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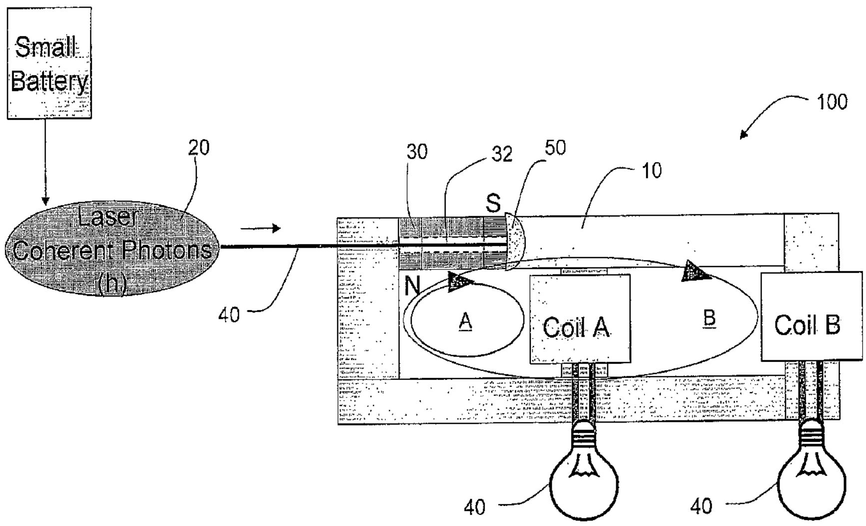

(57) Abstract: A method and apparatus for direct energy conversion employs modulated static magnetic flux emanating from the pole of a permanent magnet. Photon Cooper pair breaking is used to force a quantum state in Type II superconductor thin films by modulating a vortex channel made up of a bundle of vortex tubes isolated from each other for channeling static magnetic flux. Flux quanta are pinned inside the vortex channel by the magnetic interaction of the Meissner effect, atomic elastic forces, and an effect of electrons moving on the surfaces of the vortex tubes, and a massive shift in the permeability at the front of vortex channel. Static flux conducted through the vortex channel while in a superconducting state is modulated by forcing a quantum state of the Cooper pairs to toggle the vortex channel in and out of a superconducting state, which modifies its permeability up to $1 \times 10_6$ μ.

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METHOD AND APPARATUS FOR DIRECT ENERGY CONVERSION

CROSS-REFERENCE TO RELATED APPLICATIONS

The present patent application is based on, and claims priority from, U.S. provisional Application No. 60/813,341, filed June 14, 2006, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method and apparatus for direct energy conversion. More specifically, the invention relates to a method and apparatus for direct energy conversion for extracting electrons by employing the unique properties of Type II high temperature superconductors.

2. Related Art

The following definitions are used herein:

Atomic Elastic Force: In the normal state of matter, electrons are kept apart by mutual repulsion based on their electrostatic and magnetic properties. In the case of Type II superconductors, for example, YBCO, electrons that normally repel one another experience an overwhelming attraction to link up and form Cooper pairs when the material drops below its critical temperature, T_c. When these electrons form Cooper pairs, they take on the character of bosons, meaning that all the electrons have the same spin and energy level. Only bosons can condense and occupy a ground state that has a lower total energy than that of the normal ground state. This behavior suggests that Cooper pairs are coupling over hundreds of nanometers, three orders of magnitude larger than the crystal lattice spacing. The effective net attraction between the normally repulsive electrons produces binding energy on the order of milli-electron volts, enough to keep them paired at low temperatures. Electrons in the Cooper pair state can be considered compressed because they are closer to each other than in the normal (non-superconducting) state. In many ways, Cooper pair electrons are much like a mechanical spring under compression. The *atomic elastic force* is defined as the compressive force provided by millions of Cooper pairs in this ground state. The available potential energy increases when electrons close their interaction distance. This potential energy is released when the Cooper pair electrons absorb the energy of photons and are forced to revert from their lower total energy ground state to the higher total energy normal ground state. When this happens, the potential energy is released in a fraction of a second, producing spontaneous symmetry breaking (also known as Photon Cooper Pair Breaking). The cycle is repeated once the electron ejects a photon of a lower energy level and transitions back to the lower total energy ground state.

B: The magnetic field in which a superconductor is placed

Cooper pair: Two electrons that appear to "team up" in accordance with conventional theories of superconductivity, despite the fact that they both have a negative charge and normally repel each other. Below the superconducting transition temperature T_c, paired electrons form a condensate (a macroscopically occupied single quantum state), which flows without resistance. In addition, conventional theory holds that Cooper pairs form on the superconductor surface and spin as one large Cooper pair. In effect, Cooper pairs' electrons are so tight that they reflect the static flux away from the surface of the superconductor. This reflection of the static flux induces a thin sheet of current that leaves few fixed holes in the lattice structure, so that the current sheet acts like a moving mirror reflecting back the magnetic flux with the same polarity and force with which it was received.

Flux: A magnet's lines of force.

Fluxoid (also known as *flux line*, *fluxon*, *vortex*): One of the microscopic filaments of magnetic flux that penetrates a Type II superconductor in the mixed state, consisting of a normal core in which the magnetic field is large, surrounded by a superconducting region in which flows a vortex of persistent supercurrent which maintains the field in the core.

Conventional Flux-Pinning: The phenomenon where a magnet's flux become trapped or "pinned" inside a current-carrying Type II superconducting material in spite of the Lorentz force acting to expel it from inside the Type II superconducting material. This pinning binds the superconductor to the magnet at a fixed distance. Flux pinning is only possible when there are defects in the crystalline structure of the superconductor (usually resulting from grain boundaries or impurities).

H_c: The "critical field" or maximum magnetic field that a superconductor can endure before it is "quenched" and returns to a non-superconducting state. Usually a higher T_c also brings a higher H_c.

Meissner Effect: The exhibiting of diamagnetic properties to the total exclusion of all magnetic fields. The Meissner Effect is a classic hallmark of superconductivity.

Quantum efficiency: In an optical source or detector, the ratio of the number of output quanta to the number of input quanta.

Quench: The phenomenon where superconductivity in a material is suppressed; usually by exceeding the maximum current the material can conduct (J_c) or the maximum magnetic field it can withstand (H_c).

T_c: The critical transition temperature below, which a material begins to superconduct.

Thin Film (Deposition): A process for fabricating ceramic superconductors to more precisely control the growth of the crystalline structure to eliminate grain boundaries and achieve a desired Tc. Two types of thin film deposition are Pulsed-Laser Deposition (PLD) and Pulsed-Electron Deposition (PED) of the material.

Vortices (plural of *vortex*): Swirling tubes of electrical current induced by an external magnetic field into the surface of a superconducting material that represent a topological singularity in the wave function. These are particularly evident in Type II superconductors during "mixed-state" behavior when the surface is just partially superconducting. Superconductivity is completely suppressed within these volcano-shaped structures. The movement of vortices can produce a pseudo-resistance and, as such, is undesirable. While superconductivity is a "macroscopic" phenomenon, vortices are a "mesoscopic" phenomenon.

YBCO: An acronym for a well-known ceramic superconductor composed of Yttrium, Barium, Copper and Oxygen. YBCO was the first truly "high temperature" ceramic superconductor discovered, having a transition temperature well above the boiling point of liquid nitrogen (a commonly available coolant). Its actual molecular formula is $YBa_2Cu_3O_7$, making it a "1-2-3" superconductor. YBCO compounds exhibit d-wave electron pairing.

Superconductivity, discovered in 1911 by Heike Kamerlingh Onnes, is a phenomenon occurring in many electrical conductors at extremely low temperatures (on the order of -200° Celsius). In this phenomenon, the electrons responsible for conduction undergo a collective transition into an ordered state, an electronic fluid consisting of Cooper pairs. Attractive force between electrons from the exchange of phonons causes the pairing of electrons in Cooper pairs. As a result of its ordered state, the Cooper pair fluid has many unique and remarkable properties, including the vanishing of resistance to the flow of electric current, the appearance of a large diamagnetism and other unusual magnetic effects, substantial alteration of many thermal properties, and the occurrence of quantum effects otherwise observable only at the atomic and subatomic level.

In normal conductors, changing fields are required to induce other fields. In superconductors, static fields can also induce other fields. At the root of these effects lies a dramatic change in the permittivity and permeability of a superconductor (electron condensation).

One of the unusual magnetic effects exhibited by superconductors is the Meissner (or Meissner-Ochsenfeld) Effect. Meissner and Ochsenfeld discovered that a metal cooled into the superconducting state in a moderate magnetic field expels the field from its interior. Superconductors are defined as having "a state of perfect diamagnetism." Perfect diamagnetism implies that the superconductor material does not permit an externally applied magnetic field to penetrate into its interior. Effectively, superconductors block magnetic fields by modifying the magnetic length path, which is known as reluctance.

The exclusion of magnetic flux by a superconductor costs some magnetic energy. As long as this cost is less than the condensation energy gained by going from the normal to the superconducting phase, the superconductor will remain completely superconducting in an applied magnetic field. If the applied field becomes too large, the cost in magnetic energy will outweigh the gain in condensation energy, and the superconductor will become partially or totally normal. The manner in which this occurs depends on the geometry and the material of the superconductor. The geometry that produces the simplest behavior is that of a very long cylinder with the magnetic field applied parallel to its axis. Two distinct types of behavior may then occur, depending on the type of superconductor – Type I or Type II.

Below a critical magnetic field H_c, which increases as the temperature decreases below T_c, the magnetic flux is excluded from a type I superconductor, which is said to be perfectly diamagnetic. For a Type II superconductor, there are two critical magnetic fields, the lower critical magnetic field H_{c1} and the upper critical magnetic field H_{c2}. In applied magnetic fields less than H_{c1}, the superconductor completely excludes the magnetic field, just as a type I superconductor does below H_c. At magnetic fields just above H_{c1}, however, flux begins to penetrate the superconductor, not in a uniform way, but as individual, isolated microscopic filaments called fluxoids or vortices, each carrying one quantum of magnetic flux, $h/2e$. In other words, high levels of static flux are also known to cause vortices in Type II superconductors. The flux penetration is hindered by microscopic inhomogeneities that pin (trap) vortices. As a result, a critical state is formed with some gradient of flux density determined by the critical current.

Vortices provide a means to modulate static flux because they produce a magnetic channel whereby the static flux moves unhindered, without losses from one point to a second point. When a Type II superconductor is placed in a magnetic field B, where $H_{c1} < B < H_{c2}$, and where H_{c1} and H_{c2} are the lower and upper critical fields, respectively, the magnetic vortices that penetrate the material should form a uniform triangular lattice (Abrikosov vortex lattice), with a lattice spacing determined by the strength of B. If B is increased, the vortices become more closely spaced and their cores start to overlap. Currently theory holds that the static flux "B" causes the vortices in the surface of the Type II superconductor thin film to spin up. If the Type II superconductor thin film is configured as a cylinder, the spinning of the vortices in its surface will only cause a surface current equal and opposite to the static flux, which is enough to cause the magnetic flux to pin to the longitudinal axis of the cylinder. At H_{c2} the vortex lattice and the Cooper pairing of the electrons disappear and the material becomes normal.

