HU000030379T2

(19) **HU**

(11) Lajstromszám: **E 030 379**

(13) **T2**

MAGYARORSZÁG
Szellemi Tulajdon Nemzeti Hivatala

EURÓPAI SZABADALOM
SZÖVEGÉNEK FORDÍTÁSA

(21) Magyar ügyszám: **E 12 765183**
(22) A bejelentés napja: **2012. 03. 24.**

(96) Az európai bejelentés bejelentési száma:
EP 20120765183
(97) Az európai bejelentés közzétételi adatai:
EP 2688505 A2 **2012. 10. 04.**
(97) Az európai szabadalom megadásának meghirdetési adatai:
EP 2688505 B1 **2016. 05. 18.**

(51) Int. Cl.: ***H01S 50/68*** *(2006.01)*
A61B 18/00 *(2006.01)*
A61B 18/20 *(2006.01)*
A61F 90/08 *(2006.01)*
H01S 506/83 *(2006.01)*
A61N 50/67 *(2006.01)*
H01S 5/00 *(2006.01)*
H01S 5/06 *(2006.01)*

(86) A nemzetközi (PCT) bejelentési szám:
PCT/US 12/030480
(87) A nemzetközi közzétételi szám:
WO 12135074

(30) Elsőbbségi adatok:
201161465884 P **2011. 03. 25.** **US**

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(54) **Orvosi lézer elektronikus zárral**

Az európai szabadalom ellen, megadásának az Európai Szabadalmi Közlönyben való meghirdetésétől számított kilenc hónapon belül, felszólalást lehet benyújtani az Európai Szabadalmi Hivatalnál. (Európai Szabadalmi Egyezmény 99. cikk(1))

A fordítást a szabadalmas az 1995. évi XXXIII. törvény 84/H. §-a szerint nyújtotta be. A fordítás tartalmi helyességét a Szellemi Tulajdon Nemzeti Hivatala nem vizsgálta.

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 688 505 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
18.05.2016 Bulletin 2016/20

(21) Application number: **12765183.4**

(22) Date of filing: **24.03.2012**

(51) Int Cl.:
H01S 5/068 *(2006.01)* ***H01S 5/00*** *(2006.01)*
H01S 5/06 *(2006.01)* ***A61B 18/20*** *(2006.01)*
A61F 9/008 *(2006.01)* ***A61N 5/067*** *(2006.01)*
H01S 5/0683 *(2006.01)* *A61B 18/00* *(2006.01)*

(86) International application number:
PCT/US2012/030480

(87) International publication number:
WO 2012/135074 (04.10.2012 Gazette 2012/40)

(54) **MEDICAL LASER WITH ELECTRONIC SHUTTER**

MEDIZINISCHER LASER MIT ELEKTRONISCHEM VERSCHLUSS

LASER MÉDICAL DOTÉ D'UN OBTURATEUR ÉLECTRONIQUE

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **25.03.2011 US 201161465884 P**

(43) Date of publication of application:
29.01.2014 Bulletin 2014/05

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(56) References cited:
EP-A2- 0 425 309
EP-A2- 0 425 309
EP-A2- 0 441 709
EP-B1- 0 187 853
US-A- 5 594 748
US-A1- 2007 219 430
US-A1- 2009 097 513
US-B1- 6 350 263

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EP 2 688 505 B1

Description

FIELD OF THE INVENTION

[0001] The invention relates to medical lasers. In particular, the invention relates to lasers with electronic shutters to safely deliver laser energy for medical applications.

BACKGROUND OF THE INVENTION

[0002] Medical lasers should be designed to meet safety standards to mitigate primarily against, for example, inadvertent laser exposure to body parts, over exposure with the laser treatment and single component failure. To achieve these safety standards the currently accepted standard is to utilize an electronically controlled mechanical shutter and photodetectors to deliver the laser output as shown in **FIG. 1**.

[0003] Mechanical shutters have proven to be slow and potentially unreliable. The mechanism of action for a mechanical shutter it to control movement and maintain a mechanical obstacle in and out of the laser beam path to prevent treatment laser light being delivered to the treatment region or even exiting the laser enclosure within the device, until appropriate conditions are achieved for laser delivery. At turn-on of the device the mechanical shutter is initially "closed" (or moved into the closed position), blocking the laser output beam.

[0004] Upon appropriate conditions the shutter is moved from the "closed-to-open" position, and maintained in the "open" position to allow laser delivery and treatment. Upon a second set of conditions the shutter is moved from the "open-to-closed" position, and maintained in the closed position to prevent laser delivery and treatment. Some mechanical shutters include a laser absorber to absorb the laser energy and/or a reflector to redirect the laser energy from the laser beam path to a beam dump.

[0005] The movement from "open-to-closed" (or visa versa) is usually on the order of at least tens of milliseconds as a result of the movement of mass from a stationary position to a different stationary position and accounting for acceleration, deceleration and "de-bouncing", coming to rest in the secondary stationary position. Position sensors are typically required to confirm the shutter is in an "open", "closed" or "transition" state, and often redundancy is built around the sensor and/or the shutter itself. Mechanical shutters are based on moving parts and as such subject to wear and tear and potentially sticking in either the "closed" and even more dangerous the "open" positions, resulting in an error conditions and device failures.

[0006] A typical traditional system performs a test of safety mitigations at start-up of the device with the mechanical shutter in a "closed" position, blocking external laser exposure. Such a test involves the operation of laser emission, the operation of photodetectors and test of the calibration data. In normal operation, when the user does not intend to use the laser device, the system is in Standby Mode and the mechanical shutter is closed preventing inadvertent exposure. When the user desires that the laser may be used, the user selects the Ready Mode and the mechanical shutter is opened. The user can then activate the laser emission by depressing the Laser Activation Switch.

[0007] Photodetector signals are monitored by a Safety Monitor Circuit to manage over power traditional medical laser systems. If over power is detected by the Safety Monitor Circuit, the mechanical shutter will be closed. Again, the time scale to stop this over power situation is at least tens of milliseconds, and hence is one of the weaknesses of using mechanical shutters.

