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

(11) **EP 3 812 649 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
28.04.2021 Bulletin 2021/17

(21) Application number: **18923662.3**

(22) Date of filing: **22.06.2018**

(51) Int Cl.:
F21S 8/06 *(2006.01)* ***F21V 19/00*** *(2006.01)*
F21W 131/205 *(2006.01)*

(86) International application number:
PCT/CN2018/092381

(87) International publication number:
WO 2019/241996 (26.12.2019 Gazette 2019/52)

(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
Designated Extension States:
BA ME
KH MA MD TN

(71) Applicant: **Nanjing Mindray Bio-Medical Electronics Co., Ltd.**
Nanjing, Jiangsu 211111 (CN)

(72) Inventor: **WANG, Lei**
Nanjing, Jiangsu 211111 (CN)

(74) Representative: **KIPA AB**
P O Box 1065
251 10 Helsingborg (SE)

(54) **SURGICAL LIGHT**

(57) A surgical light, comprising a light body (1), at least one illuminating unit (2) being mounted in the light body (1), the illuminating unit (2) comprising a light source and an optical system cooperating with the light source, the illuminating unit (2) being able to form an illuminating light spot (6) in a surgical field area (5) and form an auxiliary illumination area (9) at least in a range adjacent to the illuminating light spot, the brightness of the auxiliary illumination area (9) being lower than the brightness of the illuminating light spot (6). As the illuminating unit (2) not only forms an illuminating light spot (6) in the surgical field area (5), but also forms an auxiliary illumination area (9) in a range next to the illuminating light spot, in order to increase the brightness of the area adjacent to the illuminating light spot, decreasing the contrast between the brightness inside and outside the area of the surgical field illuminating light spot (6) increases illumination uniformity in the entire field of view, changes the average brightness or luminance of the illumination in the field of view of the human eye, and reduces glare, thereby increasing the comfort of long-term observation by physicians.

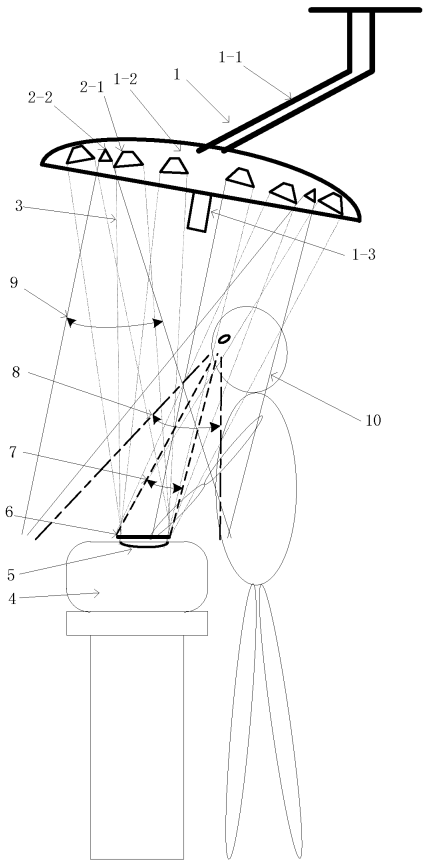

Fig. 1

EP 3 812 649 A1

Description

Technical Field

[0001] The present disclosure relates to the technical field of medical equipment, and more specifically to a surgical light.

Background Art

[0002] Surgical shadowless lights (surgical lights for short) are necessary equipment commonly used in an operating room, and surgeons usually work under the surgical light for several hours or longer during surgery. In order to get sufficient illumination to illuminate the area where the surgical field is located, the surgical light usually focuses its light on the surgical field, and a single surgical light will produce, at the position where its light is focused, a high-illuminance light spot with a diameter of about 13-25 cm, the illuminance at the center of the light spot being up to 40,000 to 160,000 lux.

[0003] With the development of surgical lights, most surgical light products have adopted LED light sources. Due to the high light-emitting efficiency and strong directivity of the LED light sources, most LED surgical light products tend to achieve a central illuminance close to 160,000 lux. The higher the illuminance, the better users can perform delicate operations. Therefore, the LED surgical lights are beneficial to the user's delicate operations. However, due to the relatively high illuminance of the LED surgical lights, users have poor viewing comfort during use, and long-term use will easily cause visual fatigue.

Summary

[0004] An embodiment of the present disclosure provides a surgical light, which can ensure both the illuminance required during surgery and the comfort of a user.

[0005] The embodiment of the present disclosure provides the following technical solution:
a surgical light, comprising a light body, at least one illuminating unit being mounted in the light body, the illuminating unit comprising a light source and an optical system cooperating with the light source, the illuminating unit being able to form an illuminating light spot in a surgical field area and form an auxiliary illumination area at least in a range adjacent to the illuminating light spot, the illuminance of the auxiliary illumination area being lower than the illuminance of the illuminating light spot.

[0006] In this embodiment, the illuminating unit not only can form an illuminating light spot in the surgical field area, but can also form an auxiliary illumination area in a range adjacent to the illuminating light spot to increase the illuminance of the area adjacent to the illuminating light spot, and in turn can decrease the contrast between the illuminances inside and outside the area of the illuminating light spot in the surgical field, increase illumination uniformity in the entire field of view, change the average brightness or illuminance of the illumination in the field of view of the human eye, and reduce glare, thereby increasing the comfort of long-term observation by surgeons.