Anisotropy effects are fundamental to superconductivity. Just about all-crystalline superconductors are in principle expected to show some anisotropy effects. There are several classes of materials with anisotropic superconducting properties, including the class of bulk anisotropic superconductors (for example, some of the transition metals) and the class of superconducting thin films. When the thickness of a film is less than the coherence length, the Cooper pairs can only interact with their neighbors in the plane of the film. In this case, the film is commonly referred to as a two-dimensional superconductor, because the Cooper pairs only interact in two directions.

Lowering the effective dimensionality of a superconductor from three to two dimensions has important and measurable consequences, deriving from the fact that the length scale for superconductivity in the direction perpendicular to the film is now the film thickness rather than the coherence length. Usually, layered superconductors show 3D anistropic superconductivity like the bulk transition metals, but sometimes they show 2D superconductivity like thin films, and sometimes they even show entirely new effects.

Research indicates that when a photon of a given energy level and wavelength is shot into the Type II superconductor, the photon is absorbed by the Cooper pair. This infusion of photon energy causes these electrons to break apart, and to seek a new higher quantum orbit. This starts a chain reaction or avalanche – not unlike a nuclear reaction – only without the adverse side effects. Previously published research findings show a quantum efficiency of up to 340 from each photon.

It is a well-known fact that permanent magnets produce a static flux that emanates off their end poles. Many devices have been invented that use this static flux to produce electrical power we use today. Static flux is ideal for converting mechanical energy into electrical energy. The basic process has not changed in 100 years. The most common method uses a moving armature that rotates inside windings, making and breaking the magnetic circuit. As Faraday and Maxwell discovered, only then can the static flux be used to extract energy. Faraday's law of induction (Equation 1) states that there is a counter electromagnetic force generated in a coil of wire when there is a difference in flux over time:

$$\varepsilon = -N\frac{d\Phi_B}{dt} \qquad \text{(Eq. 1)}$$

where the magnetic flux $\Phi_B = B\,A\cos\theta$, and where B is the magnetic field, A is the surface area of the coil, and θ is the angle between B and a line drawn perpendicular to the face of the coil.

The minus sign signifies that the direction of the induced EMF will be such that the magnetic field produced by the induced EMF resists the change in magnetic flux. The presence of the minus sign is referred to as Lenz's Law.

If a device can produce a difference in the flux density passing through a typical coil, then Faraday's law states there would be a counter electromagnet force developed across the windings. All of the present day devices that use mechanical energy perform this one simple task. Regardless of the complexity, the device only makes and breaks the flux lines, thereby creating a difference in flux, causing the secondary effect known as counter EMF. Man over the years has tried many different methods to produce electrical energy. Over time the demands for electrical energy is ever expanding. Man still uses massive generating plants linked together with thousands of miles of power distribution high voltage lines, which have to be maintained and require large financial investments.

It is to the solution of these and other problems that the present invention is directed.

SUMMARY OF THE INVENTION

It is accordingly a primary object of the present invention to provide a method and apparatus for extracting massive amounts of electrons developed and coupled by modulating the static magnetic flux emanating from the poles of permanent magnets.

It is another object of the present invention to provide a device that will provide electrical energy to power any electrical load without producing any additional CO_2 emissions.

It is still another object of the present invention to use Type II superconductors to improve the manufacture of electrical power.

It is still another object of the present invention to provide a method and apparatus for converting the potential energy from permanent magnets to kinetic energy by modulating the flux of permanent magnets.

These and other objects are achieved by a direct energy conversion generator that combines the known properties of Type II superconductors, including the Meissner Effect, to create vortices to control and modulate static flux coupled in a conventional magnetic circuit, where the laws of induction are used to produce an electrical potential to drive motors, lights, and other useful devices. This electrical energy is manufactured at the atomic level and does not require the use of moving armatures.

The direct energy conversion generator employs a vortex channel based on the Meissner Effect known to expel and pin a fixed magnetic field of a specific value emanating from the poles of a permanent magnet. A laser, a permanent magnet with an axial channel coincident with the magnet's axis, fiber optics for carrying photons from the laser through the axial channel of the magnet to the vortex channel, a diffusing mechanism between the permanent magnet and the vortex channel for evenly expanding the photon beam to the diameter of the vortex channel, and a transformer composed of two separate windings. The diffusing mechanism can be a thin diffusing lens or any other mechanism that can diffuse the incoming photons from the point source provided by the fiber optics into a larger area capable of covering the frontal surface area of the vortex channel. The transformer windings are arranged in a circuit having a first path through the permanent magnet and a first coil of the transformer windings; and a second path through the permanent magnet, the vortex channel, and the second coil of the transfer windings.

The vortex channel comprises a plurality of vortex tubes of circular cross-section arranged in a bundle with their longitudinal axes parallel to each other. The cross-section of the bundle can be any configuration, for example, approximately circular, approximately square, and approximately rectangular, etc. The number of vortex tubes in the bundle is on the order of hundreds or thousands.

The vortex tubes are glass tubes having an exterior surface (which includes the tube ends), a first buffer layer covering the exterior surface, a second buffer layer covering the first buffer layer, a Type II superconductor thin film covering the second buffer layer, and an insulating layer covering the superconductor thin film. The vortex tubes are switchable between a superconducting state and a non-superconducting state; and work together as a vortex channel to guide static magnetic flux in one direction from one end of the vortex tubes to the other, with very low or no loss, or at least very low losses.

The photons emitted by the laser must have a wavelength that will be easily absorbed by the Cooper pairs in the Type II superconductor thin film and provide the correct packet of energy, so that the liberated electron will jump precisely to the new quantum orbit. Type II YBCO material is known to have a very sharp resonance at 930 nm, at which it will absorb photons at extremely high efficiencies, causing it to revert back to the non-superconducting state.

When the vortex channel is in the non-super conducting state, it acts as a ceramic or insulator having the permeability of air, static flux is free to flow through the first path. When the vortex channel is in the superconducting state, it guides static flux quanta through the vortex channel. The static magnetic flux is held in a compressed closed loop, and static flux flows through the second path.

Photon Cooper breaking is used to toggle the Type II superconductor thin film (and thus the vortex channel) between the superconducting state and the non-superconducting state, thereby providing a time-varying magnetic field enabling power to be extracted using traditional means. In effect, the vortex channel acts like an ideal inductor with infinite permeability when it is fully superconducting, shorting the static flux to its far side (the second coil), allowing the static flux to move through what would otherwise be equivalent to a massive air gap without loss due to flux leakage. When Cooper pair breaking takes place, the vortex channel is forced to switch back into a (non-superconducting) ceramic, effectively adding a massive air gap into the magnetic loop and changing the reluctance of the magnetic circuit. Toggling the vortex channel allows the direct energy conversion generator to command passive conventional electrical components like an inductor to become inert and take on the physical properties of air.

Other objects, features and advantages of the present invention will be apparent to those skilled in the art upon a reading of this specification including the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is better understood by reading the following Detailed Description of the Preferred Embodiments with reference to the accompanying drawing figures, in which like reference numerals refer to like elements throughout, and in which:

FIGURE 1A is a schematic illustration of a direct energy conversion generator in accordance with the present invention.

FIGURE 1B is a schematic illustration of the magnetic flux path or loop of the direct energy conversion generator of FIGURE 1A when the vortex channel is in the non-superconducting state.

FIGURE 1C is a schematic illustration of the magnetic flux path or loop of the direct energy conversion generator of FIGURE 1A when the vortex channel is in the superconducting state.

FIGURE 2 is a cross-sectional view of the vortex channel of the direct energy conversion generator.

FIGURE 2A is an enlarged, cross-sectional view of one of the vortex tubes of the vortex channel.

FIGURE 3 is a schematic illustration showing the manner in which static flux is compressed and twisted as it enters the center of each vortex tube and is conducted into a very high virtual permeability thread.

FIGURE 4 is a graph illustrating how the vortex channel acts as a photon-activated switch used to modulate the static magnetic field of the permanent magnet of the direct energy conversion generator.

FIGURE 5 is the cross-sectional view of the vortex channel as shown in FIGURE 2, illustrating the area of influence surrounding the channel of the direct energy conversion generator.

FIGURE 5A is the cross-sectional view of the vortex tube of FIGURE 2A, illustrating the area of influence surrounding the vortex tube.

FIGURE 6 is a schematic illustration of the direct energy conversion generator in use as a source of electrical energy.

FIGURE 7 is a flow diagram showing the energy conversion process carried out by the direct energy conversion generator in accordance with the present invention.

FIGURE 8 is an energy generation curve for the direct energy conversion generator based on a hypothetical prototype design thereof.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In describing preferred embodiments of the present invention illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the invention is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner to accomplish a similar purpose.

The present invention is a direct energy conversion generator 100 (shown in FIGURES 1A-1C) that combines the known properties of Type II superconductors, including the Meissner Effect, to assist in the control of vortices to modulate static flux (indicated by the arrows F_s in FIGURES 1B and 1C). In the direct energy conversion generator, flux is coupled in a conventional magnetic circuit as described in greater detail hereinafter, where the laws of induction are used to produce an electrical potential to drive motors, lights, and other useful devices. This electrical energy is manufactured at the atomic level and does not require the use of moving armatures.

Referring now to FIGURES 2 and 2A, the direct energy conversion generator 100 employs a vortex channel 10 based on the Meissner Effect known to expel and pin a fixed magnetic field of a specific value emanating from the poles of a permanent magnet or an electromagnet. The vortex channel 10 comprises a plurality of vortex tubes 12 of circular cross-section arranged in a bundle with their longitudinal axes parallel to each other. As illustrated in FIGURE 2, the bundle has an approximately circular cross-section (a circle C is superimposed on the cross-section of the vortex channel 10 for the purpose of illustrating its approximately circular shape). However, the cross-section need not be approximately circular, but can be any configuration, for example, approximately square, approximately rectangular, etc. The number of vortex tubes 12 in the bundle is on the order of hundreds or thousands.

As shown in FIGURE 2A, the vortex tubes 12 are glass tubes 12a having an exterior surface 12b (which includes the tube ends), a first buffer layer 12c covering the exterior surface 12b, a second buffer layer 12d covering the first buffer layer, a Type II superconductor thin film 12e covering the second buffer layer, and an insulating layer 12f covering the superconductor thin film. As discussed in greater detail hereinafter, the vortex tubes 12 are switchable between a superconducting state and a non-superconducting state; and work together as a vortex channel 10 to guide static magnetic flux in one direction from one end of the vortex tubes 12 to the other, with very low or no loss, or at least very low losses.

In an exemplary embodiment, the vortex channel 10 is constructed of approximately 500 vortex tubes. Each glass tube 12a has a maximum 0.0125-inch outside diameter and a 1.0- inch length. The first buffer layer 12c is a thin film coating of Y_2O_3 stabilized with ZrO_2. The second buffer layer 12d is a thin film coating of cerium oxide (CeO_2). The superconductor thin film 12e is a thin film of YBCO. The insulating layer 12f is a very thin layer of Parylene.

