuous DC pulse signal is specified to enable electrical power applications requiring continuous direct current. In this case, 2400 electrical pulses are generated, contributing to a continued DC pulse signal.

[0025] The physical dimensions of each LPS generator are completely arbitrary and only describe one of a plurality of proof of concept prototypal systems. Many types of photovoltaic materials have been tested, with many different form factors of geometric configurations for mechanical rotors. The incident light concentration ratio depends on the type of photovoltaic material utilized, from single junction to multijunction, organic solar cells, perovskite, thin film, graphene, and the like. A concentration ratio of 32×, **62***a*, is used in one case. The 12-gon generator rotates, e.g., in a counterclockwise direction **63**, **63***a*, and the concentrated incident light energizes each facet cluster in turn due to the physical rotating movement of the generator. The focal point may vary in width from 13 MM to 19 MM **58**, **58***a*, because of the design constraints imposed by the limitations of a 500 MM long by 105 MM wide linear Fresnel lens. In FIGS. **2**A and **2**B, however, with the application of planar optical concentrators, a focal point of 19 MM by 96 MM **47** illuminates the entire facet-cluster **51**, **51**-**51**L as the generator rotates in an (a) to (l) sequence. The focal point **58**, at the focal plane **44** illuminates each facet-cluster **51***a*-**51**L in a timed sequence 1-12 as the 12-gon generator rotates.

[0026] In FIGS. **1**A and **1**B, the photovoltaic generator illustrated in perspective view **50***a* and side view **50***b* is comprised of a plurality of facet-clusters of sections of PV material, for example, 12 facet-clusters **51***a* through **51**L, that rotate and pass by, or under, the concentrated incident light focal point in a cyclical manner. A continuous power level is maintained during the interval between facet clusters because each facet cluster sustains its own continuous power well after rotating out of the concentrated incident light focal point. In fact, a continuous, if diminishing, power level is maintained by each facet cluster until it rotates back under the concentrated incident light focal point, at which point, the power level output by the facet-cluster increases. An electrical rise time of the photovoltaic material occurs as a physical phenomenon when incident light hits the material, causing it to absorb photons and release electrons at a higher energy state. The main photovoltaic effect is a quantum state that rectifies light into electric current. In more detail, the photovoltaic effect is a consequence of three main quantum mechanical processes: (a) absorption of photons, (b) generation of electron-hole pairs, and (c) separation and collection of electron-hole pairs as usable electrical current. More concentrated light, in one embodiment, 32× optical concentration ratio, optimizes these quantum effects, which yields an increase of electrons and generates much more electrical current to an electrical load point. In some cases, the optical concentration ratio may be increased or decreased.

[0027] Depicted in FIG. **1**A and **1**B, simultaneously, one pulse of a continuous periodic waveform **76**, as depicted graphically as a replica of a generated image on the screen of an oscilloscope or comma-separated value (CSV) that is a universal data format used to measure electrically generated power with many types of source measure units (SMU). A continuous periodic waveform **76** produced by a rotating solar power generator comprises a continuous electrical power signal. Typically, generated waveforms are sinusoidal. In this case, the LPS electrical waveform is a sawtooth waveform **76** without sinusoidal characteristics, as depicted and discussed further below with reference to FIG. **5**. The waveform may be manipulated by facet output electrical circuitry depending on how it is configured to output the waveform to load. The generated signal from each facet cluster may be combined in a common circuit topology, according to one embodiment. As shown in FIG. **1**A, mechanical rotation of a facet cluster under the focal point produces electrical current generation, which begins at rise time **56** at the waveform's leading edge **56***b*. As the facet-cluster **51***a* rotates counterclockwise **63**, **63***a*, the pulse waveform quickly increases in amplitude as denoted by the pulse top amplitude **59** and voltage **60**, which equates to the wave-top **59***a* in this case. The wave-top width **55** is sustained for a duration of **55***a* based on the time frame that the facet-cluster is under the focal point. In one case, a 12-gon generator rotates at 200 RPM, producing 2400 PPM.