Brief Description of the Drawings

[0007] In order to illustrate the technical solutions in the embodiments of the present disclosure more clearly, a brief introduction to the drawings required for the embodiments will be provided below. Obviously, the drawings in the following description are merely some of the embodiments of the present disclosure, and those of ordinary skill in the art would also have been able to obtain other drawings according to these drawings without involving any inventive effort.

Fig. 1 is a structural schematic diagram of a particular embodiment of a surgical light provided by the present disclosure;
Fig. 2 is a curve of the illuminance of an illuminating light spot of a first light source which is turned on alone;
Fig. 3 is a curve of the illuminance of a field of view of a second light source which is turned on alone;
Fig. 4 is a curve of the composite illuminance of the first light source and the second light source which are both turned on; and
Fig. 5 is a structural schematic diagram of another particular embodiment of a surgical light provided by the present disclosure.

[0008] Reference numerals in the accompanying drawings are as follows:
light body 1, suspension system 1-1, light holder 1-2, handle 1-3, illuminating unit 2, first illuminating unit 2-1, second illuminating unit 2-2, light ray 3, patient's body 4, surgical field area 5, illuminating light spot 6, opening angle of an illuminating light spot relative to eyes 7, opening angle of normal observation angle of view 8, auxiliary illumination area 9, and user 10.

Detailed Description of Embodiments

[0009] An embodiment of the present disclosure discloses a surgical light, which decreases the contrast between the illuminances inside and outside the area of the illuminating light spot in the surgical field, changes the average brightness or illuminance of the illumination in the field of view of the human eye, and reduces glare, thereby increasing the comfort of long-term observation by surgeons.

[0010] The technical solutions of the embodiments of the present application will be described below clearly and comprehensively in conjunction with the drawings of the embodiments of the present disclosure. Obviously, the embodiments described are merely some embodiments of the present disclosure and are not all the possible embodiments. Based on the embodiments in the present disclosure, other embodiments obtained by those of ordinary skill in the art without involving any inventive effort shall all fall within the scope of protection of the present disclosure.

[0011] Studies have found that discomfort in illumination environments is usually caused by glare. Glare is a phenomenon of discomfort or reduced visual function caused by uneven distribution of illumination brightness or excessive brightness in the field of view of human eyes. The generation of glare is mostly related to the brightness of a light source. When the brightness of the light source is too high, the lower the brightness of the surrounding environment, the more significant the glare. According to the research on uncomfortable glare, a method for determining the generation of uncomfortable glare and the feeling of discomfort is summarized, which is generally calculated by a formula, for example, British glare index system used by CIBSE. For a single glare source, it can be calculated by the following formula:

$$G = (0.9L_S^{1.6} \times \omega^{0.8})/(L_b \times P^{1.6}) \quad (1)$$

where G is glare feeling; L_S is the brightness of a glare source in cd/m^2; ω is a solid angle of the glare source relative to eyes; L_b is the average brightness of a field of view in cd/m^2; and P is the Guth position index, which is the position of the glare source relative to the line of sight.

[0012] The value of G is between 10 and 30, 10 indicating that no glare is felt, and 30 indicating very uncomfortable glare. According to the results of subsequent research, its calculation and evaluation methods are similar to the above formula in basic form.

[0013] For a surgical light, the problem often concerned is the glare caused by the light rays from a light source of the surgical light directly illuminating the human eyes, and thus the surgical light is manufactured such that the light rays are focused on the surgical field as much as possible, rather than scattered to the human eyes, thereby reducing the glare. However, in the practical clinical environment, the area of the surgeon's field of view during surgery is much larger than the area of an illuminating light spot in a surgical field. The illuminance of the area of the illuminating light spot in the surgical field is generally between 40,000 lux and 160,000 lux, the illuminance of the area outside the light spot in the surgical field is generally several hundred lux to several thousand lux, and the illuminance decreases rapidly as it moves away from the light spot. When the brightness varies greatly in different areas of the field of view, the eyes search for a target in different areas, and the pupil size changes continuously, which will cause an uncomfortable glare symptom or feeling.

[0014] To this end, the surgical light provided by the present application not only can form an illuminating light spot in the surgical field area, but can also form an auxiliary illumination area in a range adjacent to the illuminating light spot, and in turn can decrease the contrast between the illuminances inside and outside the area of the illuminating light spot in the surgical field, and increase illumination uniformity in the entire field of view, thereby increasing the comfort of long-term observation by surgeons.

[0015] The surgical light provided by the present application comprises a light body 1. In the light body 1, at least one illuminating unit 2 is generally mounted inside a light holder. The illuminating unit 2 comprises a light source and an optical system. The light body 1 is a main body support structure of the surgical light, and as shown in Fig. 1, the light body 1 comprises a suspension system 1-1, a light holder 1-2 and a handle 1-3. One end of the suspension system 1-1 is mounted on a ceiling of an operating room, and the light holder 1-2 is suspended on the other end of the suspension system. The light holder 1-2 generally comprises a light holder housing, the sterile handle 1-3 for manipulation by a surgeon, a control circuit for controlling the operating state of the surgical light, and a control interface for interacting with the surgeon. One or more illuminating units 2 each comprising a light source and its optical system may be specifically mounted inside the light holder 1-2.