Type II superconductor thin film (YBCO) is deposited over the second buffer layer 12d (CeO_2). The Type II superconductor to make a vortex tube, the exterior surface 12b of the glass tube 12a must first be cleaned of SiO_2, for example using an Excimer laser in a vacuum. The first buffer layer 12c (a thin film coating of Y_2O_3 stabilized with ZrO_2) keeps the tube material (Si) from migrating into the Type II superconductor thin film 12e (YBCO) and making it ineffective as a superconductor.

To improve the crystal lattice interface between the Type II superconductor thin film 12e (YBCO) and the first buffer layer 12c (thin film coating of Y_2O_3 stabilized with ZrO_2), a second buffer layer 12d is required. Cerium oxide (CeO_2) is selected for the second buffer layer 12d because it provides an ideal base for the deposit of the YBCO thin film. The second buffer layer 12d brings the error between the crystal lattice interface to ~ 0.5%. Next, a very thin film 12e of the thin film 12e (YBCO) is deposited in a very thin shell over the first and second buffer layers 12c and 12d so as to cover the exterior surface 12b of the tube without defects.

After the Type II superconductor thin film 12e (YBCO) is deposited, it is coated with a very thin layer of Parylene, which is an electrical insulator that is capable of coating the Type II superconductor thin film 12e (YBCO) one molecule at a time without gaps, to electrically isolate the vortex tubes 12 from each other, making the vortex generated within each vortex tube 12 operate independently of the vortices generated in the other vortex tubes 12, neutralizing the Lorentz force, and locking each vortex tube 12 to a fixed position within the vortex channel 10 so that each vortex tube 12 works independent of its neighbor.

Referring again to FIGURES 1A-1C, in addition to the vortex channel, the direct energy conversion generator 100 includes a laser 20, a permanent magnet or electromagnet 30 (preferably cylindrical) with an axial channel 32 coincident with the magnet's axis, fiber optics 40 for carrying photons from the laser 20 through the axial channel 32 of the magnet or electromagnet 30 to the vortex channel, a diffusing mechanism 50 between the permanent magnet or electromagnet 30 and the vortex channel 10 for evenly expanding the photon beam to the diameter of the vortex channel 10, and a transformer composed of two separate windings. The diffusing mechanism 50 can be a thin diffusing lens or any other mechanism that can diffuse the incoming photons from the point source provided by the fiber optics 40 into a larger area capable of covering the frontal surface area of the vortex channel 10. The permanent magnet or electromagnet 30, the vortex channel 10, and the transfer windings make up the rest of the circuit.

The transformer windings are arranged in a circuit having a first path A (shown in FIGURE 1B) through the permanent magnet or electromagnet 30 and a first coil A of the transformer windings; and a second path B (shown in FIGURE 1C) through the permanent magnet or electromagnet 30, the vortex channel 10, and the second coil B of the transfer windings. When the amount of magnetic flux flowing through the transformer windings changes due to modulation of the magnetic flux by the vortex channel, electricity is produced. This electricity can be used to power a load 60, for example, a light bulb.

The photons emitted by the laser 20 must have a wavelength that will be easily absorbed by the Cooper pairs in the Type II superconductor thin film and provide the correct packet of energy, so that the liberated electron will jump precisely to the new quantum orbit.

Thus, in the exemplary embodiment in which the Type II superconductor thin film 12e is YBCO, the laser 20 has a wavelength of 930 nm with a power output of approximately 1-watt, and electron-photon conversion quantum efficiency of at least 30%. The transformer conventionally includes a ferromagnetic core (for example, soft ferrites) and windings made of a conductive material like copper wire or a superconductive wire. The flux density of the permanent magnet or electromagnet 30 is approximately 2000 gauss at the magnet poles.

It is noted that Type II YBCO materials normally saturate at a flux density of approximately 2000 gauss. This saturation is prevented in the direct energy conversion generator 100 in accordance with the present invention by the design and fabrication of the vortex channel. For example, if the vortex channel 10 is made up of approximately 500 vortex tubes, then each vortex tube 12 must carry a flux density of approximately 4 gauss. A flux density of approximately 4 gauss is still well above the normal amount that Type II YBCO materials can carry without saturation. However, the rotating Cooper pairs in the Type II superconductor thin film 12e deposited on the outside surface of each vortex tube 12 exert an atomic force that emanates from the moving electrons and interacts with the incoming static flux, causing the static flux to be pinned to the centers of the vortex tubes by atomic force pinning. This flux pinning is used to extract the potential energy through the operations of the direct energy conversion generator.

As shown in FIGURE 3, static flux is compressed and twisted as it enters the center of each vortex tube 12 and is conducted into a very high virtual permeability thread where it is maintained at a distance from the outside surface of the vortex tube 12e. The electrons orbiting inside the crystal lattice structure on the surface of the vortex tubes 12 provide the dynamic force to do this work function. The dynamic force is supplied by the superconductor thin film 12e only when it is in the superconducting state. Reflection of the static flux induces a thin sheet of current, so that the current sheet acts like a moving mirror reflecting back the magnetic flux with the same polarity and force with which it was received. The thin sheet of current covers the circumference of the vortex tubes 12 along their full lengths, compressing the static flux over the full lengths of the vortex tubes 12 and thus over the full length of the vortex channel 10.

When the vortex channel 10 is in the non-super conducting state, it acts as a ceramic or insulator having the permeability of air, static flux is free to flow through path A. When the vortex channel 10 is in the superconducting state, it guides static flux quanta through the vortex channel 10, which is a low energy magnetic circuit for the purpose of generating electrical energy. The static magnetic flux is held in a compressed closed loop, and static flux flows through path B.

Each vortex tube 12 can only handle a given amount of static flux before it will saturate. The vortex channel '10 therefore must be made up of enough vortex tubes 12 to spread out the static flux by passing it through their open centers away from the Type II superconductor thin film when the Type II superconductor thin film 12e is in its superconducting state. The vortex channel, while in its superconducting state, produces a super high virtual permeability state, as a result, provides a new low energy path for the static flux to flow through. The higher the permeability, the less energy it takes for the static flux to flow. Static flux always takes the path of least resistance, i.e., lowest energy path.

FIGURE 4 is a graph illustrating how the vortex channel 10 acts as a photon activated magnetic switch to modulate the magnetic field of the permanent magnet or electromagnet 30 of the direct energy conversion generator 100. When the Type II superconductor thin film 12e is in its superconducting state, the combination of the Meissner Effect and the atomic elastic forces between the electrons and the static flux results in flux pinning at the center of the vortex tubes. More specifically, rotating Cooper pairs around the exterior surface of the vortex channel 10 create a massive pinning force in the center of the vortex channel, whereby the static flux is held off the interior and exterior surfaces of the vortex tubes 12 due to the Meissner Effect and the force excreted by the electrons magnetic forces in opposition to the static magnetic forces, and is pinned inside the vortex tubes 12 along their longitudinal axes so as to have no contact with the superconductor thin film. As a result of this geometry, the direct energy conversion generator 100 can operate at much higher flux density than would otherwise be possible, because the static flux does not come into direct contact with the superconducting thin film.

In the normal (that is, the non-superconducting) state, the vortex channel 10 does not affect the magnetic path, because the vortex channel 10 (and more specifically, the superconductor thin film 12e that coats the vortex tubes 12) is just a non-superconducting ceramic, with no known magnetic properties of any kind. Static flux emanating off the south pole of the permanent magnet or electromagnet 30 is coupled or linked to the magnetic path provided by the inductor in path A and returned to the north pole by the magnetic path provided by the inductor loop completing the magnetic loop.

In addition, the atomic forces found in the crystal lattice structure of the Type II superconductor thin film 12e play a role in pinning the static flux. These forces are applied evenly around the circumference of each vortex tube 12e along its entire length, analogous to the manner in which a magnetic field is evenly distributed around the circumference of a wire along its entire length when current is flowing through that wire. Each vortex tube 12 acts independently, pulling flux quanta into its center. The area of influence is much greater then the frontal area of each vortex tube, as shown in FIGURES 5 and 5A. More energy is required for magnetic flux to take a path outside of this area of influence of the vortex tube 12 than to take a path within the area of influence. Only the longitudinal axis of the vortex tube 12e represents the lowest energy path or the preferred path.

By combining many man made vortex tubes 12 together an artificial or virtual high permeability vortex channel 10 is defined. A disk of virtual high permeability rotates at the front or upstream end of each vortex tube. 12 This virtual high permeability increases radially in an inward direction from the circumference to the longitudinal axis of each vortex tube 12, providing an ever-increasing pinning force that induces the flux quanta to flow towards the longitudinal axis of each vortex tube 12 and away from its outer surface.

Both the Meissner Effect and the atomic elastic forces, i.e., magnetic and static forces of the electrons, found circulating in the super thin sheet of current flowing on the external surface of the vortex tubes 12, force the static flux away from the Type II superconductor thin film 12e, pinning the static flux to the longitudinal axis of each vortex tube.

This pinning is only possible because the Type II superconducting material resists the penetration of the static flux emanating off the surface of one of the poles of the permanent magnet. This static flux bias causes the Type II superconductor to develop a counter force, known as "J", or current flow, which flows on the external surface of the vortex tubes 12 in the form of a supper thin sheet of current and is restricted to the outside surface of the thin film 12e of each vortex tube 12.

The energy cost of developing this counterforce is zero, with the exception that the environment must be maintained at LN2 temperatures. In effect, the vortex tubes 12 are performing a work function by producing a low energy flux channel, which is preferred by the static flux emanating off the pole of the permanent magnet or electromagnet 30. For static flux to take a different path would require more energy and therefore is rejected. Static flux will always pass through the path of lowest energy or least resistance. The path of least resistance is always the longitudinal axis A_L of the vortex tube. Because the vortex channel 10 is made up of many vortex tubes 12, the static flux will be forced to fall into one of these low energy paths rather than to turn and select path A. When the vortex channel 10 is in the superconducting state, path B will provide a million times lower energy path for the static flux to follow back to the opposing pole, in this case the opposite pole of the same magnet.

A process known as "photon Cooper breaking" is used to toggle the Type II superconductor thin film 12e between the superconducting state and the non-superconducting state, thereby providing a time-varying magnetic field enabling power to be extracted using traditional means. In effect, the vortex channel 10 acts like an ideal inductor with infinite permeability when it is fully superconducting, shorting the static flux to its far side (coil B), allowing the static flux to move through what would otherwise be equivalent to a massive air gap without loss due to flux leakage. When Cooper pair breaking takes place, the vortex channel 10 is forced to switch back into a (non-superconducting) ceramic, effectively adding a massive air gap into the magnetic loop and changing the reluctance of the magnetic circuit. It is noted that when the YBCO thin film is in the superconducting state it is a perfect diamagnetic material, rather than a ceramic. Toggling the vortex channel 10 allows the direct energy conversion generator 100 to command passive conventional electrical components like an inductor to become inert and take on the physical properties of air. The efficiency of this conversion is almost 99.999%, far better then the standard losses related to the hysteresis found in normal inductor materials.