[0008] To mitigate single component failure in traditional medical laser a duplication of power monitoring and safety circuits is used. Accordingly, traditional medical lasers have redundant photodetectors, internal switches in the Laser Activation Switch and redundancy on the mechanical shutter and/or sensors within.

[0009] The design of medical lasers has evolved from high voltage systems to drive gas lasers and arc lamps to pump the laser material, to high current diodes for direct laser emission and/or to pump laser material. Coming from a high voltage origin, where current sensors are not used and switching in the main electrical path are not encouraged, safety mitigations were put in place such as the mechanical shutter to block the laser light, and primary safety monitoring was done with photodedectors to monitoring the laser light directly. In particular, the mechanical shutter and photodectectors have persisted with time and through the evolution of medical laser designs, further the additional cost, design complexity and safety monitoring have previously precluded the need to build further redundancy and the concept of removing the mechanical shutter has not been implemented to date.

[0010] An alternative to a mechanical shutter is an optical shutter (for example a Pockels Cells). Rather than moving a mechanical object into the beam path to control the transmission of laser energy, an optical component is placed in the beam path which have the ability to switch from optically opaque to optically transparent. Optically opaque is analogous to a "closed" shutter position in case of a mechanical shutter blocking the laser treatment beam and optically transparent, is analogous to an "open" shutter position in case of a mechanical shutter, allowing the laser energy to be delivery to the treatment region. Optical shutters are typically expensive and have the potential of being damaged at the laser power levels utilized for medical treatments and as such are not utilized in medical laser devices.

[0011] Accordingly, there is a need in the art to develop new techniques other than mechanical or optical shutters for monitoring and safely controlling the laser output during medical laser treatments. The focus of the present invention is a medical laser device that utilizes an electronic shutter and does not include a mechanical or an

optical shutter.

[0012] US 2009/097513 A1 discloses a medical laser which does not comprise a mechanical shutter for controlling the laser output, comprising a laser diode source for delivering the laser output, wherein said laser diode source receives input from a laser power supply; and further comprises a solely electronic shutter circuit for monitoring and safely controlling said laser output, wherein said electronic shutter circuit comprises a safety monitor circuit providing input to a solely electronic safety current switch; a first current sensor and a second current sensor, wherein said first current sensor and said second current sensor both yet independently provide input to said safety monitor circuit, and wherein said second current sensor provides input to said laser power supply; wherein the first current sensor is used to control the laser current at a commanded level; and and wherein the second current sensor is monitored to determine whether the laser current is greater than that permitted by a limit resistor. The electronic shutter circuit of this document includes at least two FET safety switches independent from the laser power supply, one of which constitutes a "high-side current switch" being on the positive voltage side of the laser source, and the other of which constitutes a "low-side current switch" being on the negative voltage side of the laser source.

[0013] EP 0 425 309 A2 discloses an opthalmic medical laser comprising a laser source for delivering a laser output, wherein said laser source receives input from a laser power supply; and an electronic shutter circuit for monitoring and safely controlling said laser output, wherein said electronic shutter circuit further comprises a safety monitor circuit including control electronics; and a first photodetector and a second photodetector, wherein said first photodetector and said second photodetector both yet independently provide input to the control electronics of the safety monitor circuit, wherein the first photodetector and the second photodetector are each arranged to monitor a laser emission power; and wherein the first photodetector is used in a closed loop iteration to adjust the laser power supply output such that a desired laser emission level is reached, and wherein the second photodetector is used to monitor for indications of unsafe conditions. The electronic shutter circuit includes at least two electronic safety switches independent from the laser power supply, namely a power MOSFET passbank on the positive voltage side of the laser source, and a crowbar circuit which constitutes a shunt current switch across the laser source.

SUMMARY OF THE INVENTION

[0014] The invention is defined in claim 1. Embodiments are set out in the dependent claims.

[0015] A medical laser using solely an electronic shutter circuit for controlling the laser output, without any mechanical shutter mechanism, is provided for use in clinical applications. A laser source (e.g. an ophthalmic laser, a diode pump solid state laser photocoagulator, or the like) powered by a laser power supply delivers a laser output. An electronic shutter circuit monitors and safely controls the laser output. The electronic shutter circuit is based on a safety monitor circuit, at least two current sensors, at least two photodetectors, and a set of electronic safety switches independent from the laser power supply. The set of switches is a set of one, two or three electronic safety switches. In one embodiment, the electronic shutter circuit has a first current sensor and a second current sensor. The first current sensor and the second current sensor both yet independently provide input to the safety monitor circuit, and the second current sensor provides input to the laser power supply. The electronic shutter circuit further has a first photodetector and a second photodetector. The first photodetector and the second photodetector both yet independently provide input to the safety monitor circuit and both sample the treatment laser beam. The electronic safety current switches are: (i) a high-voltage-side current switch, (ii) a low-voltage-side return current switch, or (iii) a shunt current switch across the laser source. The switches have a switch response time on order of 0.1 ms to 0.005 ms for clinical applications. In another example, the electronic safety current switches are: (i) a first electronic current safety switch receiving input from the laser power supply and providing input to the laser source, (ii) a second electronic current switch receiving input from the laser source and providing return path to the laser power supply, or (iii) a third electronic current switch across the laser source receiving input either directly from the laser power supply or indirectly from the laser power supply via the second electronic current switch. The safety monitor circuit could provide input to an electronic safety current switch, whereby the electronic safety current switch is independent from the laser power supply.