[0016] The light source and the optical system of the illuminating unit 2 are in cooperation with each other, and the light rays 3 emitted by the light source, after being collected, refracted or reflected by the optical system, form a light beam with a certain spatial distribution. Specifically, an illuminating light spot 6 is formed in a surgical field area 5, and an auxiliary illumination area 9 is formed at least in a range adjacent to the illuminating light spot 6, the illuminance of the auxiliary illumination area 9 being lower than the illuminance of the illuminating light spot 6.

[0017] The illuminating light spot 6 refers to a directional light beam with a certain spatial distribution that is formed

by the light rays 3 emitted by the light source after being collected, refracted or reflected by the optical system, and in the surgical light, the directional light beam generally has a small angle of divergence and is directed below the surgical light. The light rays 3 emerge from the light holder of the surgical light and are focused on the surgical field area 5 on the surface of the patient's body 4 to form a high-illuminance illuminating light spot 6 so as to facilitate the surgical operation by the surgeon. The boundary of the illuminating light spot 6 is clear, which is very advantageous when the surgeon operates the surgical light to precisely position the illuminating light spot 6 on a surgical incision in the surgical field, such that the surgeon can quickly overlap the illuminating light spot 6 with the surgical incision, and enable the high-illuminance area to illuminate the site where precise operation is needed. However, due to the great difference between the illuminances inside and outside the illuminating light spot 6, it is likely to cause uncomfortable glare or produce uncomfortable feelings during long-term observation.

[0018] The auxiliary illumination area 9 refers to a light beam with a certain spatial distribution that is formed by the light rays 3 emitted by the light source after being collected, refracted or reflected by the optical system. The light beam has a large angle of divergence and a relatively uniform spatial intensity distribution and is directed below the surgical light, such that the surgical light has the function of large-range illumination. Consequently, the average illuminance in the range of the field of view of the surgeon is increased, and the difference and contrast between the illuminances inside and outside the illuminating light spot 6 in the surgical field area 5 are reduced. According to formula 1, with other conditions unchanged, increasing the average illuminance in the range of the field of view of the surgeon can ameliorate glare feelings, thereby improving the experience of the user 10 on the surgical light.

[0019] It should be noted that an auxiliary illumination area 9 is formed at least in a range adjacent to the illuminating light spot 6, i.e., the auxiliary illumination area 9 comprises at least an area adjacent to the illuminating light spot 6. The "adjacent" described here and below means that the auxiliary illumination area 9 is next to the illuminating light spot 6. Taking the illuminating light spot 6 being a circular light spot as an example, the auxiliary illumination area 9 may be tangent to the illuminating light spot 6, and the contrast between the illuminances on two sides of the tangent point is reduced, so as to reduce visual fatigue caused by observation by the human eyes in the areas on both sides. Preferably, the auxiliary illumination area 9 is adjacent to the illuminating light spot 6 along a predetermined length of the circumference of the illuminating light spot, and if the predetermined length is the perimeter, the auxiliary illumination area 9 surrounds the illuminating light spot 6.

[0020] The auxiliary illumination area 9 comprises at least an area adjacent to the illuminating light spot 6, which illustrates the case where the auxiliary illumination area 9 is only adjacent to the illuminating light spot 6. In addition, the case where the auxiliary illumination area 9 intersects the illuminating light spot 6 is also included, i.e., the auxiliary illumination area 9 not only comprises an area adjacent to the illuminating light spot 6, but also comprises an area overlapping with the illuminating light spot 6, and the light source and the optical system are arranged conveniently.

[0021] The auxiliary illumination area 9 comprises at least an area adjacent to the illuminating light spot 6, and the case where the illuminating light spot 6 is included within the auxiliary illumination area 9 is also included, so as to avoid the surgeon's visual fatigue to the greatest extent. Specifically, the auxiliary illumination area 9 is not smaller than the range of the field of view of the user 10 during a surgical operation. During surgery, the surgeon needs to perform the operation in a comfortable posture, and can touch a handle under the center of the surgical light to adjust the surgical light. According to ergonomic restrictions, the distance from a lower surface of the surgical light to the surgical field area 5 is about 100 cm, and the distance from the surgeon's head to the surgical field area 5 is about 40 cm to 60 cm, and the light spot diameter of the illuminating light spot 6 varies according to the type of operation and is generally 13 cm to 30 cm. In this case, the opening angle 7 of the illuminating light spot 6 relative to the eyes is about 12-36 degrees. As the opening angle 8 of the normal observation angle of view of the human eyes is about 50-60 degrees, the area of the field of view of the surgeon during surgery is much larger than the area of the illuminating light spot 6 in the field of view. Thus, the auxiliary illumination area 9 is set to be not smaller than the range of the field of view of the user 10 during a surgical operation, i.e., the auxiliary illumination area 9 is set to be larger than or equal to the range of the field of view of the user 10 during the surgical operation, and thus within the range of the field of view of the user 10, the difference between the illuminances inside and outside the illuminating light spot 6 is small, thereby increasing the comfort of long-term observation by surgeons.

[0022] In the application of the surgical light provided by the present application, the illuminating unit 2 not only can form an illuminating light spot 6 in the surgical field area 5, but can also form an auxiliary illumination area 9 in a range adjacent to the illuminating light spot 6 to increase the illuminance of the area adjacent to the illuminating light spot 6, and in turn can decrease the contrast between the illuminances inside and outside the area of the illuminating light spot 6 in the surgical field, increase illumination uniformity in the entire field of view, change the average brightness or illuminance of the illumination in the field of view of the human eye, and reduce glare, thereby increasing the comfort of long-term observation by surgeons.