When a photon of the correct energy level and wavelength is shot into the Type II superconductor, the photon is absorbed by one of the electrons forming the Cooper pair. This infusion of photon energy causes the Cooper pair to break apart, and the electron that absorbed the photon's energy can no longer remain in a Cooper pair or its low energy quantum orbit; and it will seek a new higher quantum orbit, starting a chain reaction or avalanche. Note that Cooper pair electrons are much closer to each other orbit wise and this state could be called a compressed state (atomic elastic forces are compressed), similar to a compressed spring, which stores potential energy. In effect, energy is removed from the superconducting material to make Cooper pairs.

Once the photon energy is absorbed by one of the electrons, both electrons fly apart with great force, hitting other Cooper pairs and affecting the energy state of the crystal lattice structure. Because the photons were coherent, the avalanche wave moves away from the first impact site where the photons were injected in a linear wave turning the superconducting vortex channel into a variable magnetic air gap. This act of adding energy to the Cooper pair is what forces the Type II superconducting material to toggle out of the superconducting state, known to be a diamagnetic material and then change back to the ceramic state which is normal at room temperatures. In this case, Type II YBCO superconducting ceramic material is designed to act as a variable, solid state, magnetic air gap. Converting the vortex channel is extremely efficient, because it takes place at the atomic level. This process can be either bolometric or non-bolometric, and can be repeated thousands of time every second without moving parts.

The vortex channel 10 exhibits a very large permeability shift at its upstream end greater than 1×10^6 μ, and thus can be used to modulate the static flux between a permeability of 1×10^0 μ and 1×10^6 μ. Once the additional energy from the photons is introduced into the device, the static flux emanating from the poles of the permanent magnet or electromagnet 30 can be re-directed so it can be modulate through transfer coils, producing conventional electrical energy.

When the source of photons (that is, the laser 20) is turned off, the electrons give up the energy they had received from absorbing the photon and drop back into Cooper pairs, in effect producing a "self organized criticality" (the theory of self organized criticality asserts that complex systems far from equilibrium spontaneously evolve toward a critical state without external tuning). A good example of self organized criticality is what happens when mousetraps are arranged in a container in a two-dimensional array, set, and loaded with ping pong balls, and a ball is dropped from above on one of the mousetraps. The set and loaded mousetraps are in an organized critical state. The dropped ball is analogous to a photon ejected into a superconductor that is in the superconducting state, and the ping pong balls loaded in the set mousetraps are analogous to Cooper pair electrons. Once the dropped ball springs the first mousetrap and launches the ping-pong ball that was loaded on the first mousetrap, the launched ping-pong balls initiates an avalanche in which the remaining mousetraps are sprung and their ping pong balls are launched. The avalanche is over in a few seconds, after which the ping-pong balls come to rest at a new energy level, i.e., a new ground state.

According to quantum physics, one cannot measure the amount of energy required to "reset" the Type II superconductor, but the effects of the expenditure of this energy are perceivable, because the superconductor resets to a state of criticality each time it toggles between the normal state and the superconductor state. The direct energy conversion generators is taking this unknown source of potential energy and converting it into kinetic energy, which is used to modulate the potential energy of the permanent magnet or electromagnet 30 (static magnetic flux) and thereby convert this potential energy to a time varied static flux so that electrical energy can be produced through conventional means.

Operation of the direct energy conversion generator 100 creates a difference in the magnetic flux path, developing a counter-electromotive force in the transformer windings where the static flux is converted into free electrons. Electrical energy is produced by moving flux through the transformer windings in a given time period, which results in the flow of electricity. The rate of generation is related to the rate of change of the photon source (the laser 20) that is switched on and off, but there is a theoretical optimum limit at around 1 megahertz.

As shown in FIGURE 6, the direct energy conversion generator 100 requires for its operation a cryogenic liquid 200 to maintain the Type II superconductor thin film 12e below its transition temperature T_c and thus maintain its superconducting state, as well as a Dewar vessel 250 for containing the cryogenic liquid 200, control circuit 300 for executing control logic, and a battery 400 or other power source to provide power to the laser 20 and control circuit 300.

The control circuit 300 is designed to provide pulse width modulation (PWM) of the laser output and to regulate the output of the direct energy conversion generator 100 for a given load. The technology of such control circuits 300 is well developed, and the design and construction of such a control circuit 300 is well within the ordinary skill in the art.

Any cryogenic liquid capable of maintaining the superconductor below its transition temperature can be used; but liquid nitrogen ("LN2") is preferred because it is the most practical and will have the lowest cost of operations. Although it takes energy to manufacture LN2, other energy sources (particularly those normally rejected) can be used to manufacture LN2. For example, the LN2 can be supercooled by solar energy or other clean zero CO2 energy sources like wind, wave and hydro and nuclear.

Operational heat losses evaporate the LN2 200 using the known process of "Latent Heat of Vaporization" (in which the state of a cryogenic liquid is changed from a liquid to a gas). The LN2 200 boils off as a gas due to waste heat manufactured from the production of electrical energy and evaporates into the open space or atmosphere, where it is dispersed without adverse ecological effects because nitrogen gas represents approximately 78% of our present atmosphere. Once all the cryogenic liquid has changed to a gas state, the electrical generating process or cycle ends.

Because the direct energy conversion generator 100 is extremely efficient, only a small fraction of the energy converted generates heat. Unlike a nuclear power plant, which only converts approximately 25% to electrical energy, the direct energy conversion generator 100 will convert approximately 99.8% to electrical energy and only give off approximately 0.2% as waste heat losses.

In effect, the direct energy conversion generator 100 is solid state, having no moving parts. This lack of traditional moving parts and use of the novel thermal cycle as described herein results in extremely high conversion efficiency when compared to traditional methods of generating electrical energy, making the direct energy conversion generator 100 ideal for many new applications.

With reference to FIGURE 7, the energy conversion process carried out by the direct energy conversion generator 100 includes the following steps:

Step 1 – a power source 400 (for example, a small battery) powers a small laser 20 to initiate a photon stream into the fiber optics 40

Step 2 – the diffusing lens 50 evenly distributes the photons into the vortex channel, which is in the superconducting state, so that the photons interact with the electrons in the Type II superconductor thin film 12e arranged in Cooper pairs.

Step 3 – the photons disrupt the Cooper pairs

Step 4 – magnetic flux flowing through the vortex tubes 12 is shunted, forced to find an alternate route to return

Step 5 – the change in magnetic flux produces electrical current in the transfer windings

Step 6 – feedback loop provides electricity for the laser 20, and optionally, also to provide electricity for use in generating additional LN2

Step 7 – excess electricity (10 KW) powers outside loads until the LN2 completely evaporates and the vortex channel 10 returns to the non-superconducting state.

The direct energy conversion generator 100 is theoretically 99.8% efficient with only 0.2% waste heat, compared with other energy systems, where 30% efficiency is considered high. The process is clean, cold, and can be adopted to eventually replace the planet's entire energy infrastructure.

Table 1 sets forth the energy gain from magnetic flux modulation in accordance with the present invention, where $\Delta Y = 18000 - 3600 = 14400$, $\Delta X = 100000 - 20000 = 80000$, slope = 0.18, and $Y = 0.18X$.

Table 1

Energy gain from magnetic flux modulation			
Static Flux (J)	Switching Rate (Hz)	Watt-Hours	KW-h
0.18	60	11	0.011
0.18	400	72	0.072
0.18	20000	3600	3.6
0.18	27000	4860	4.86
0.18	50000	9000	9.0
0.18	65000*	11700	11.7
0.18	100000	18000	18.0
0.18	1000000	180000	180
*Estimated operational design limit of initial prototype			

Table 2 sets forth the data for the energy generation curve for a hypothetical direct energy conversion generator, as shown in FIGURE 8. The data in Table 2 is just an estimated energy computation based on standard power magnetics switch mode power supply design parameters.

Table 2

Frequency	Energy Gain from Flux Modulation	Ambient Heat Loss	Transformer Core Heat Loss	Photon Laser Loss	Photon Heat Loss	Copper Wire Heat Loss	AC Copper Wire Loss	LN2 Generation (in W-h)	Energy Feedback Input	Net Energy Gain/Loss (in W-h)	Efficiency (in %)
60	11	2	0	1	1	0	0	18	19	8	42.105263
400	72	2	0.1	1	1	0	0	18.6	19.6	68.9	351.53061
20000	3600	2	3.6	1	1	4.4	4.4	92.4	93.4	3584.6	3837.9015
27000	4860	2	4.86	1	1	8	8	143.16	144.16	4836.14	3354.7031
50000	9000	2	9	1	1	13.77	25	304.62	305.62	8949.23	2928.2213
65000	11700	2	11.7	1	1	23.3	50	528	529	11612	2195.0851

Due to its energy density, it is calculated that a one-cubic-meter direct energy conversion generator 100 could quietly produce approximately 250 megawatts, with no pollution and zero CO_2 emissions. That much electrical output is comparable to the output of a nuclear power plant. The only byproducts of the direct energy conversion generator's electrical energy production (not taking into consideration the methods used for supercooling the nitrogen) are waste heat (which would be negligible), nitrogen gas, and clean, quiet electrical energy.

A one-liter sized direct energy conversion generator 100 would be large enough to power an average home. The direct energy conversion generator 100 can also be used to power an electric car, providing a range of 200+ miles before the nitrogen must be replenished. The cryogenic converter and the direct energy conversion generator 100 together would easily fit in the space of a spare-tire compartment. Before retiring for the night, one could simply plug in a direct energy conversion generator-powered car into a standard 115 V AC outlet to recharge the next day's worth of liquid nitrogen. For farther-range driving, one would need to refill at stations that carry liquid nitrogen. It is therefore envisioned that an electric car powered by the direct energy conversion generator 100 would require both nitrogen regenerative and nitrogen input capabilities.

Direct energy conversion generators similarly can be designed to fit into trains, planes, ships, and other vehicles and forms of transportation. It is also envisioned that the direct energy conversion generator 100 can provide massive amount of electrical power in space. If a direct energy conversion generator in outer space were shaded from the Sun, the background temperature of 3° Kelvin would eliminate the need for cryogenics. In effect, a space craft could be powered with zero mass loss – ideal for deep-space missions in our solar system, making trips in weeks, which now take years with current conventional, unclassified propulsion technologies.

Modifications and variations of the above-described embodiments of the present invention are possible, as appreciated by those skilled in the art in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims and their equivalents, the invention may be practiced otherwise than as specifically described.

WHAT IS CLAIMED IS:

1. A direct energy conversion generator comprising:

magnet means for generating static magnetic flux;

vortex channel means for channeling and modulating the static magnetic flux, the vortex channel means having a first state in which it acts like an ideal inductor with infinite permeability and a second state in which it acts as an insulator having the permeability of air;

toggling means for selectively toggling the vortex channel means between its first and second states; and

electricity-producing means for producing electricity from modulation of the static magnetic flux by the vortex channel means.

2. The direct energy conversion generator of claim 1, wherein the electricity producing means comprises:

a first transformer winding in a first magnetic circuit path with the vortex channel means, wherein magnetic flux flows through the first magnetic circuit path when the vortex channel means is in the first state; and

a second transformer winding in a second magnetic circuit path with the vortex channel means, wherein magnetic flux flows through the second magnetic circuit path when the vortex channel means is in the second state.