[0016] The medical laser with an electronic shutter according to the invention has several advantages compared to medical lasers with mechanical shutters. These advantages can be defined in terms of the speed of the electronic shutter, increased reliability, increased safety, smaller, and less expense. The medical laser according to the present invention will shut the laser down in less than 100 microseconds making it far superior to what would be possible with a typical mechanical shutter which would take at least 10 ms to disable the laser. Safety and reliability is a result of an electronic shutter circuit with at least two current sensors, at least two photodetectors and a set of one, two or three fast electronic satefy switches. Such a design may also be used in the device for calibration data and also internally within the laser activation switch multiple switches to ensure - one switch held high and one switch held low, i.e. the high-voltage-side switch requires an active low control signal to activate while the shunt and low-voltage-side switches require active high signals to activate.

[0017] Applications of embodiments of the invention can generally be found in the medical field where lasers

are used for treatment with emphasis on ocular conditions, laser treatment of diabetic retinopathy, and retina breaks and tears.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG. 1 shows a medical laser device using a mechanical shutter for controlling the laser output according to an example in the art.

FIG. 2 shows a medical laser device using an electronic shutter according to a first exemplary embodiment of the invention.

FIG. 3 shows a medical laser device using an electronic shutter according to a second exemplary embodiment of the invention.

DETAILED DESCRIPTION

[0019] **FIGs. 2-3** show embodiments of the invention of a medical laser with a laser source powered by a laser power supply for delivering a laser output and an electronic shutter circuit for monitoring and safely controlling the laser output. The electronic shutter circuit entirely eliminates the need for a mechanical shutter or an optical shutter while still fullfilling the satefy demands and requirements and yet even improving the safety and control of a medical laser.

[0020] For the active laser delivery control, the electronic shutter circuit includes at least two photodetectors, at least two current sensors, a safety monitor circuit and a set of one, two or three fast electronic switches. The current sensors and photodetectors are used in laser emission power (or energy) monitoring, its active control, and in safety controls. Safety control and power monitoring is a result of an electronic shutter circuit with at least two current sensors, at least two photodetectors and a set of one, two or three fast electronic satefy switches, such that in the event of a single component failure, the device fails yet remains safe, with no laser emission.

[0021] As shown in **FIGs. 2-3,** at least two current sensors monitor current flow through the electronic shutter circuit to prevent a single point failure as this is now a critical function. A first current sensor is used to control current at the commanded level. A second current sensor is monitored to assure the current is well below the lasing threshold while idling. If the current exceeds the inadvertent detection threshold current the device disables current flow with a set of one, two or three fast (i.e. on order of 0.1 ms to 0.005 ms, and for no clinical effect the switch could be as slow as about lms) electronic safety switches before lasing can occur. The switches in each set can be a high-side current switch, a low-side return current switch, a shunt current switch, or any combination thereof. **FIG. 2** shows two electronic satefy switches and a shunt safety switch. Electron current flow from negative to positive indicated by the arrows in **FIGs. 2-3**. High-side is regarded as being on the positive voltage side of the laser source and vice versa for the low-side. **FIG. 3** shows one electronic satefy switch, which is a low-side switch. The electronic high-side current switch has control of the switching power supply that provides current flow through the laser source, and thus laser emission from the laser source. To control laser delivery, this switch has the function of enabling or disable the high side current from the power supply. The electronic low-side return current switch has control to enable or disable the direct connection from low-side of the laser source thus actively controlling the current flow and thus laser emission of the laser source.

[0022] The electronic shunt (short-circuit) current switch shorts across the laser source shunting any current that would otherwise conduct through the laser source directly to ground thus disabling laser emission.

[0023] As shown in **FIGs. 2-3**, at least two photodetectors monitor the laser emission power (or energy). These photodetectors are used to prevent a single point failure. According to the embodiments of **FIGs. 2-3**, a first photodetector is used to control the laser source current via the power control circuit. A second photodetector is used to compare its output against a secondary reference and is verified to be within a predetermined safety window (i.e. typically secondary measurement need to be within 50 to 150% of the redundant reference). If the measurement from the second photodetector is outside this predetermined safety window, a safety error is flagged in the Safety Monitor Circuit and the medical laser device disables laser emission with a set of one, two or three fast electronic switches before lasing can occur. The switches in each set, as described *supra,* can be a high-side current switch, a low-side return current switch, a shunt current switch, or any combination thereof.

[0024] In the medical laser device, without a mechanical shutter, laser emission would not be internally contained within the device. So to mitigate the potential of inadvertent laser exposure, the devices utilizes at least 3 states of the device: Standby, Ready and Treat modes.

1. Standby - the device is in the Standby mode, by default. In this mode the electronic shutter prevents laser emission (i.e. where applicable the high-side, low-side switches are open and the shunt switch is closed). No electrical current can flow through the laser source, thus laser emission cannot occur.

2. Ready - the user has to actively select the transition to this mode. At this point, the electronic shutter prepares the switches, where applicable, such that electrical can flow through the laser source. Typically the laser source has current passing through it below the threshold for laser emission, at the predetermined idle current (monitored by the current sensors). The laser source does not emit in this mode, but is ready to emit. Safety mitigations are active, i.e. current sensors and photodetectors monitoring

current is below the threshold for laser emission and no laser emission is detected with the photodetectors.

Inadvertent laser exposure can be mitigated according to the following example. If there is a failure in the first current sensor, the current will rise uncontrolled until it hits 5 amps, as measured by the second current sensor. This will cause the laser to shut down the laser before any light is emitted at the lasing threshold of 10 amps or more.

3. Treat - only when the device is in the Ready mode can it transition to Treat mode. Laser emission is activated by the user selecting the Laser Activation Switch. This increases the current through the Laser Source to achieve laser emission. To achieve a user desired laser power, the request laser power supply output is calculated in the power control circuit utilizing calibration data, this request is sent to the laser power supply and the current increases through laser source. As the current increases above the laser current threshold, laser emission occurs. There are two photodetectors that sample the main laser emission beam. The photodetectors measure the laser light emitted. One photodetector is used in a closed loop iteration to adjust the laser powersupply output such that the desired laser emission level is reached. The second photodetector is compared to the first photodetector to ensure that they are consistent.