[0023] Specifically, the light source may use an LED light source. LED is a semiconductor device, and has the characteristics of small light-emitting area, high brightness, high light-emitting efficiency, etc. The LED light source used has a high light-emitting efficiency and a high total power, and the LED surgical light usually has a high illuminance in the

surgical field. Since the LED as a light source has a small light-emitting area and a high brightness and is almost a point light source, by means of the optimized design for the optical system, the spatial distribution of the directional light beam of LED can be easily controlled by the matching optical system, such that more energy is concentrated in the center of the directional light beam, and the surrounding stray light is reduced, so that the surgical field area 5 is illuminated with a clear illumination boundary. Less stray light and the illuminating light spot 6 with a clear boundary are beneficial to improve the optical energy utilization of the optical system, reduce the power of the whole machine, and improve the effect of showing the light spot.

[0024] Further, reference is made to Fig. 1. Fig. 1 is a structural schematic diagram of a particular embodiment of a surgical light provided by the present disclosure. In this embodiment, the illuminating unit 2 comprises a first illuminating unit 2-1 and a second illuminating unit 2-2. The first illuminating unit 2-1 comprises a first light source and a corresponding first optical system, and is used for forming an illuminating light spot 6. The second illuminating unit 2-2 comprises a second light source and a corresponding second optical system, and is used for forming an auxiliary illumination area 9. That is, the surgical light comprises at least one first illuminating unit 2-1 and at least one second illuminating unit 2-2. The first light source and the first optical system of the first illuminating unit 2-1 are in cooperation with each other to form the illuminating light spot 6. The second light source and the second optical system of the second illuminating unit 2-2 are in cooperation with each other to form the auxiliary illumination area 9. That is, the second illuminating unit 2-2 is additionally provided inside the light body 1 to provide the auxiliary illumination area 9. Specifically, a plurality of second illuminating units 2-2 are comprised, and the plurality of second illuminating units 2-2 are uniformly distributed inside the light body 1. The plurality of second illuminating units 2-2 cooperate to provide auxiliary illumination. When the plurality of second illuminating units 2-2 are used and uniformly distributed inside the light holder, the chance of large-range illumination being blocked by the surgeon's body can be reduced, thereby having a more excellent use effect.

[0025] In the implementation described above, the second illuminating unit 2-2 is additionally provided inside the light body 1 to provide the auxiliary illumination area 9, and in other particular embodiments, the light source comprises a first light source and a second light source. The first light source cooperates with the optical system to form the illuminating light spot 6; and the second light source cooperates with the optical system to form the auxiliary illumination area 9. That is, in one illuminating unit 2-1, the first light source and the second light source share the same optical system, and the illuminating light spot 6 and the auxiliary illumination area 9 are respectively formed through different cooperation of the first light source and the second light source with the optical system. In other words, a second light source can be added to an existing surgical light that only forms the illuminating light spot 6 by using the first light source and the matching optical system, and the second light source is used to form the auxiliary illumination area 9 by using the optical system originally cooperating with the first light source.

[0026] Specifically, the first light source is located at a focus or a virtual focus of the optical system, and the second light source is located outside the focus and the virtual focus. When the first light source is located at the focus or the virtual focus of the optical system, the light beam formed by the first light source has a small angle of divergence and forms the illuminating light spot 6. The second light source is disposed outside the focus or the virtual focus of the optical system. As it is not at the focus, the light emitted by the second light source is collected by the optical system and then emitted at a large angle of divergence, thereby forming background illumination, i.e., the auxiliary illumination area 9. However, the uniformity of the auxiliary illumination area 9 generated by this method is slightly inferior to that generated by the method of separately providing the first lighting unit 2-1 and the second lighting unit 2-2.

[0027] As described above, the first light source and the second light source are separately disposed relative to the position of the optical system to form the illuminating light spot 6 and the auxiliary illumination area 9. In another implementation, the optical system comprises a first optical part and a second optical part, the first optical part cooperating with the first light source to form the illuminating light spot 6, and the second optical part cooperating with the second light source to form the auxiliary illumination area 9. That is, by means of additionally providing a light source or a type or a sub-type of light source and additionally providing an optical feature, i.e., the second optical part, in the optical system, the newly added light source, i.e., the second light source, and the new optical feature has the illumination effect of the second illuminating unit 2-2, thereby forming the auxiliary illumination area 9. The first light source then cooperates with the first optical part to form the illuminating light spot 6.

[0028] In the above embodiments in which a second light source is provided, the first light source and the second light source are respectively electrically connected to switches for respectively controlling the turning on and off of the first light source and the second light source. That is, both the first light source and the second light source can be turned on and off alone to meet and improve the illumination demands at different stages in the operation process. For example, before making a surgical incision, the patient's body 4 needs to be disinfected on a large area, and at this time, if the illuminating light spot 6 is used for illumination, it is likely to cause uncomfortable glare because the skin and the disinfectant reflect the light rays 3 strongly, the intensity of the illuminating light spot 6 is very high, and the light spot is small. At this stage, the second light source can be turned on alone, and the uniform large-range illumination of the second light source can be used for large-area disinfection for the patient's body 4. As another example, after the main operation process is completed, the second light source may be turned on during the cleaning of the patient or an

operation table to serve as a supplement to the regular illumination of the operating room.