3. The direct energy conversion generator of claim 1, wherein the first state of the vortex channel means is a superconducting state and the second state is a non-superconducting state.

4. The direct energy conversion generator of claim 3, wherein the toggling means uses photon Cooper breaking to toggle the vortex channel means from the superconducting state to the non-superconducting state.

5. The direct energy conversion generator of claim 4, wherein the vortex channel means comprises a plurality of vortex tubes of circular cross-section arranged in a bundle with their longitudinal axes parallel to each other, wherein each of the vortex tubes is a glass tube having a multiple-layer coating over its exterior surface, and wherein one of the layers is a Type II superconductor thin film.

6. The direct energy conversion generator of claim 5, wherein the multiple-layer coating has four layers, wherein the first layer is a first buffer layer covering the exterior surface, the second layer is a second buffer layer covering the first buffer layer, the third layer is the Type II superconductor thin film and covers the second buffer layer, and the fourth layer is an insulating layer covering the superconductor thin film.

7. A direct energy conversion method using a vortex channel capable of channeling and modulating static magnetic flux, the vortex channel having a first state in which it acts like an ideal inductor with infinite permeability and a second state in which it acts as an insulator having the permeability of air, comprising the steps of:

generating static magnetic flux;

selectively toggling the vortex channel between its first and second states to cause magnetic flux to flow alternately through a first transformer winding in a first magnetic circuit path when the vortex channel is in the first state and through a second transformer winding in a second magnetic circuit path when the vortex channel is in the second state; and

using electricity produced by a changing amount of magnetic flux flowing through the first and second transformer windings to power a load.

8. The direct energy conversion method of claim 7, wherein the first state of the vortex channel means is a superconducting state and the second state is a non-superconducting state.

9. The direct energy conversion generator of claim 8, wherein the toggling means uses photon Cooper breaking to toggle the vortex channel means from the superconducting state to the non-superconducting state.

10. A direct energy conversion electric generator comprising:

means for producing a static magnetic field;

a channel made at least in part from a Type II superconducting material, wherein the channel channels the static magnetic flux when the Type II superconducting material is in a superconducting state and acts as an insulator preventing the flow of the static magnetic flux when the Type II superconducting material is in a non-superconducting state;

means for periodically disrupting Cooper pairs in the Type II superconducting material by introducing at least one of heat, photons, RF energy, magnetic energy and electrical current into the superconducting material; and

electricity-producing means for producing electricity from the change of flow of the static magnetic flux through the vortex channel.

11. The direct energy conversion generator of claim 10, wherein the means for disrupting modulates vortices in a superconductor by introducing excitation photons of a relatively constant energy and wavelength.

12. The direct energy conversion generator of claim 10, wherein the electricity-producing means includes one of a coil and a loop, wherein the means for disrupting forces the Type II superconducting material to revert to a non-superconducting state in a given time period for modulating the static magnetic flux to produce a counter EMF in the coil or single loop from which electrical energy can be extracted.

13. The direct energy conversion generator of claim 10, wherein when the Type II superconducting material is in the superconducting state, rotating Cooper pairs around the exterior surface of the channel create a massive pinning force along the longitudinal axis of the channel, pinning flux quanta at the longitudinal axis.

14. The direct energy conversion generator of claim 10, wherein the channel comprises a plurality of vortex tubes of circular cross-section arranged in a bundle with their longitudinal axes parallel to each other, wherein each of the vortex tubes is a glass tube having a multiple-layer coating over its exterior surface, and wherein one of the layers is a Type II superconductor thin film.

15. The direct energy conversion generator of claim 14, wherein the multiple-layer coating has four layers, wherein the first layer is a first buffer layer covering the exterior surface, the second layer is a second buffer layer covering the first buffer layer, the third layer is the Type II superconductor thin film and covers the second buffer layer, and the fourth layer is an insulating layer covering the superconductor thin film.

16. The direct energy conversion generator of claim 15, wherein the means for disrupting utilizes photons to force Cooper pairs in the type II superconducting material to break up, causing the channel to act as a solid state variable magnetic air gap.

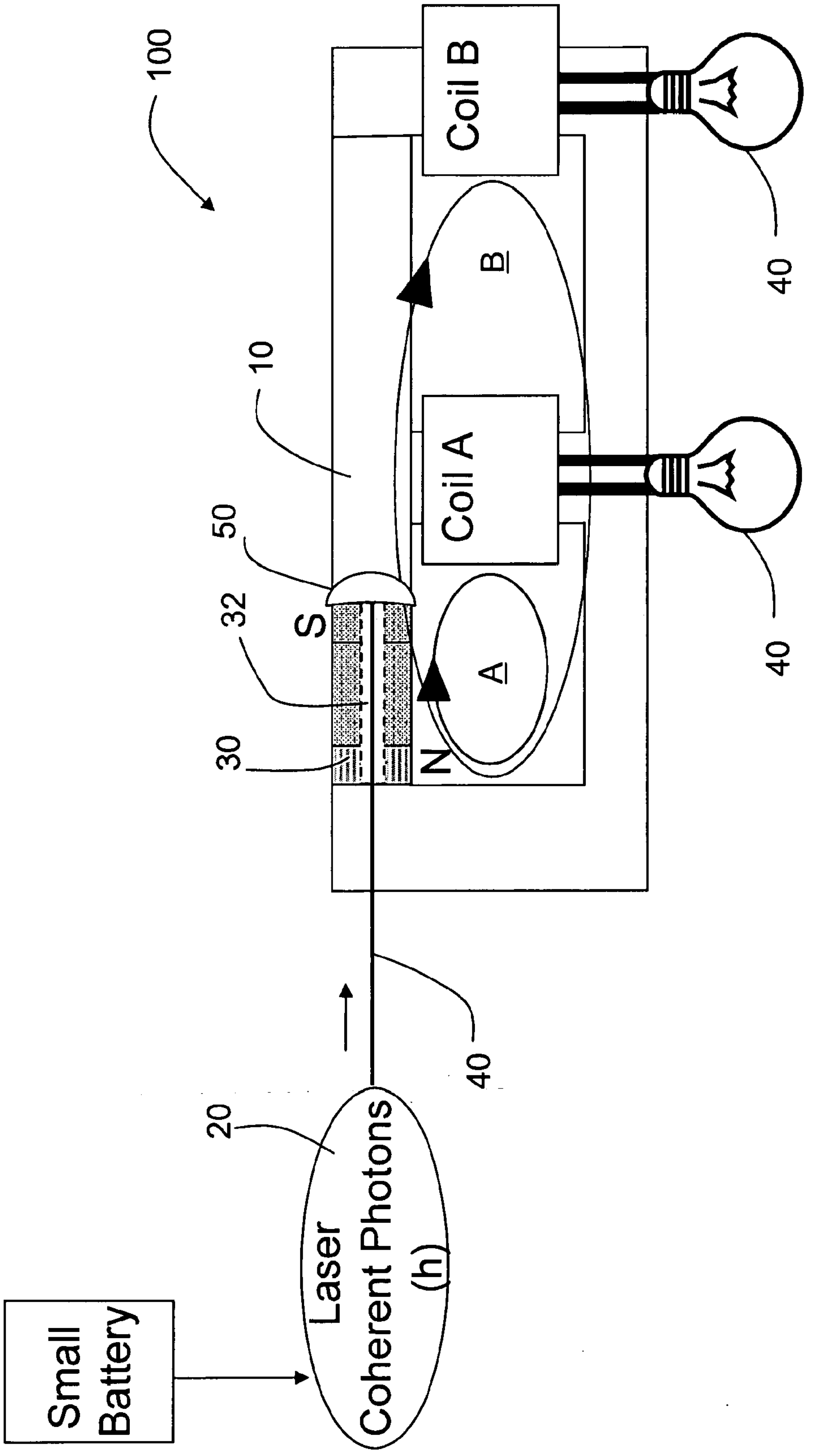
100
Coil B
Coil A
B
A
10
50
32
30
S
N
40
40
40
20
Laser
Coherent Photons
(h)
Small
Battery

FIG. 1A

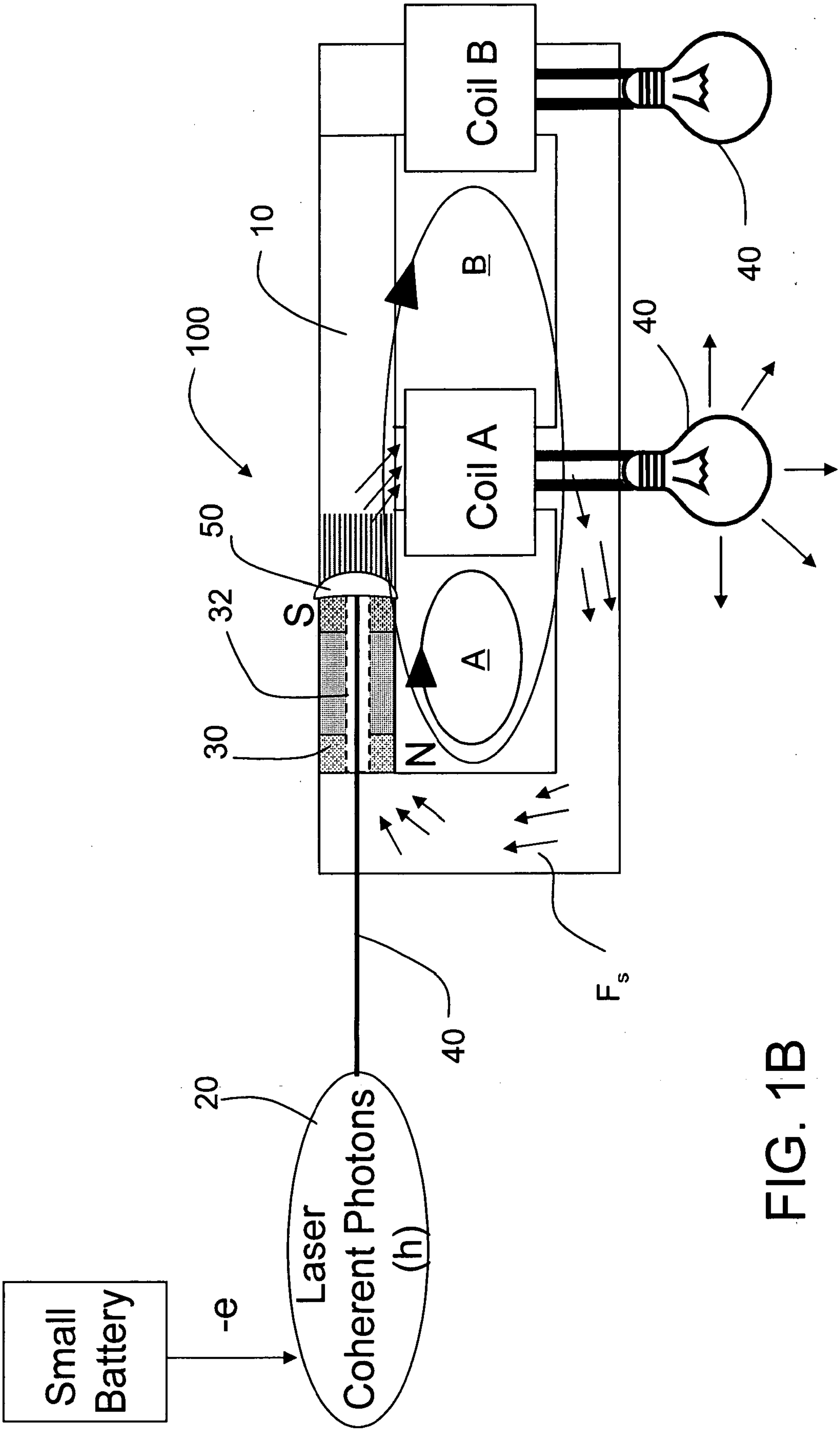
Small Battery
-e
Laser Coherent Photons (h)
20
40
30
32
S
N
50
A
B
Coil A
Coil B
10
100
40
40
40
F_s