[0028] In FIGS. **1**B, **2**A, **2**B and **2**C, as the facet-cluster **51***a* moves past the focal point **58**, **58***a*, the physical and electrical fall time **57**, **57***b* coincides with the trailing edge **57***a*, **57***c* due to the rotation of the generator at 200 RPM and producing 2400 PPM, ensuring that electrical energy continues to be generated when each facet-cluster **51***a* to **51***f* moves in and out of the concentrated light focal point **58**, 13 MM-19 MM in height **58***a*, generating continuous electrical energy from each facet-cluster, as the generator rotates 360° degrees.

[0029] In the first instance, the facet-cluster **51***a* rotates into the optically concentrated light **58***a*, initiating shock interval **66**, **66***b*. The optically concentrated incident light, with condensed photonic energy, creates a high electric field **209**, initiating impact ionization **211** in the PV material of the facet-cluster during the interval, which is a phenomenon when an energetic charge carrier collides with an atom in the photovoltaic material crystal lattice, transferring enough energy to excite a bound electron into the conduction band, leaving behind a hole in the valence band. An electron-hole pair gains sufficient energy to liberate a bound electron from the valence band to the conduction band, creating another electron-hole pair. This process creates a high electric field **209**, which leads to impact ionization **211**, which initiates a chain reaction **212** known as electron avalanching **213**, and continues to accelerate the initial energetic charge carrier to a higher energy state, accelerating electrons and causing ionization that further creates a plasma field within the photovoltaic material crystal lattice substrate during the interval **66**. Thus, the PV material in the facet-cluster generates an electrically conductive plasma. The physical gap **67** between each of the **12** facet clusters in material space is a distinct optoelectrical boundary that creates a leading-edge **56***a* rise time **56** between each facet cluster **51***a* to **51***f*.

[0030] In FIGS. **1**B, **2**A, **2**B and **2**C, examining each facet cluster of the generator rotor side view, for example, **50***b*, the facet cluster **51***a* is fully charged. As this facet-cluster rotates out of the focal point from the optically concentrated incident sunlight at 200 RPM, the process of impact ionization and electron avalanching continues during a full 360-degree rotation vector. Electrical energy does dissipate to a level commensurate with the intensity of impact ionization and electron avalanching of each facet cluster **51***a* to **51**L which is governed by the available incident sunlight. Each facet cluster continues to generate electrical energy in and out of the optical focal point, thus creating a continuous waveform **76** signal in 360° degrees of continuous electromechanical rotation. This waveform is enabled without needing an inverter and can produce alternating current (AC) waveforms and standard sinewaves with the onboard power electronics **48**. This waveform can be converted to a standard alternating current (AC) squarewave, sinewave, etc. The continuous waveform continues as long as an electromechanical generator source continues to function in the presence of incident sunlight. In this case, the 12-gon generator continues to rotate due to the reception of concentrated incident light; the generated waveform remains constant. Generated electrical power only fluctuates due to the instant atmospheric condition that affects the full spectrum incident sunlight level received by an LPS generator.

[0031] As depicted in FIGS. **2**A and **2**B, there is an example of an LPS 12-gon generator **50** in perspective view **50***a* and side view **50***b*, mated together with a planar light guide module, comprised of a primary optic array **53***a*, that is populated with a lens or lens array, for example, a fused hexagonal plano-convex lens array **53***b*. A hexagonal plano-convex lens is a lens with one flat surface and one convex surface that is shaped like a hexagon. In this case, a hexagonal lens **53***b* can be 5 MM to 20 MM plus in diameter as depicted at **54**. Hexagonal lenses **53***b* comprise the primary optic, which gathers incident light vertically. Each microlens focuses and couples into and out of each optical fiber and a larger format light guide. In FIG. **2**, and FIG. **2**B, a hexagonal lens **53***b* has a f-number of f/3.01, **72** in one example. An F/3.01 hexagonal lens is a lens with a maximum aperture of f/3.01. The aperture is the opening in a lens that controls the amount of light passing through. The f-number is a ratio that describes the size of the aperture. It's calculated by dividing the lens's focal length **57** by the diameter of the aperture. A smaller f-number means a wider aperture, and a larger f-number means a narrower aperture. Additional optical elements include numerical aperture (NA) **60**. NA is a dimensionless number that characterizes the range of angles over which an optical system, like a lens, fiber optic, or light pipe **75**, can accept or emit light. The acceptance angle **181** is the maximum angle within that cone at which the light can strike the fiber's core and light pipe core and still be guided through it via total internal reflection.