[0029] The second light source can be turned on and off during the operation to meet different demands and preferences of the user 10. For example, when the surgeon needs to accurately position the illuminating light spot 6 of the surgical light in the early stage of the operation, the surgeon can turn off the second light source such that the edge of the light spot looks sharper to facilitate the sufficient overlapping of the illuminating light spot 6 and the surgical incision. When performing a long-term operation after the positioning is completed, the surgeon can turn on the second light source. As another example, when the surgeon performs certain precision operations and thinks that he/she can be more attentive when the surrounding environment is dark, the second light source may be turned off.

[0030] As an example in which the auxiliary illumination area 9 is not smaller than the range of the field of view, as shown in Fig. 2, the first light source is turned on alone. Fig. 2 is a curve of the illuminance of the illuminating light spot 6 of the first light source which is turned on alone. The D 10 diameter of the illuminating light spot 6 of the surgical light is about 14 cm, and D50 is about 8.5 cm, which meets the requirements of YY 0627-2008 for the light spot distribution of the surgical light. However, the illuminance of the illuminating light spot 6 decreases very quickly in the range outside D 10, and the illuminance is only 2% of the central illuminance when the diameter is 18 cm, and is less than 1% when the diameter is greater than 20 cm. Thus, when observing the light spot shown in Fig. 2 by way of example, the edge of the light spot is clear, and there is almost no illumination on the periphery of the light spot. As shown in Fig. 3, the second light source is turned on alone. Fig. 3 is a curve of the illuminance of a field of view of the second light source which is turned on alone. A uniform, large-range, low-illuminance illumination curve is provided within the range of the field of view in the plane of the surgical field. As shown in Fig. 4, the first light source and the second light source are both turned on. Fig. 4 is a curve of the composite illuminance of the first light source and the second light source which are both turned on. An illuminance curve is formed in the plane of the surgical field, that is, there is a very high illuminance at the center to meet the requirements of the operation, the D10 light spot diameter remains unchanged, and the background illumination in the area outside the diameter of the illuminating light spot 6 is uniform and has a reasonable brightness.

[0031] Further, the surgical light further comprises a switch control unit electrically connected to the switches for automatically controlling actions of the switches according to a pre-stored control instruction to control the turning on and off of the first light source and the second light source. Specifically, the switch control unit may be a control chip in a master controller of the surgical light, or may be a separately arranged switch controller. The switch control unit, in which a control instruction is pre-stored, automatically controls, according to the control instruction, the switches respectively connected to the first light source and the second light source, so as to control the turning on or off of the first light source and the second light source respectively. Specifically, the pre-stored control instruction may be pre-stored by manually inputting by the user 10, or may be directly built-in during the preparation of the surgical light.

[0032] In the above embodiments in which the second light source is provided, the second light source is connected to a second controller used for controlling the brightness thereof. Specifically, the second controller may adjust the power of the second light source through the control of the voltage or current thereof, thereby achieving the purpose of adjusting the brightness thereof, so as to meet the usage habits of different users 10 or different requirements for the brightness of the second light source in different surgical stages of the user 10.

[0033] Specifically, the surgical light further comprises a brightness acquisition device used for acquiring a brightness instruction input by the user 10, wherein the second controller is electrically connected to the brightness acquisition device to correspondingly adjust the brightness of the second light source according to the brightness instruction acquired by the brightness acquisition device. That is, the second controller may correspondingly adjust the brightness according to the demands and preferences of the user 10. The brightness acquisition device may specifically be an input device, such as a touch screen, a keyboard and a knob. The user 10 inputs the required brightness instruction, the brightness acquisition device acquires the corresponding brightness instruction and sends it to the second controller, and the second controller correspondingly adjusts the brightness of the second light source according to the received brightness instruction. In this way, the user 10 can freely adjust the brightness of the second light source during the operation, so that the use of the surgical light is more user-friendly.

[0034] Further, the first light source is connected to a first controller used for adjusting the brightness thereof; and the second controller is electrically connected to the first controller for synchronously adjusting the brightness of the second light source according to the adjustment of the brightness of the first light source by the first controller. The first controller is used for adjusting the brightness of the second light source. Specifically, the first controller may adjust the power of the first light source through the control of the voltage or current thereof, thereby achieving the purpose of adjusting the brightness thereof. That is, the brightness of the first light source and the second light source may be respectively adjusted by the first controller and the second controller, the second controller is electrically connected to the first controller such that when the first controller adjusts the brightness of the first light source, the second controller automatically and correspondingly adjust the brightness of the second light source. For example, when the surgeon increases the brightness of the first light source by means of the first controller, the brightness of the second light source is synchronously increased by the second controller, and when the surgeon decreases the brightness of the first light

source by means of the first controller, the brightness of the second light source is synchronously decreased by the second controller. Specifically, the magnitude of change in the brightness of the second light source and the magnitude of change in the brightness of the first light source may be proportionally changed, and may also be increased or decreased simultaneously according to another calculation logic.