FIG. 1B

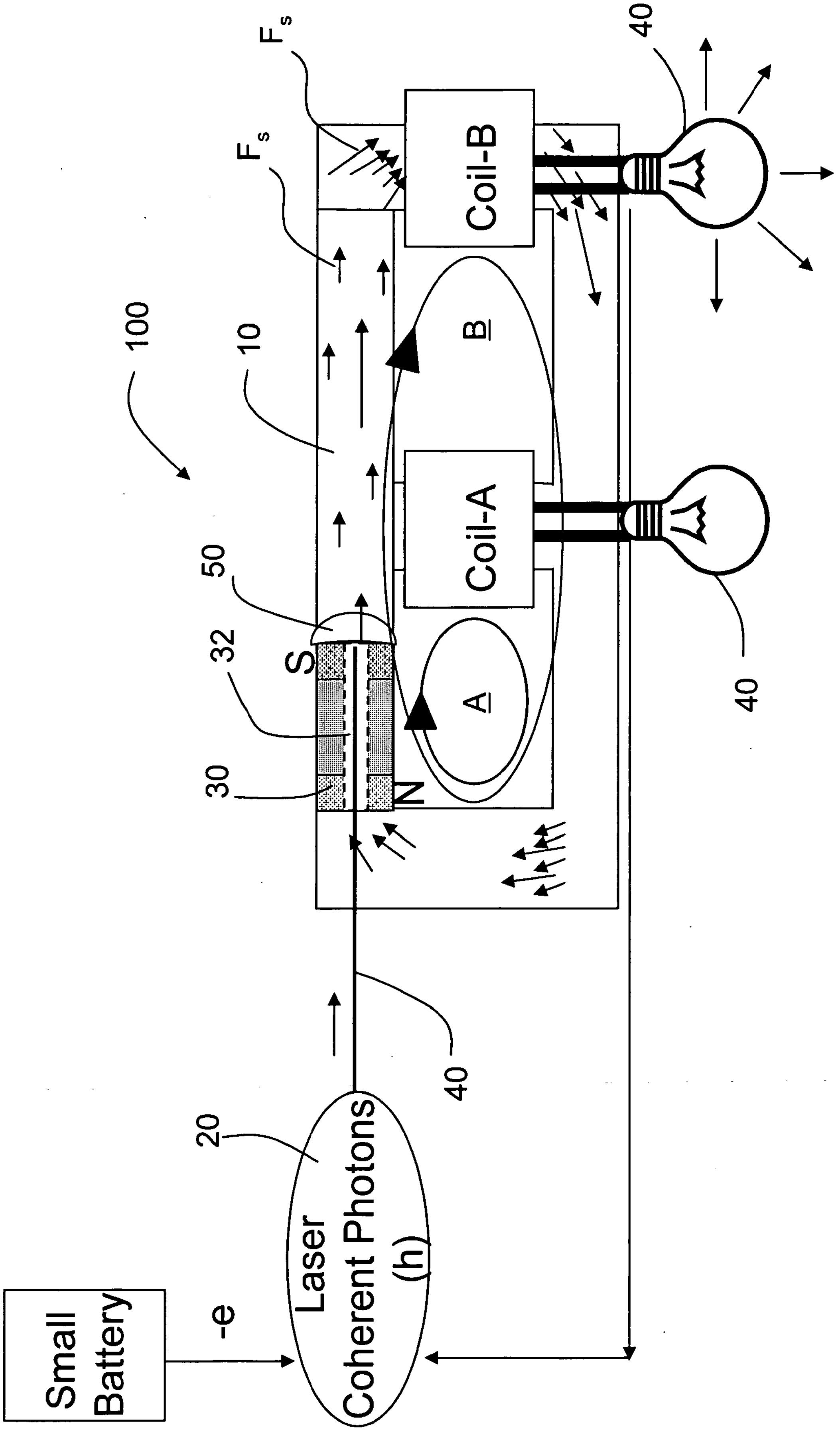
Small Battery
-e
Laser Coherent Photons (h)
20
40
30
32
N
S
50
A
B
Coil-A
Coil-B
10
100
F_s
F_s
40
40