[0025] By idling the laser before generating a laser output and monitoring with a redundant current sensor, one can now identify many failures in the laser power supply that may cause a situation where the laser would fire uncontrolled before the laser is allowed to fire. In addition, there is an added benefit of extending the laser diode life, by not shutting it all the way off between pulses.

Variations and additional embodiments

[0026] Three independent shutdown methods can be used to insure the laser is disabled and cannot have an unintended exposure event. The first shutdown is direct control of the laser power supply that provides current to the laser diode to fire the laser. This control will disable the internal switching element(s) (such as a FET, IGBT, BJT) used to provide current to the laser. The second shutdown can be an electronic switch external to the laser powersupply such that provides the return path for the laser diode. This switching element will be disabled whenever an error condition occurs or when the laser is in any mode where current should not be flowing through the laser diode. The third method can be a switching element that provides a shunt (short circuit) in parallel with the laser diode. This switching element will be enabled whenever an error condition occurs or when the laser is in any mode where current should not be flowing through the laser diode.

[0027] When a laser power supply shutdown occurs three independent circuits can be utilized to immediately disable the laser output. The first circuit disables the switching elements that source current to the laser diode. The second circuit disables the switching element that sinks current from the laser diode. The third circuit shorts a switching element across the output of the laser power supply assuring no current can conduct through the laser diode.

[0028] To further assure power output level is correct the system compares the primary and secondary power control signals with a hardware comparator, if the primary and secondary control signals are not within 10% of each other the power supply is disabled and the laser cannot be fired.

Claims

1. A medical laser, comprising:

(a) a laser source for delivering a laser output, wherein said laser source receives input from a laser power supply; and

(b) an electronic shutter circuit for monitoring and safely controlling said laser output, wherein said electronic shutter circuit comprises:

(i) a safety monitor circuit;

(ii) a first current sensor and a second current sensor, wherein said first current sensor and said second current sensor are arranged to both yet independently provide input to said safety monitor circuit, and wherein said second current sensor is arranged to provide input to said laser power supply; wherein the first current sensor and the second current sensor are each arranged to monitor a laser current provided by said laser power supply; wherein means are provided for using the first current sensor to control the laser current at a commanded level; and wherein means are provided for monitoring the second current sensor to assure whether the laser current is below a threshold current; and

(iii) a first photodetector and a second photodetector, wherein said first photodetector and said second photodetector are arranged to both yet independently provide input to said safety monitor circuit, wherein the first photodetector and the second photodetector are each arranged to monitor a laser emission power;

wherein the first photodetector is arranged to be used in a closed loop iteration to adjust the laser power supply output such that a desired laser emission level is reached; and

wherein means are provided for comparing the output of the second photodetector with that of the first photodetector to ensure that they are consistent.

2. The medical laser as set forth in claim 1, wherein said electronic shutter circuit further comprises a set of electronic safety switches independent from said laser power supply, wherein said set is a set of one, two or three electronic safety switches.

3. The medical laser as set forth in claim 2, wherein said electronic safety current switches are: (i) a high-voltage-side current switch, (ii) a low-voltage-side return current switch, or (iii) a shunt current switch across said laser source.

4. The medical laser as set forth in claim 2, wherein said electronic safety current switches have a switch response time on order of 0.1 ms to 0.005 ms.

5. The medical laser as set forth in claim 2, wherein said electronic safety current switches are: (i) a first electronic current safety switch receiving input from said laser power supply and providing input to said laser source, (ii) a second electronic current switch receiving input from said laser source and providing return path to said laser power supply, or (iii) a third electronic current switch across said laser source receiving input either directly from said laser power supply or indirectly from said laser power supply via said second electronic current switch.

6. The medical laser as set forth in claim 1, wherein said safety monitor circuit provides input to an electronic safety current switch, wherein said electronic safety current switch is independent from said laser power supply.

7. The medical laser as set forth in claim 1, wherein said medical laser does not comprise a mechanical shutter for controlling said laser output.

8. The medical laser as set forth in claim 1, wherein said laser source is an ophthalmic laser.

9. The medical laser as set forth in claim 1, wherein said laser source is a diode pump solid state laser photocoagulator.

Patentansprüche

1. Ein medizinischer Laser umfassend:

(a) eine Laserquelle zur Abgabe einer Laserleistung, wobei besagte Laserquelle eine Eingabe von einer Laserstromversorgung erhält und

(b) eine elektronische Schließeinheit zur Überwachung und sicheren Kontrolle besagter Laserleistung, wobei besagte elektronische Schließeinheit umfasst:

(i) eine Sicherheitsmonitorschaltung;
(ii) einen ersten Stromsensor und einen zweiten Stromsensor, wobei besagter erster Stromsensor und besagter zweiter Stromsensor so angeordnet sind, dass beide unabhängig voneinander eine Eingabe an besagte Sicherheitsmonitorschaltung liefern und wobei besagter zweiter Stromsensor so angeordnet ist, dass er eine Eingabe an besagte Laserstromversorgung liefert, wobei der erste Stromsensor und der zweite Stromsensor jeweils so angeordnet sind, dass sie einen Laserstrom überwachen, der durch besagte Laserstromversorgung geliefert wird, wobei Hilfsmittel zur Nutzung des ersten Stromsensors zur Kontrolle des Laserstroms bei einer geforderten Höhe bereitgestellt werden und wobei Hilfsmittel zur Überwachung des zweiten Stromsensors bereitgestellt werden, um sicherzugehen, dass der Laserstrom unter einem Stromgrenzwert ist und
(iii) ein erster Fotodetektor und ein zweiter Fotodetektor, wobei besagter erster Fotodetektor und besagter zweiter Fotodetektor so angeordnet sind, dass beide unabhängig voneinander eine Eingabe an besagte Sicherheitsmonitorschaltung liefern, wobei der erste Fotodetektor und der zweite Fotodetektor jeweils so angeordnet sind, dass eine Laseremissionsleistung überwacht wird;
wobei der erste Fotodetektor so angeordnet ist, dass er in einer geschlossenen Iterationsschleife verwendet wird um die Laserstromversorgungsleistung so einzustellen, dass ein gewünschtes Laseremissionsniveau erreicht wird; und wobei Hilfsmittel zur Verfügung gestellt werden um die Leistung des zweiten Fotodetektors mit der des ersten Fotodetektors zu vergleichen, um sicherzugehen, dass sie einheitlich sind.