[0035] Still further, the surgical light further comprises a diameter control device used for adjusting the light spot diameter of the illuminating light spot 6, wherein the second controller is electrically connected to the diameter control device for synchronously adjusting the brightness of the second light source according to the adjustment of the light spot diameter of the illuminating light spot 6 by the diameter control device. Specifically, the diameter control device may be an operating handle of the surgical light, and the user 10 controls the light spot diameter of the illuminating light spot 6 by means of the operating handle. For the specific structure and adjustment principle of the operating handle, reference is made to the prior art, which will not be repeated here. The second controller is electrically connected to the diameter control device, and thus when the diameter control device adjusts the light spot diameter of the illuminating light spot 6, the brightness of the second light source is correspondingly adjusted. For example, the brightness of the second light source is increased when the light spot diameter increases, and the brightness of the second light source is decreased when the light spot diameter decreases. The specific correspondence of the change in the light spot diameter and the change in the brightness of the second light source may be set as required, which is not specifically limited here. That is, the brightness of the second light source may be changed according to the adjustment of the diameter of the illuminating light spot 6. It can be seen from formula 1 that the glare feeling increases when the solid angle of the glare source relative to the human eyes increases, and at this time, the background brightness may be increased for compensation. Therefore, when the surgeon increases the diameter of the illuminating light spot 6 of the surgical light by means of the diameter control device, the second controller controls the second light source to synchronously increase the brightness, and when the surgeon decreases the diameter of the illuminating light spot 6 of the surgical light by means of the diameter control device, the second controller controls the second light source to synchronously decrease the brightness.

[0036] The formation of the auxiliary illumination area by means of additionally providing the first illuminating unit 2-1 or additionally providing the second light source is respectively as described above. The glare may be improved as required without additionally providing the second illumination unit 2-2 or additionally providing the light source, but by only changing the illumination distribution of the illuminating light spot in the surgical field area of the surgical light. As shown in Fig. 5, it is a structural schematic diagram of another particular embodiment of a surgical light provided by the present disclosure. In this embodiment, the illuminating unit 2 comprises a plurality of light sources, and the optical system cooperates with the plurality of light sources to form an illumination distribution including the illuminating light spot and the auxiliary illumination area. By changing the design of the matching optical system of the illuminating unit 2, more energy is distributed outside the original illuminating light spot of the surgical light, thereby increasing the average illuminance in the entire range of the field of view of the surgeon and reducing glare discomfort. In the embodiment, although the flexibility of control is sacrificed to some extent and the user cannot be absolutely satisfied, the comfort can be improved to a certain extent, and at the same time the cost is low. As shown in Fig. 5, at this time, the light rays 3 emitted by the illuminating unit 2 of the surgical light have a larger angle of divergence, but most of its energy is in the range of 3-1, and this part of the energy forms a small-range, high-brightness illumination light spot in the surgical field. A small part of the energy is in the range 3-2 at the periphery, and this range is substantially comparable to or larger than the range of the field of view of the surgeon, forming the background illumination for the entire surgical field in the surgical field area, i.e., the auxiliary illumination area.

[0037] In the above embodiments, the ratio of the illuminance value of the auxiliary illumination area to the maximum illuminance value at the center of the illuminating light spot is in the range of 1 : 20 to 1 : 80. The above formula 1 is mainly for the evaluation of the light source system, but during the use of the surgical light, the surgeon observes the illuminating light spot in the surgical field and the area outside the illuminating light spot. Human tissues and surgical instruments are generally located inside the illumination light spot, and objects such as sterile cloth, the surgeon's arm gloves and surgical instruments are located in the area outside the illumination light spot. These objects have different light reflectivities and are different in the brightness in the human eyes. Therefore, the illuminance value of the large-range illumination in the present disclosure is not simply calculated according to formula 1, and needs to be determined according to the clinical evaluation and the surgeon's preferences during actual use. Preferably, the ratio of the illuminance value of the auxiliary illumination area to the maximum illuminance value at the center of the light spot in the surgical light is in the range of 1 : 20 to 1 : 80, which can meet the requirements of surgical illuminance and is beneficial for the comfort of long-term observation by surgeons. At the same time, the uniformity of the auxiliary illumination area is of great help to improve comfort.

[0038] The various embodiments in this specification are described in a progressive manner, each embodiment focuses on the differences from other embodiments, and the same and similar parts of the various embodiments can be referred to each other.

[0039] The above description of the disclosed embodiments enables those skilled in the art to implement or use the

present disclosure. Various modifications to these embodiments will be apparent to those skilled in the art. The general principles defined herein may be implemented in other embodiments without departing from the spirit or scope of the present disclosure. Therefore, the present disclosure will not be limited to the embodiments shown herein, but should conform to the widest scope consistent with the principles and novel features disclosed herein.

Claims

1. A surgical light, characterized in thatcomprises a light body, at least one illuminating unit being mounted in the light body, the illuminating unit comprising a light source and an optical system cooperating with the light source, the illuminating unit being able to form an illuminating light spot in a surgical field and form an auxiliary illumination area at least in a range adjacent to the illuminating light spot, an illuminance of the auxiliary illumination area being lower than an illuminance of the illuminating light spot.

2. The surgical light of claim 1, **characterized in that** the illuminating unit comprises a first illuminating unit and a second illuminating unit, the first illuminating unit comprises a first light source and a corresponding first optical system and being used for forming the illuminating light spot; and the second illuminating unit comprises a second light source and a corresponding second optical system and being used for forming the auxiliary illumination area.

3. The surgical light of claim 2, characterized in thatcomprises a plurality of said second illuminating units that are uniformly distributed inside the light body.