FIG. 1C

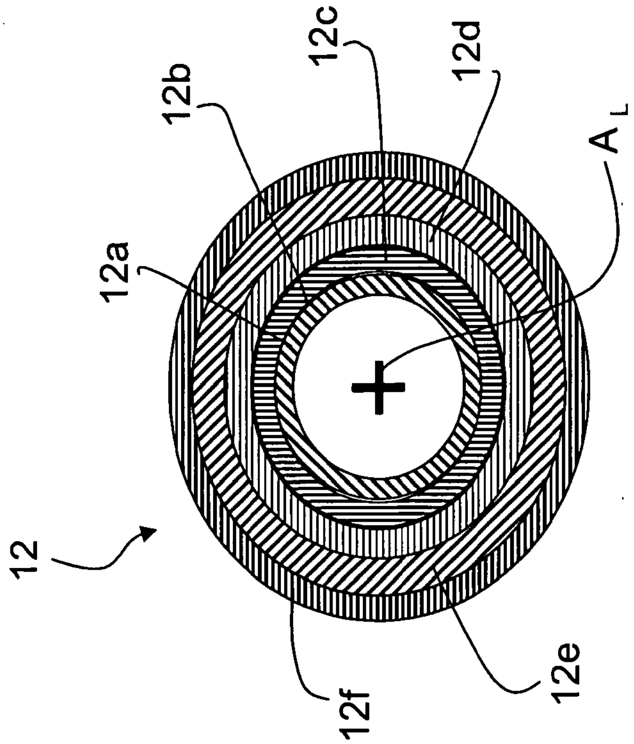

FIG. 2A

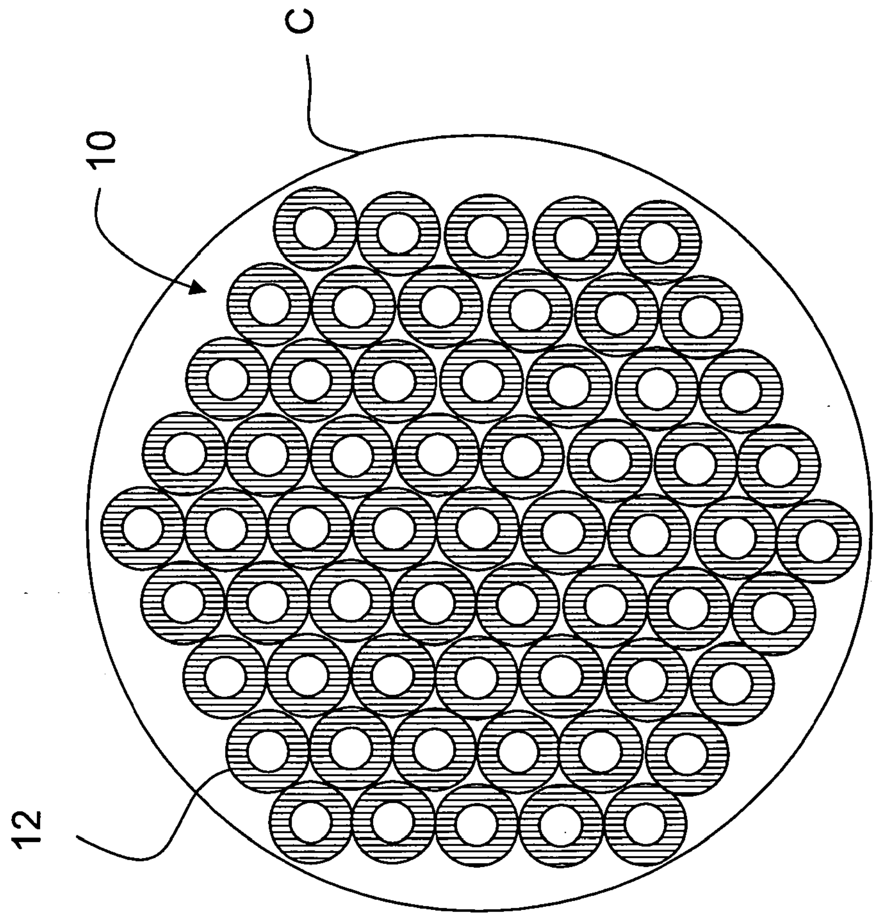

FIG. 2

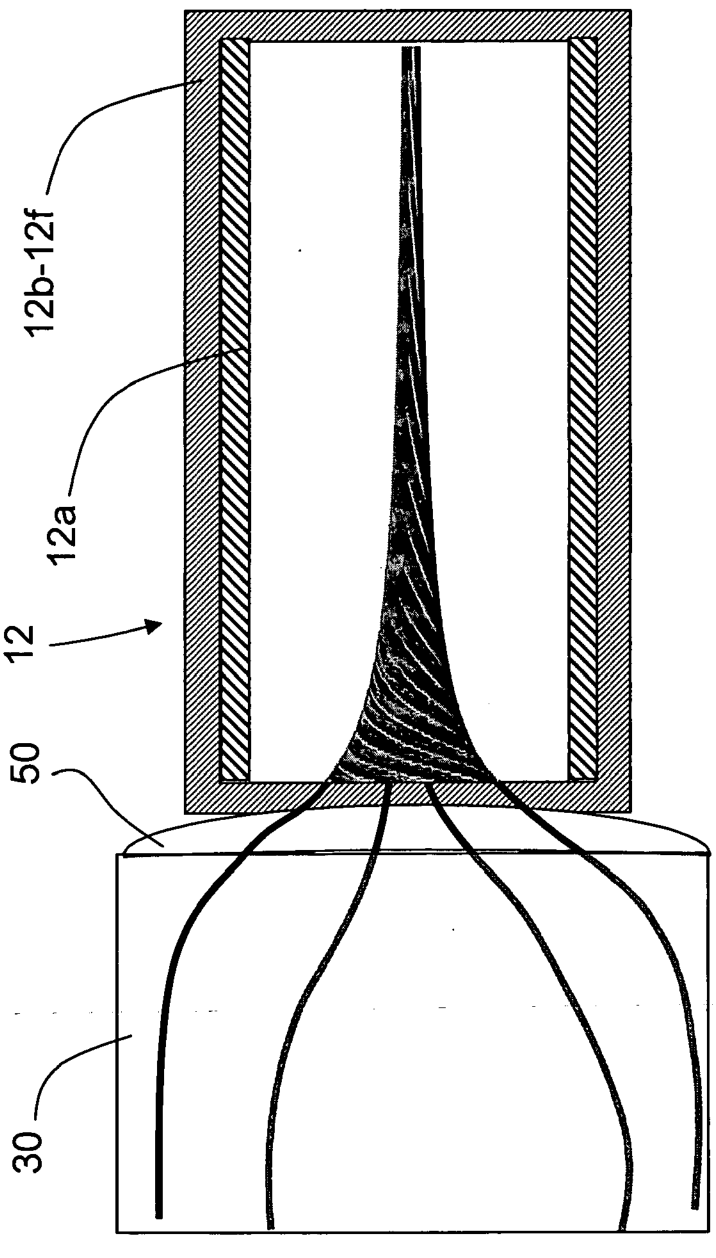

FIG. 3

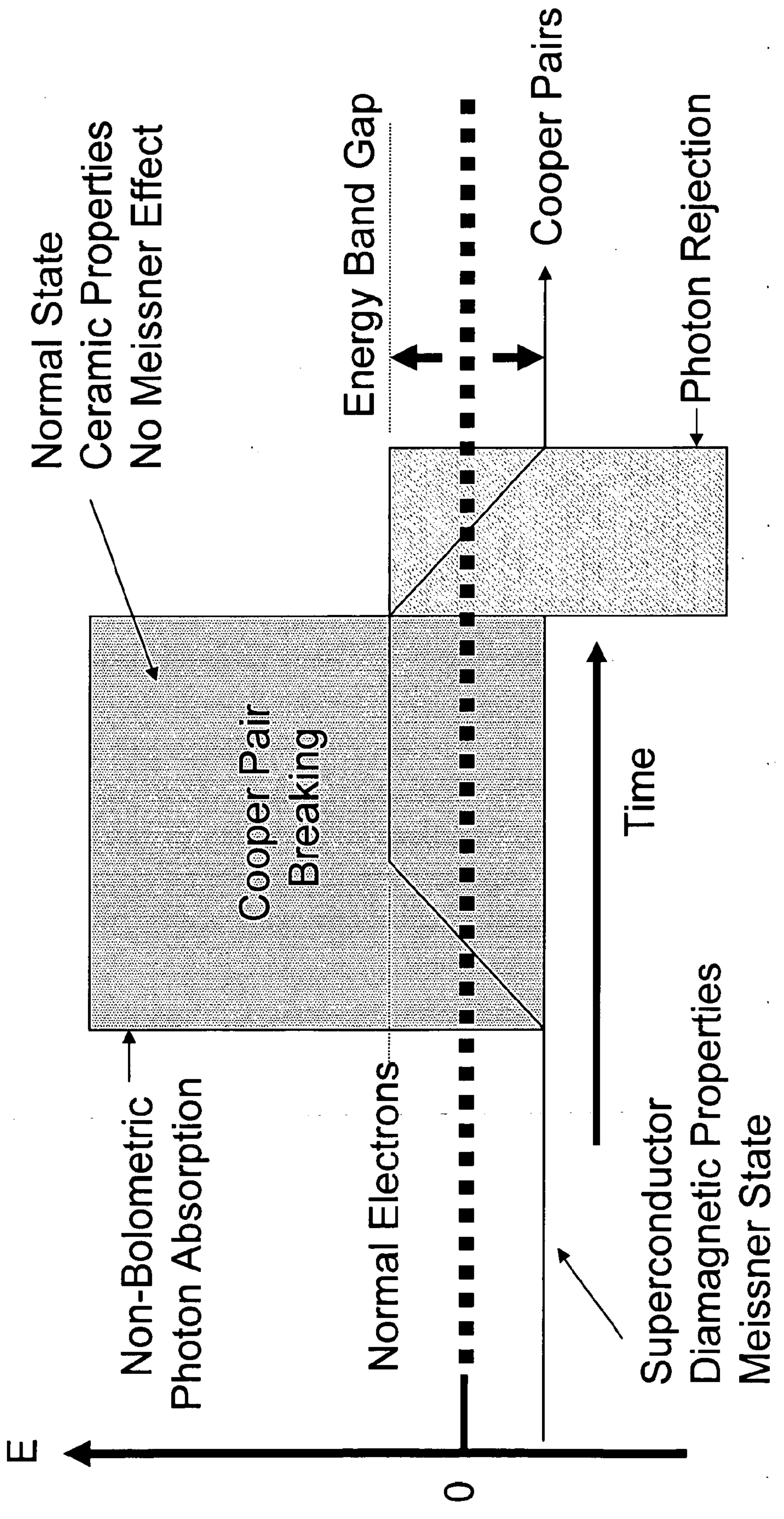
Normal State
Ceramic Properties
No Meissner Effect
Energy Band Gap
Cooper Pairs
Photon Rejection
Cooper Pair
Breaking
Time
Non-Bolometric
Photon Absorption
Normal Electrons
Superconductor
Diamagnetic Properties
Meissner State
E
0