[0032] This gathered light propagates through the core of an optical fiber or light pipe with a process called total internal reflection (TIR) within the optical structure of an accumulative multimode **81**, light pipe **75** fiber optic waveguide **74**. A more efficient and versatile alternative to hexagonal microlenses is optical metalenses **74**, **74***a* as depicted in FIGS. **2**B and **2**C. Metalens are typically thin and lightweight. Metalenses can be much thinner and lighter than traditional lenses. Metalens comprise an arrangement of meta-atoms that create nanostructures such as nanorods, nanofins, rectangles, triangles, and the like. These nanostructures can be twisted, titled, and arrayed to manage light phase profiles and the like. Metalenses can be designed to perform various optical functions, including focusing, beam shaping, light bending, and polarization control. Metalens nanostructures can array in concentric rings, grids, and spirals to perform several useful functions, such as optical tracking of the sun as it traverses across the azimuth from horizon to horizon. Metalenses can be cheaper to manufacture than traditional lenses, especially as nanofabrication techniques advance. Metalenses can be designed to have specific focal lengths and variable focal lengths. In this case, like the hexagonal lens **53***b* a metalens can be 5 MM to 20 MM **54** plus in diameter.

[0033] In FIGS. **2**A, **2**B and **2**C, hexagonal plano-convex lenses and or metalenses **74** capture and direct incident light **45**, which is collimated at **85** and focused on the optical output plane **44** to the focal plane. The focal plane is perpendicular to the optical axis that passes through the focal point **58**, with a physical dimension that can range from 13 MM to 19 MM **58***a,* where focused light gathers and converges with equal collimation on each facet-cluster **51** as the generator rotates on the axle **61** from **51***a* to **51**L. The distance between the output plane of the shaped fiber light guide bundle **78** that comprises the secondary optics **79** is a close gap **184** that allows the LPS generator frame angles to pass by the optical output plane surface while enabling minimal light scattering so that each facet-cluster absorbs as much optically concentrated light as possible. Metalenses **74**, **74***a* enable accurate gradient index configurations (GRIN) by tuning each nanostructure during manufacture. Gradient indexing in optics enables shifting refractive index, and shifting phase from the surface of a metalens optic to bend light from one direction and point the same light to the collimated **85** output plane **44**. Metalenses and gradient lenses, manipulate light by precisely controlling the phase of the light waves. They do this by introducing tiny structures or variations in material properties that cause different parts of the light wave to experience different phase shifts. In this way, gathered light incident on the surface is projected perpendicularly to the surface of each LPS generator facet-cluster through the shaped fiber bundle **78** that acts as the secondary optic **79**.

[0034] Each facet-cluster is 20 MM in length by 96 MM-105 MM in width, and the shaped fiber light guide bundle is also 13 MM-20 MM in length by 96 MM-105 MM in width. The object is to ensure that all output incident light comprised of photons energizes the rotating LPS generator. In FIG. **2**C, another variation of the planar micro-optic waveguide **94**, **94***a* that utilizes a micro metalens array **74**, **74***a.* The only significant difference is that instead of utilizing optical fibers and light pipe arrays, the planar waveguide comprises polymethyl methacrylate (PMMA) acrylic optical plastics. Set within the bottom of the slab waveguide is an array of coupling mirrors **96** that can be etched, micro-milled, formed with SU-**8** plastics, and the like. Light projected from each microlens is bent at an angle that sends the light to the divergent output **95**. As shown in FIG. **2**A, a heat filter **70** can be applied. Heat filters and antireflection compounds can be applied by spraying as a coating during manufacturing to ensure the highest optical efficiency possible.