2. Der medizinische Laser wie in Anspruch 1 beschrieben, wobei besagte elektronische Schließeinheit weiterhin eine Gruppe an elektronischen Sicherheitsschalter unabhängig von besagter Laserstromversorgung umfasst, wobei besagte Gruppe eine Gruppe von einem, zwei oder drei elektronischen Sicherheitsschaltern ist.

3. Der medizinische Laser wie in Anspruch 2 beschrieben, wobei besagte elektronische Sicherheitsstrom-

schalter: (i) ein Hochspannungsseiten-Stromschalter, (ii) ein Niederspannungsseiten-Rückstromschalter oder (iii) ein Umgehungs-Stromschalter über besagter Laserquelle sind.

4. Der medizinische Laser wie in Anspruch 2 beschrieben, wobei besagte elektronische Sicherheitsstromschalter eine Schalteransprechzeit in der Größenordnung von 0.1 ms bis 0.005 ms aufweisen.

5. Der medizinische Laser wie in Anspruch 2 beschrieben, wobei besagte elektronische Sicherheitsstromschalter: (i) ein erster elektronischer Sicherheitsstromschalter, der eine Eingabe von besagter Laserstromversorgung erhält und eine Eingabe an besagte Laserquelle liefert, (ii) eine zweiter elektronischer Stromschalter, der eine Eingabe von besagter Laserquelle erhält und eine Rückleitung zu besagter Laserstromversorgung bietet oder (iii) ein dritter elektronischer Stromschalter über besagter Laserquelle, der eine Eingabe entweder direkt von besagter Laserstromversorgung oder indirekt von besagter Laserstromversorgung über einen zweiten elektronischen Stromschalter erhält, sind.

6. Der medizinische Laser wie in Anspruch 1 beschrieben, wobei besagte Sicherheitsmonitorschaltung eine Eingabe an den elektronischen Sicherheitsstromschalter liefert, wobei besagter elektronischer Sicherheitsstromschalter unabhängig von besagter Laserstromversorgung ist.

7. Der medizinische Laser wie in Anspruch 1 beschrieben, wobei besagter medizinischer Laser keinen mechanischen Verschluss zur Kontrolle besagter Laserleistung umfasst.

8. Der medizinische Laser wie in Anspruch 1 beschrieben, wobei besagte Laserquelle ein ophthalmischer Laser ist.

9. Der medizinische Laser wie in Anspruch 1 beschrieben, wobei besagte Laserquelle ein Diodenpumpen-Festkörperlaser-Fotokoagulator ist.

Revendications

1. Laser médical, comprenant

(a) une source laser pour délivrer une sortie laser, dans lequel ladite source laser reçoit une entrée d'une alimentation laser ; et
(b) un circuit d'obturateur électronique pour surveiller et réguler en sécurité ladite sortie laser, dans lequel ledit circuit d'obturateur électronique comprend :
(i) un circuit de surveillance de sécurité ;
(ii) un premier détecteur de courant et un second détecteur de courant, dans lequel ledit premier détecteur de courant et ledit second détecteur de courant sont agencés pour fournir tous les deux mais indépendamment une entrée au dit circuit de surveillance de sécurité, et dans lequel ledit second détecteur de courant est agencé pour fournir une entrée à ladite alimentation laser ; dans lequel le premier détecteur de courant et le second détecteur de courant sont chacun agencés pour surveiller un courant laser fourni par ladite alimentation laser ;
dans lequel un moyen est fourni pour utiliser le premier détecteur de courant pour réguler le courant laser à un niveau commandé ; et dans lequel un moyen est fourni pour surveiller le second détecteur de courant pour s'assurer que le courant laser est en-dessous d'un courant seuil ; et
(iii) un premier photodétecteur et un second photodétecteur, dans lequel ledit premier photodétecteur et ledit second photodétecteur sont agencés pour fournir tous les deux mais indépendamment une entrée au dit circuit de surveillance de sécurité, dans lequel le premier photodétecteur et le second photodétecteur sont chacun agencés pour surveiller une puissance d'émission laser ;
dans lequel le premier photodétecteur est agencé pour être utilisé dans une itération de boucle fermée pour ajuster la sortie d'alimentation laser pour qu'un niveau d'émission laser souhaité soit atteint ; et
dans lequel un moyen est fourni pour comparer la sortie du second photodétecteur à celle du premier photodétecteur pour s'assurer qu'elles sont cohérentes.

2. Laser médical selon la revendication 1, dans lequel ledit circuit d'obturateur électronique comprend en outre un ensemble de commutateurs de sécurité électroniques indépendant de ladite alimentation laser, dans lequel ledit ensemble est un ensemble d'un, deux ou trois commutateurs de sécurité électroniques.

3. Laser médical selon la revendication 2, dans lequel lesdits commutateurs de courant de sécurité électroniques sont (i) un commutateur de courant côté haute tension, (ii) un commutateur de courant retour côté basse tension, ou (iii) un commutateur de courant de dérivation dans ladite source laser.

4. Laser médical selon la revendication 2, dans lequel lesdits commutateurs de courant de sécurité élec-

troniques ont un temps de réponse de commutation de l'ordre de 0,1 ms à 0,005 ms.

5. Laser médical selon la revendication 2, dans lequel lesdits commutateurs de courant de sécurité électroniques sont : (i) un premier commutateur de courant de sécurité électronique recevant une entrée de ladite alimentation laser et fournissant une entrée à ladite source laser, (ii) un second commutateur de courant électronique recevant une entrée de ladite source laser et fournissant une voie de retour à ladite alimentation laser, ou (iii) un troisième commutateur de courant électronique dans ladite source laser recevant une entrée soit directement de ladite alimentation laser soit indirectement de ladite alimentation laser via ledit second commutateur de courant électronique.