FIG. 4

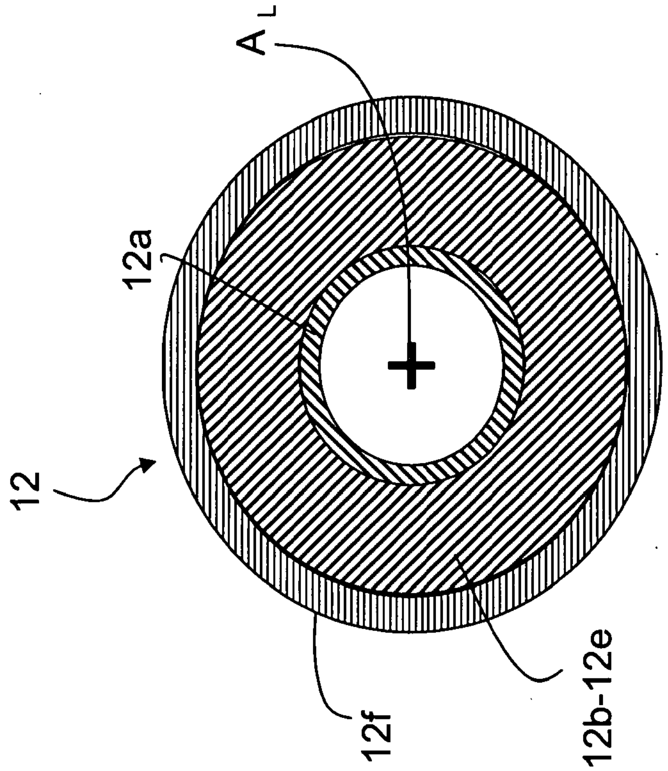

FIG. 5A

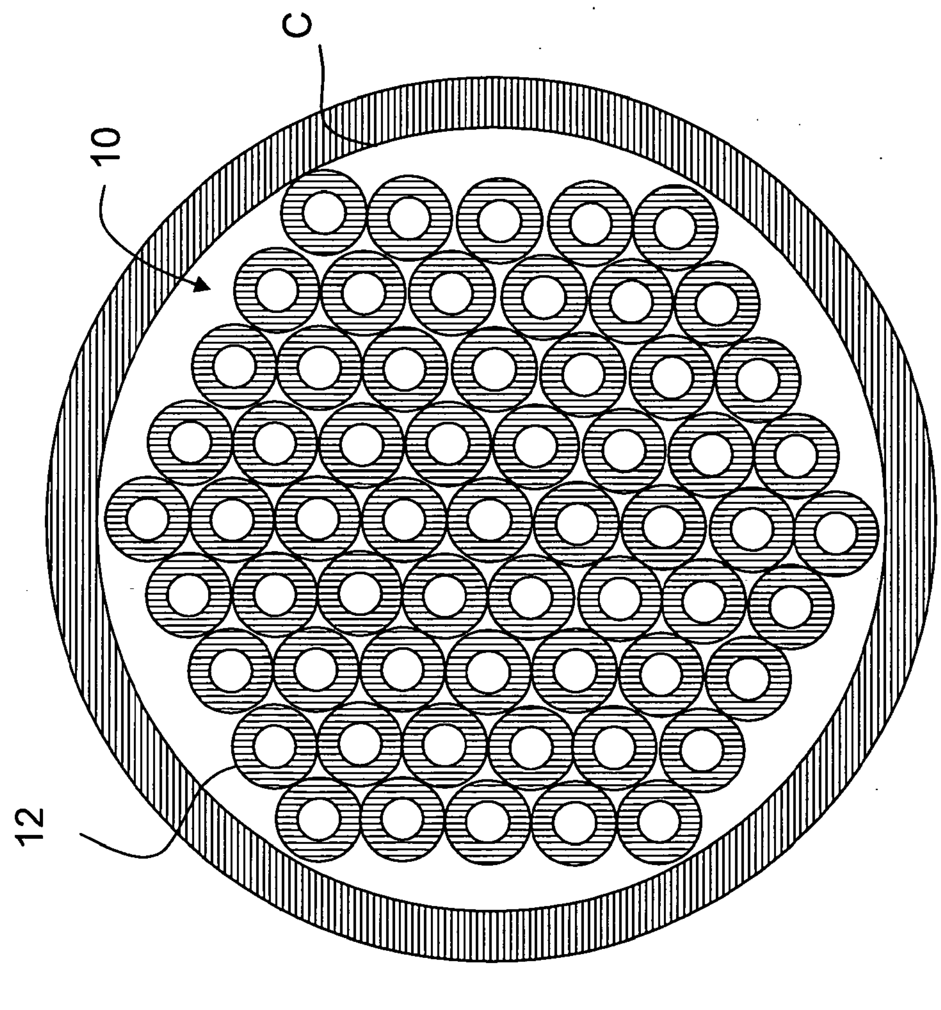

FIG. 5

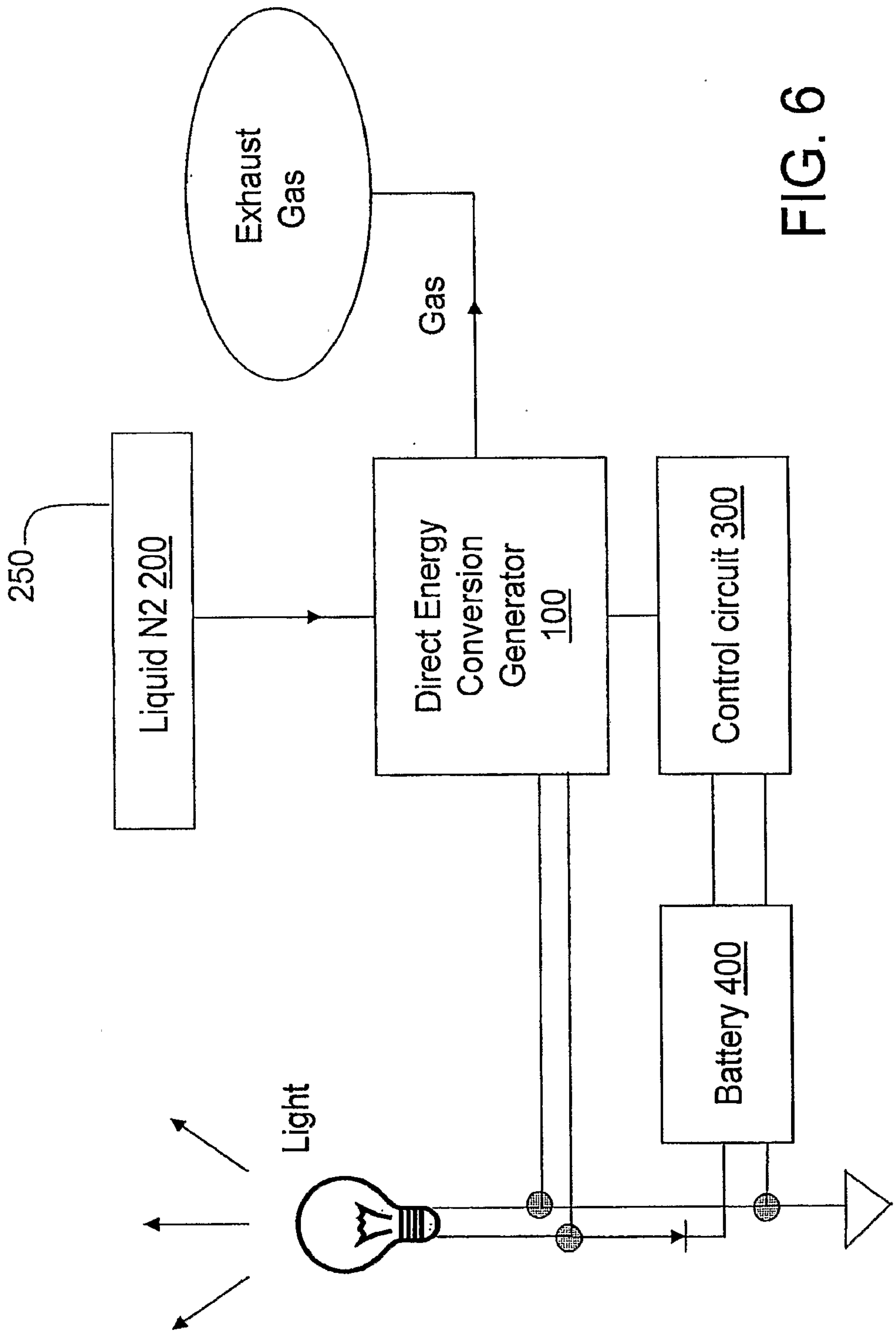
Exhaust Gas
Gas
250
Liquid N2 200
Direct Energy Conversion Generator 100
Control circuit 300
Battery 400
Light

FIG. 6

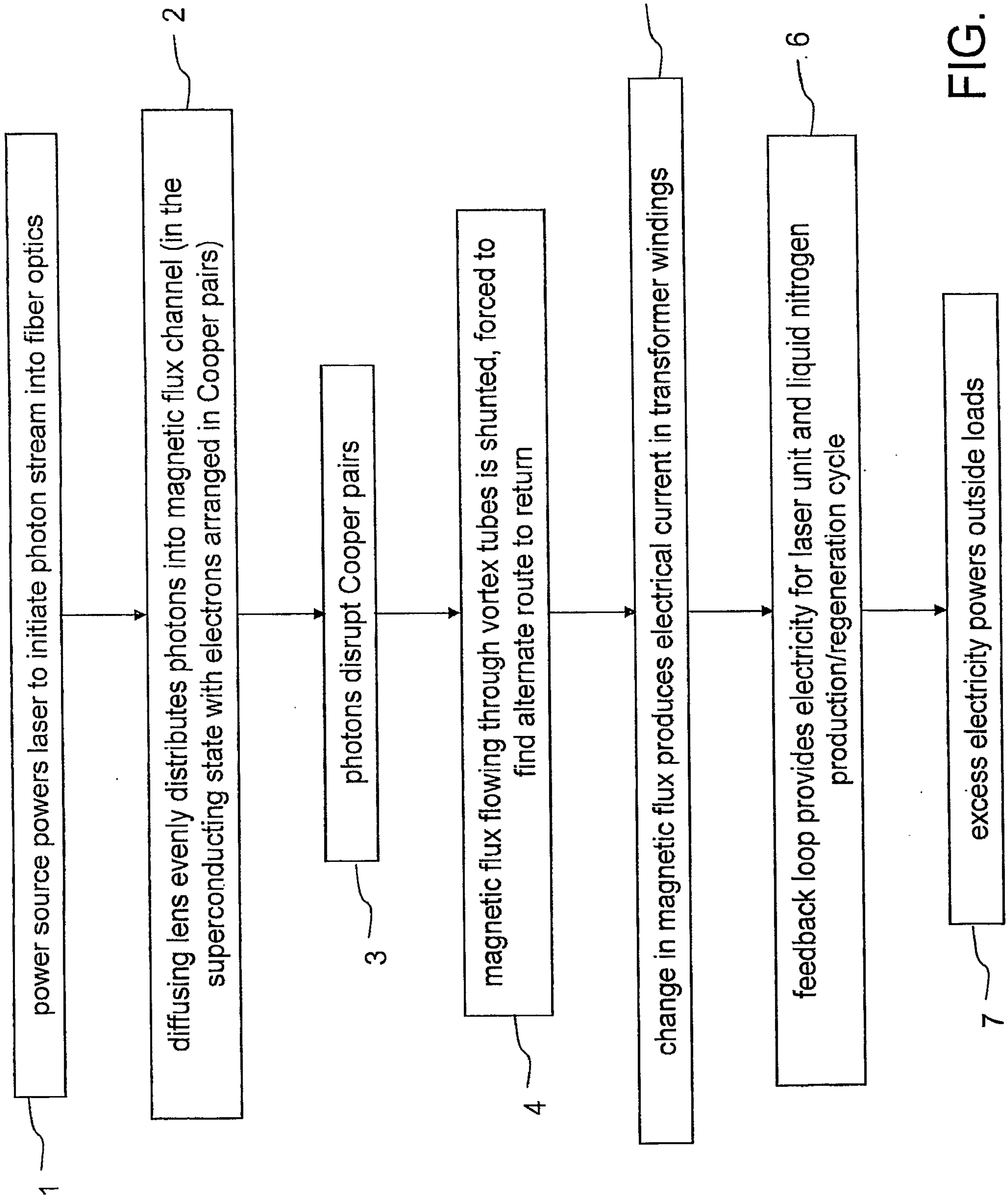
power source powers laser to initiate photon stream into fiber optics
1
diffusing lens evenly distributes photons into magnetic flux channel (in the superconducting state with electrons arranged in Cooper pairs)
2
photons disrupt Cooper pairs
3
magnetic flux flowing through vortex tubes is shunted, forced to find alternate route to return
4
change in magnetic flux produces electrical current in transformer windings
5
feedback loop provides electricity for laser unit and liquid nitrogen production/regeneration cycle
6
excess electricity powers outside loads
7

FIG. 7

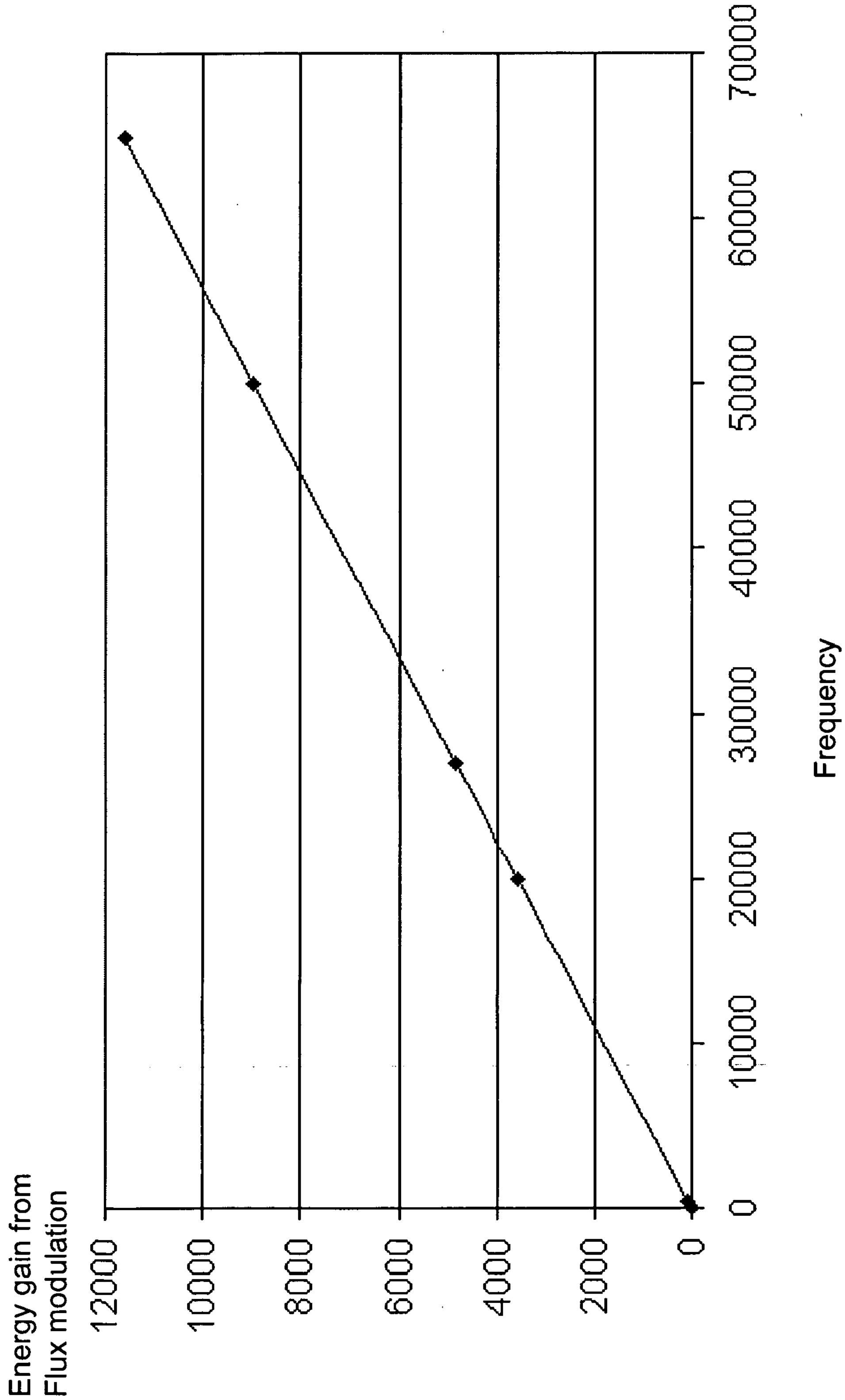
Energy gain from Flux modulation
12000
10000
8000
6000
4000
2000
0
0
10000
20000
30000
40000
50000
60000
70000
Frequency

FIG. 8