[0035] FIG. **3** depicts a multi-generator commercial flat panel, e.g., a 32-generator commercial flat panel. All the detailed specifications of the single LPS generator **50**, **50***a* depicted in FIG. **1**A, FIG. **1**B, and FIGS. **2**A-**2**C, are the exact specifications and configurations of the **32** generators that are disclosed in FIG. **3**, according to one disclosed embodiment. In FIG. **3**, the LPS 32+ generator system utilizes two magnetic DC drives, **69** and **69***a,* comprising magnetic coils with no surface wear points. Once started, these drives consume very little electrical energy because there is nominal rotational resistance once the threshold of 200 RPM is sustained. These DC drive bearings ride on a permanent magnetic field. The axle assembly system **61**, **61***a* utilizes magnetic bearings on each end of the **16**-generator array assembly **118**, **118***a.* The **32** LPS system is designed as a commercial solar panel, with a length of 2000 MM **91***a* and a width of 1757 MM **91***b.* Tests in 32× concentrated sunlight showed that each generator **50**, as shown in FIGS. **1**A and **1**B has produced average power equal to 100% efficiency under I/V curve testing with a source measure unit (SMU). This same generator design array, a total of 16 generators on each of two common axles **61** and **61***a* for a total of 32 generators, produces 2000 watts or more of electrical power under the I/V curve and/or electrical load points. A standard commercial panel with approximately the same physical dimensions produces only 400-600 watts with ideal atmospheric conditions on a good day. This 32-generator panel utilizes planar micro-optic waveguide modules **56**, **56***a,* **56***b.*

[0036] In FIG. **3**, each optical module is 500 MM **90** in length by 105 MM **90***a* in width. The LPS-32 system can also utilize another form of micro-optic slab concentrator that combines an array of microlenses and metalenses with a multimode slab waveguide **94***a,* as shown in FIGS. **2**A-**2**C. In FIG. **3**, this generator example uses a DC servo motor **69**, **69***a,* to rotate LPS generator on array **118**, **118***a* on common axles. FIG. **3** depicts an LPS generator array comprised of 32 generators. Each one is the same configuration as generator **50** depicted in FIGS. **1**A and **1**B. The generator also uses a 24-channel rotary transformer to transfer positive and negative electrical energy from all 12 facets from the rotating medium (rotor) to a stator (stationary) to associated electronics that convert the originating electrical pulse wave to any type of desired waveform such as standard electrical sinewave. As depicted in FIG. **3**, 24-channel rotary transformers **68** and **68***a* are more efficient than electrical slip rings. Rotary transformers do not have any friction points. Like most electrical transformers, a rotary transformer comprises a primary and secondary coil. All transformers use electromagnetic induction to transfer electrical energy between coils or circuits through a magnetic field. The disclosed embodiments use a 1:1 equal transfer between the primary coil-rotor that is physically and electrically connected to the 24-channel output of the 16-18 LPS generator arrays depicted on each side of the 32 generators. Electromagnetic induction transfers the electrical energy generated from each 16-generator array to the secondary coil-stator (stationary). The 32 generator panels power electronics **48** receive a continuous waveform **76**, as shown in FIGS. **1**A and **1**B, which convert this source signal to standard AC waveforms and other signals to selected electrical load points. Power Electronics **48** control the DC drive that rotates the generator **50***b.* During rotation, optically pulsed **221** incident light at the focal point **58***a*, generates continuous periodic waveforms **76**, and optomechanical control **215**

that is managed with the LPS generator power electronics **48**. In FIG. **3**, each LPS generator **50***a*, **50***b* comprises facet-clusters and each facet-cluster is constructed of multiple sections of photovoltaic material partitioning **49**, **49***a*.