6. Laser médical selon la revendication 1, dans lequel ledit circuit de surveillance de sécurité fournit une entrée à un commutateur de courant de sécurité électronique, dans lequel ledit commutateur de courant de sécurité électronique est indépendant de ladite alimentation laser.

7. Laser médical selon la revendication 1, dans lequel ledit laser médical ne comprend pas d'obturateur mécanique pour réguler ladite sortie laser.

8. Laser médical selon la revendication 1, dans lequel ladite source laser est un laser ophtalmique.

9. Laser médical selon la revendication 1, dans lequel ladite source laser est un photocoagulateur laser à l'état solide pompé par diode.

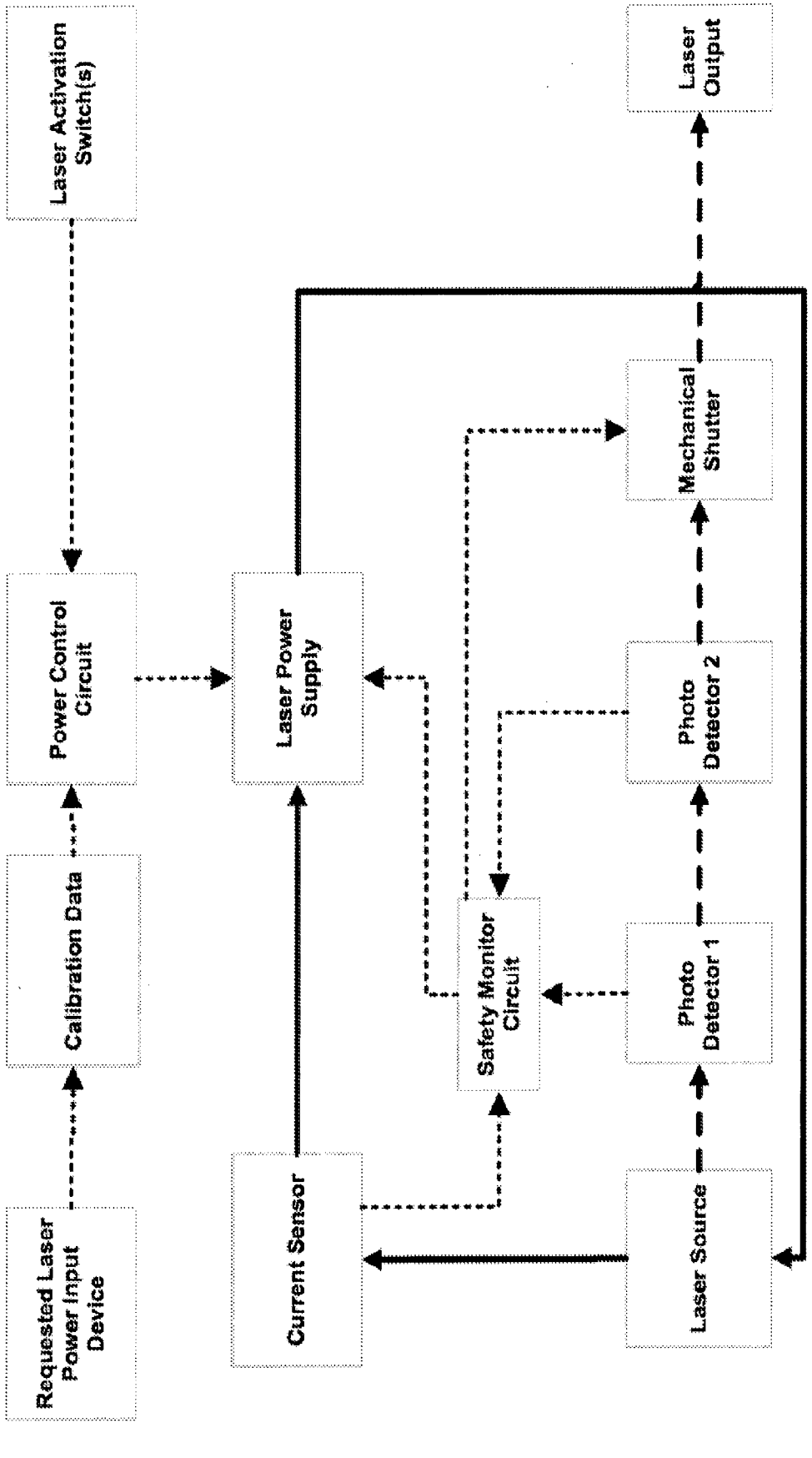
Laser Activation Switch(s)
Power Control Circuit
Calibration Data
Requested Laser Power Input Device
Laser Power Supply
Current Sensor
Safety Monitor Circuit
Laser Source
Photo Detector 1
Photo Detector 2
Mechanical Shutter
Laser Output
Laser Current Path
Control Signals
Laser