4. The surgical light of claim 1, **characterized in that** the light source comprises a first light source and a second light source, the first light source cooperating with the optical system to form the illuminating light spot; and the second light source cooperating with the optical system to form the auxiliary illumination area.

5. The surgical light of claim 4, **characterized in that** the first light source is located at a focus or a virtual focus of the optical system, and the second light source is located outside the focus and the virtual focus.

6. The surgical light of claim 4, **characterized in that** the optical system comprises a first optical part and a second optical part, the first optical part cooperating with the first light source to form the illuminating light spot, and the second optical part cooperating with the second light source to form the auxiliary illumination area.

7. The surgical light of any one of claims 2-6, **characterized in that** the first light source and the second light source are respectively electrically connected to switches for respectively controlling on and off of the first light source and the second light source.

8. The surgical light of claim 7, characterized in thatfurther comprises a switch control unit electrically connected to the switches for automatically controlling the switches according to a pre-stored control instruction so as to control on and off of the first light source and the second light source.

9. The surgical light of any one of claims 2-6, **characterized in that** the second light source is connected to a second controller used for controlling a brightness thereof.

10. The surgical light of claim 9, characterized in thatfurther comprises a brightness acquisition device used for acquiring a brightness instruction inputted by a user, wherein the second controller is electrically connected to the brightness acquisition device to correspondingly adjust the brightness of the second light source according to the brightness instruction acquired by the brightness acquisition device.

11. The surgical light of claim 9, **characterized in that** the first light source is connected to a first controller used for adjusting a brightness thereof; and the second controller is electrically connected to the first controller for synchronously adjusting the brightness of the second light source according to the adjustment of the brightness of the first light source by the first controller.

12. The surgical light of claim 9, characterized in thatfurther comprises a diameter control device used for adjusting a diameter of the illuminating light spot, wherein the second controller is electrically connected to the diameter control device for synchronously adjusting the brightness of the second light source according to the adjustment of the diameter of the illuminating light spot by the diameter control device.

13. The surgical light of claim 1, **characterized in that** the illuminating unit comprises a plurality of said light sources, and the optical system cooperates with the plurality of said light sources to form an illumination distribution including the illuminating light spot and the auxiliary illumination area.

14. The surgical light of claim 1, **characterized in that** the auxiliary illumination area is greater than or equal to a view range of a user during a surgical operation.

15. The surgical light of claim 1, **characterized in that** a ratio of an illuminance value of the auxiliary illumination area to a maximum illuminance value at a center of the illuminating light spot is in a range of 1:20 to 1:80.