[0037] As depicted in FIGS. **4**A, **4**B, and **4**C, photovoltaic partitioning **49** is illustratively shown in multiple cases. The LPS generator shown in perspective view **50***a*, has 12 facet-clusters **51***a* to **51**L. Facet-cluster **51** shows an exploded view **87** of approximately 100 MM of partitioned monocrystalline single junction **99** photovoltaic material. An entire 6"×6" wafer is YAG-laser cut monocrystalline single junction solar cell **98** into multiple sections. In FIG. **4**B additional modifications include adding thicker center electrode **92** on the top N-layer electrode **92***a*, and the bottom P-layer electrode **92***b*. The conductive fingers **93** are also better connected to center electrodes **92** on both N-layer electrode **92***a*, and P-layer electrode **92***b* with military-grade solder. In FIG. **4**A, the exploded view **87** shows six 19 MM by 16 MM photovoltaic sections **88**. Each section **89** to **89***e* generates 0.55 volts, for a total of 3.3 volts **43**. In FIG. **4**C, exploded view **87***a* illustrates photovoltaic partitioning where each 6"×6" monocrystalline wafer is YAG-laser cut into even smaller sections. Note four subsections **89***f*, **89***g*, **89***h*, and **89***i*. Each subsection generates 0.55 volts for a total of 2.2 volts **108**. The total dimensional space is 19 MM by 16 MM **88***a*. The exploded view **87***b* depicts four sections **89***j*, **89***k*, **89***l*, **89***m*, **89***n*, and **89***o*, each being YAG-laser cut into four subsections. All 24 subsections equate to 13.2 v per facet-cluster **108***a*. One 12-gon generator has 144 subsections. Total voltage potential is 79.2 volts. In still another configuration, one facet-cluster **89***p* section is YAG-Laser cut into eight subsections, which equate to 4.4 volt **108***b*, x6=26.4 volt **108***c* equals 158.4 volts for all 12 facets clusters equals 316 volts for the complete LPS 12-gon generator in this case. Each LPS generator has unique and specialized circuit topological patterns **142** designed for maximum electrical power generation and distribution.

[0038] FIG. **5** illustrates graphically the continuous power output of a single facet-cluster, e.g., facet-cluster **51***a* in FIG. **1**B, as it completes a 360-degree rotation in the generator according to the disclosed embodiments. At time **t0**, presume the generator is just starting and facet-cluster **51***a* is positioned in the 1 o'clock position. The generator rotates the chassis in a counterclockwise position, so that facet-cluster **51***a*, given it is mounted to the chassis, also rotates during time **t0** to **t1**, so that at time **t1**, facet **51***a* is entering the 12 o'clock position under the focal point **58***a*. As the generator continues to rotate in a counterclockwise position, facet-cluster **51***a* passes directly under the focal point (at the 12 o'clock position) and therefore receives optically concentrated incident light. The optically concentrated light induces electron avalanche in PV material sections in the facet-cluster **51***a*, resulting in the facet-cluster **51***a* producing power output of approximately 5.6 watts during time **t1**-**t2**, while the facet-cluster is receiving the optically concentrated incident sunlight. This power output is much greater than the power output of the facet-cluster in a static/stationary flat panel display in a one-sun environment, which would only achieve power output of about 3 watts for the same unit area of PV material.

[0039] During time **t2**-**t3**, the facet-cluster **51***a* rotates out from under the focal point and is positioned in the 11 o'clock position. Even though the facet-cluster **51***a* is no longer receiving incident light, the facet-cluster **51***a* continues to output power, at a level only slightly diminished from the level output during time **t1**-**t2**, because the PV material continues to be in a state of electron avalanche and therefore continuing to produce power. In contrast, the facet-cluster in a static/stationary flat panel display in a one-sun environment would not continue to output power, since no sunlight is incident on the facet-cluster and no electron avalanching occurs.

[0040] During time **t1**-**t2**, the PV material in facet-cluster **51***a* nominally heats up when receiving the optically concentrated incident light. However, during time **t2**-**t3**, the facet-cluster **51***a* cools down immediately **66***a* since it is no longer receiving incident light **45**. This cooling continues during intervals **t3**-**t4**, **t4**-**t5** and so on, until the facet-cluster **51***a* rotates all the way around and back under the focal point **58***a* at interval **t13**-**t14** in this disclosed embodiment. This cooling of the PV material is important to avoid electron avalanche breakdown. Also, during the period of time that spans time intervals **t2**-**t13**, the facet-cluster **51***a* continues to output power, albeit at a slightly diminished level, reaching about 3 watts of output power by the time the facet-cluster **51***a* is reenergized at interval **t13**-**14**, at which point the above-described process repeats. In this manner, a single facet-cluster of PV material produces continuous output power.