Fig. 1

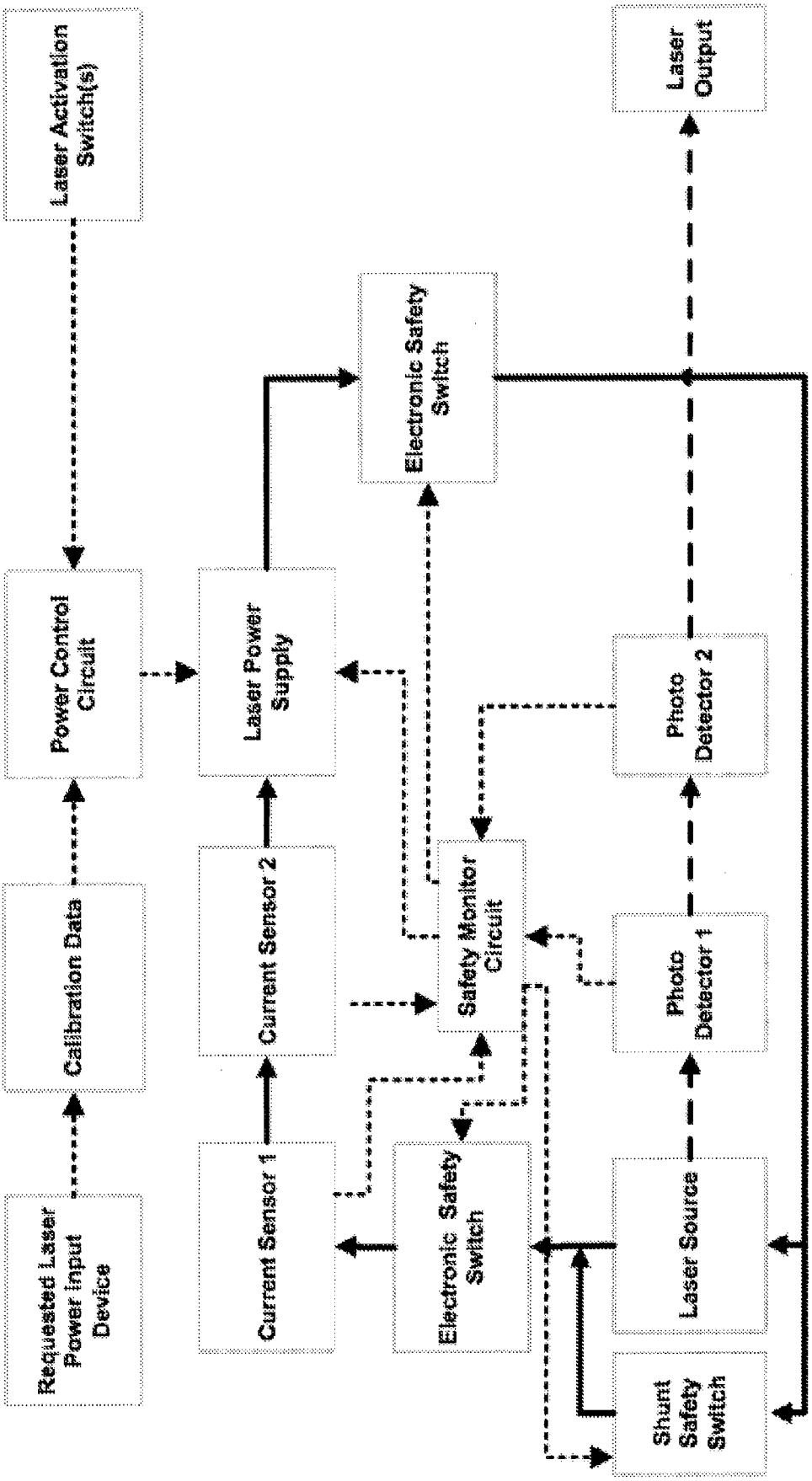
Laser Activation Switch(s)
Power Control Circuit
Laser Power Supply
Electronic Safety Switch
Laser Output
Requested Laser Power Input Device
Calibration Data
Current Sensor 2
Safety Monitor Circuit
Photo Detector 2
Current Sensor 1
Electronic Safety Switch
Photo Detector 1
Laser Source
Shunt Safety Switch
Laser Current Path
Control Signals
Laser Light

Fig. 2

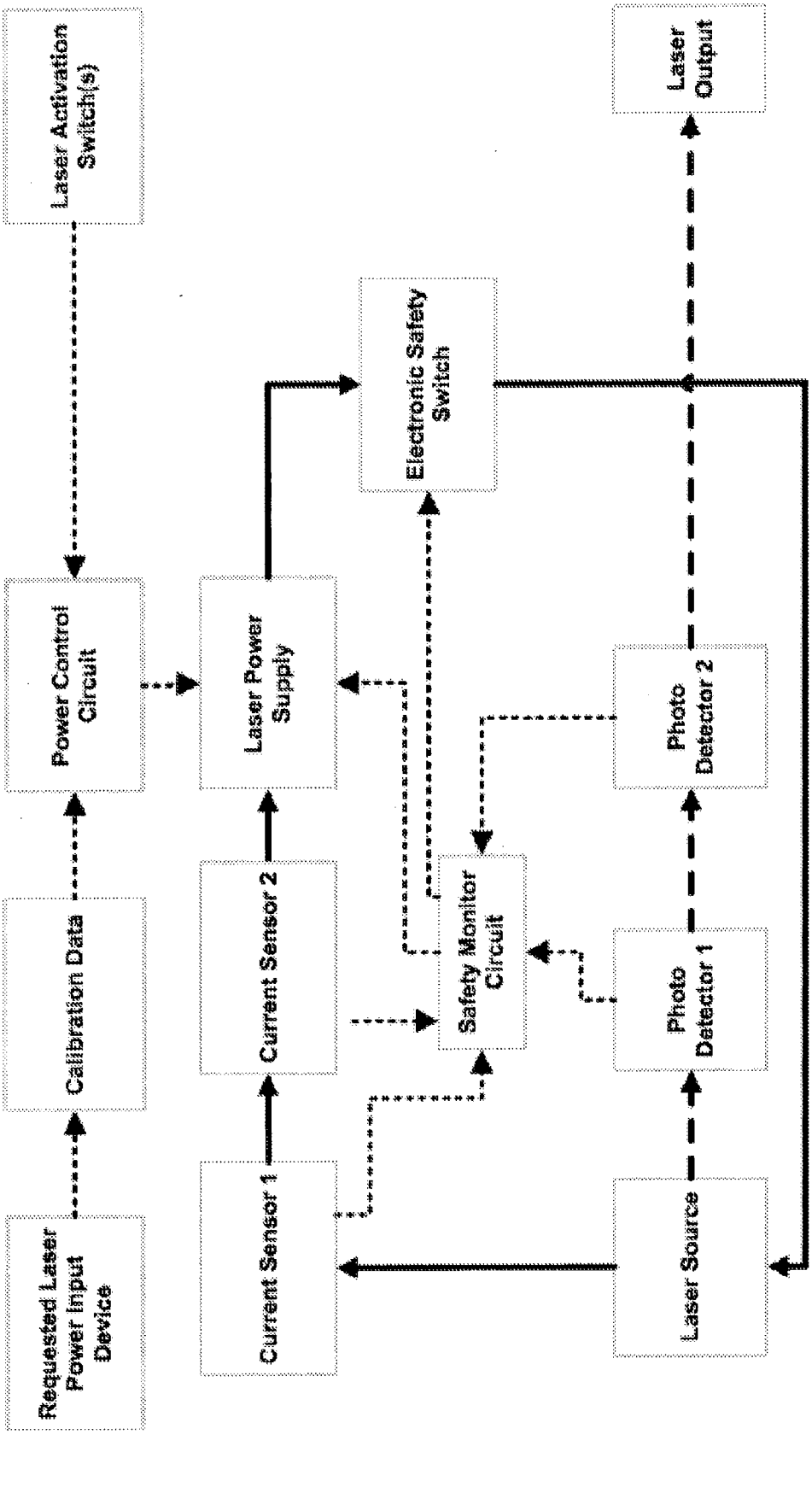
Laser Activation Switch(s)
Power Control Circuit
Calibration Data
Requested Laser Power Input Device
Laser Power Supply
Current Sensor 2
Current Sensor 1
Electronic Safety Switch
Safety Monitor Circuit
Laser Output
Photo Detector 2
Photo Detector 1
Laser Source
Laser Current Path
Control Signals
Laser Light

Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2009097513 A1 **[0012]**
- EP 0425309 A2 **[0013]**

Szabadalmi igénypontok

1. Orvosi lézer, amely tartalmaz

(a) lézerforrást lézer kimenet kibocsátására, ahol a lézerforrás bemenetet kap egy lézer tápegységtől; és

(b) elektronikus záráramkört a lézer kimenet ellenőrzésére és biztonságos vezérlésére, ahol az elektronikus záráramkör tartalmaz

(i) biztonsági ellenőrző áramkört;

(ii) első áramérzékelőt és második áramérzékelőt, ahol az első áramérzékelő és a második áramérzékelő úgy van elrendezve, hogy mindegyik függetlenül bemenetet ad a biztonsági ellenőrző áramkörnek, és ahol a második áramérzékelő úgy van elrendezve, hogy bemenetet ad a lézer tápegységnek; ahol az első áramérzékelő és a második áramérzékelő mindegyike úgy van elrendezve, hogy ellenőrizze a lézer tápegység által kiadott lézeráramot; ahol eszköz van arra, hogy felhasználja az első áramérzékelőt a lézeráram egy vezérlési szintre való vezérlésére; és ahol eszköz van a második áramérzékelő ellenőrzésére, hogy biztosítva legyen, hogy a lézeráram egy küszöbérték alatt van; és

(iii) első fénydetektort és második fénydetektort, ahol az első fénydetektor és a második fénydetektor úgy van elrendezve, hogy mindegyik függetlenül bemenetet ad a biztonsági ellenőrző áramkörnek, ahol az első fénydetektor és a második fénydetektor mindegyike úgy van elrendezve, hogy ellenőrizzen egy lézer emissziós teljesítményt;

ahol az első fénydetektor úgy van elrendezve, hogy felhasználható egy zártkörű iterációban a lézer tápegység kimenetének szabályozására úgy, hogy egy kívánt lézer emissziós szint legyen elérhető; és

ahol eszköz van a második fénydetektor kimenetének az első fénydetektor kimenetével való összehasonlítására annak biztosításához, hogy azok konzisztensek legyenek.

2. Az 1. igénypont szerinti orvosi lézer, amelyben az elektronikus záráramkör tartalmaz továbbá a lézer tápegységtől független elektronikus biztonsági kapcsoló

együttest, ahol az együttes egy, kettő vagy három elektronikus biztonsági kapcsolót tartalmazó együttes.

3. A 2. igénypont szerinti orvosi lézer, amelyben az elektronikus biztonsági áramkapcsolók a következők: (i) nagyfeszültség oldali áramkapcsoló, (ii) kisfeszültség oldali visszatérő áramkapcsoló, vagy (iii) sönt áramkapcsoló a lézerforráson keresztül.

4. A 2. igénypont szerinti orvosi lézer, amelyben az elektronikus biztonsági áramkapcsolóknak 0,1 ms-tól 0,005 ms-ig terjedő nagyságrendben lévő kapcsolási válaszidejük van.

5. A 2. igénypont szerinti orvosi lézer, amelyben az elektronikus biztonsági áramkapcsolók a következők: (i) első elektronikus áramkapcsoló, amely bemenetet kap a lézer tápegységtől és bemenetet ad a lézerforrásra, (ii) második elektronikus áramkapcsoló, amely bemenetet kap a lézerforrástól és visszavezetést ad a lézer tápegységre, vagy (iii) harmadik elektronikus áramkapcsoló a lézerforráson keresztül, amely kapcsoló bemenetet kap vagy közvetlenül a lézer tápegységtől, vagy közvetve a lézer tápegységtől a második elektronikus áramkapcsolón keresztül.

6. Az 1. igénypont szerinti orvosi lézer, amelyben a biztonsági ellenőrző áramkör bemenetet ad egy elektronikus biztonsági áramkapcsolónak, ahol az elektronikus biztonsági áramkapcsoló független a lézer tápegységtől.

7. Az 1. igénypont szerinti orvosi lézer, amelyben az orvosi lézer nem tartalmaz mechanikus zárat a lézer kimenet szabályozására.

8. Az 1. igénypont szerinti orvosi lézer, amelyben a lézerforrás szemészeti lézer.

9. Az 1. igénypont szerinti orvosi lézer, amelyben a lézerforrás diódapumpált félvezető lézeres fotokoagulátor.