[0041] Additionally, the other facet-clusters **51***b*-**51**L produce the same power output waveform or curve as facet-cluster **51***a*, time shifted according to their respective location in the generator. So, for example, facet-cluster **51***b* is producing 5.6 watts of output power while under focal point **58***a* at time interval **t2**-**t3**, while facet-cluster **51***a* is in the 11 o'clock position, facet-cluster **51***c* is generating peak power output while under focal point **58***a* at time interval **t3**-**t4**, while facet-cluster **51***a* is in the 10 o'clock position and facet-cluster **51***b* is in the 11 o'clock position. Thus, each facet-cluster generates continuous power output, and the combination of facet-clusters generates a continuous power output that is the sum of the instantaneous power output of each facet-cluster. While the described embodiment contemplates 12 facet-clusters, it is appreciated that fewer or more facet-clusters may be used in an embodiment. Thus, more generally, if the full rotation time for the generator is T, and there are n facet-clusters, each facet cluster receives optically concentrated light under the focal point for a period of time equal to 1/n(T), and cools down for a period of time equal to (n−1)/n(T), so as to maintain electron avalanche in the PV material in the facet-cluster, which in turn yields greater power output compared to flat panel systems under one-sun conditions, and at the same time avoids electron avalanche breakdown that otherwise occurs due to sustained overheating of the PV material.

[0042] LIGHT PULSE GENERATOR METHOD AND APPARATUS

1. A solar power generator system, comprising:

a photovoltaic (PV) material onto which optically concentrated incident sunlight is transmitted from the optical concentrator during a first series of time intervals, thereby inducing and maintaining a state of continuous electron avalanche in the PV material, the PV material continually generating an electrical current that exceeds an electrical current generated by the PV material in the absence of a state of continuous electron avalanche in the PV material;

a control means that reduces a temperature of the PV material during a second series of time intervals that alternate with the first series of time intervals to maintain integrity of the PV material while the state of continuous electron avalanche is maintained in the PV material, a state of electron avalanche breakdown is avoided in the PV material, and the PV material continues to generate the electrical current; and

an electrical load to receive the electrical current continually generated by the PV material.

2. The solar power generation system of claim **1**, further comprising:

a lens through which passes incident sunlight; and

an optical concentrator having an input aperture and an output aperture, the input aperture to receive the incident sunlight that passes through the lens, the optical concentrator to optically concentrate the incident sunlight received via the input aperture, the output aperture to transmit the optically concentrated sunlight.

3. A solar power generator, comprising:

a lens, positioned in a two-dimensional plane, through which to receive radiant energy from the sun;

an optical concentrator having an input aperture and an output aperture, the input aperture to receive the radiant energy from the sun that passes through the lens, the optical concentrator to optically concentrate the radiant energy received via the input aperture, the output aperture to transmit the optically concentrated radiant energy;

a drive shaft having a longitudinal axis positioned near and substantially parallel to the two-dimensional geometric plane of the lens and the optical concentrator;

a motor coupled to one end of the drive shaft to rotate the drive shaft about the longitudinal axis at a constant speed; and

a plurality of solar modules coupled to the drive shaft, each comprising photovoltaic material, and each forming one of a corresponding plurality of planar facets in coaxial alignment with respect to the drive shaft, such that as the motor rotates the drive shaft at a constant speed, each of the plurality of solar modules repeatedly rotates by the output aperture of the optical concentrator for a respective first time period, receives the optically concentrated radiant energy during the respective first time period, thereby inducing and maintaining a state of continuous electron avalanche in the PV material and continually generating an electrical current that exceeds an electrical current generated by the solar module in the absence of a state of continuous electron avalanche in the PV material, each of the solar modules rotating outside the output aperture of the optical concentrator during a respective second time period during which a temperature of the PV material reduces to maintain integrity of the PV material while the state of continuous electron avalanche is maintained in the PV material, a state of electron avalanche breakdown is avoided in the PV material, and the solar module continues to generate the electrical current.

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