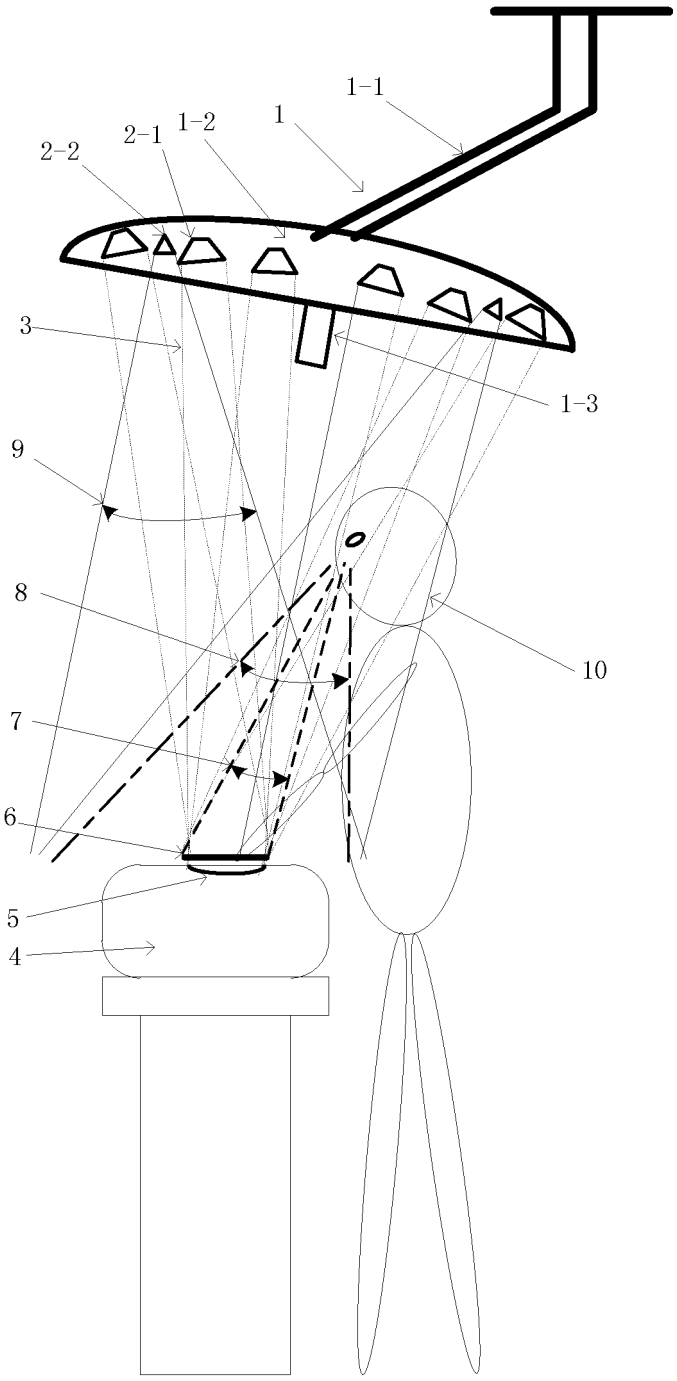

Fig. 1

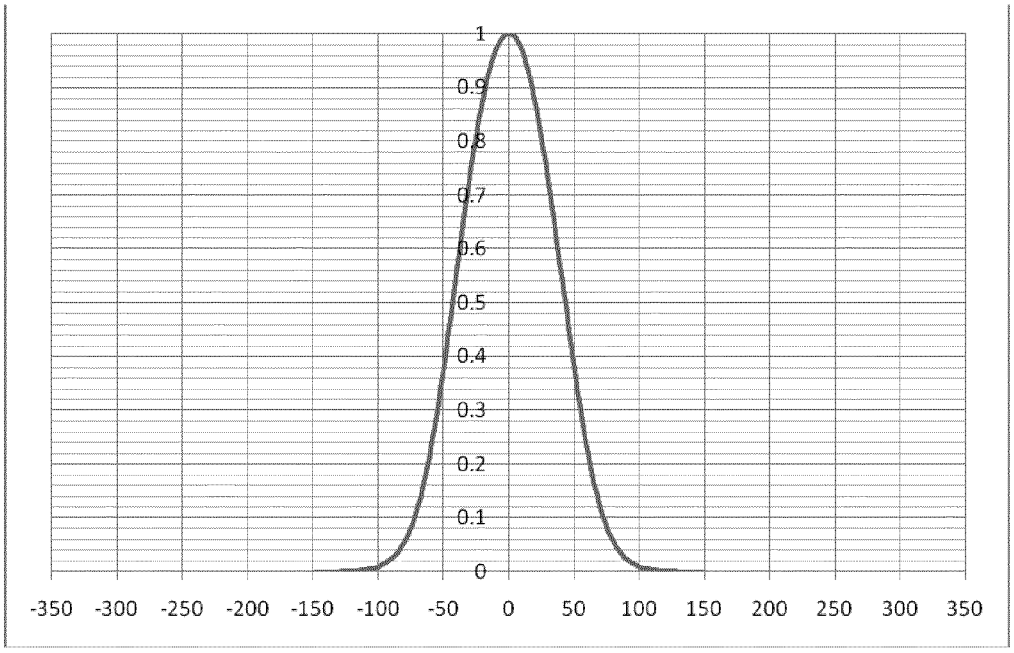
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350

Fig. 2

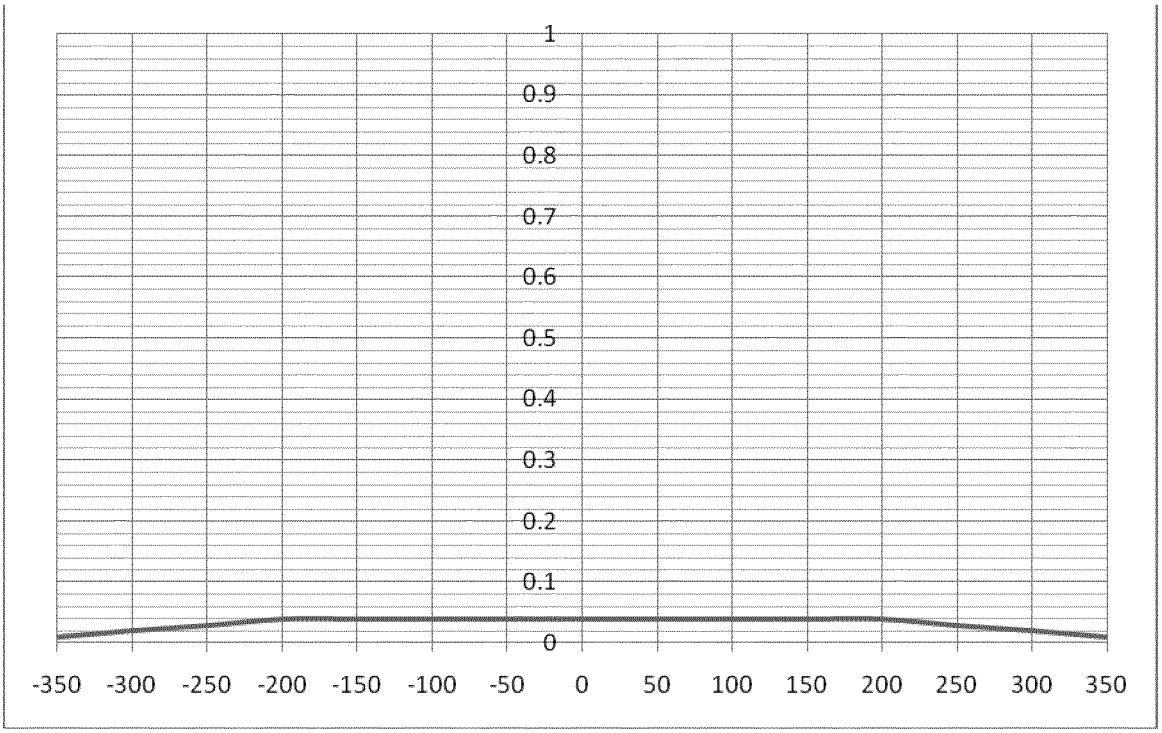
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350

Fig. 3

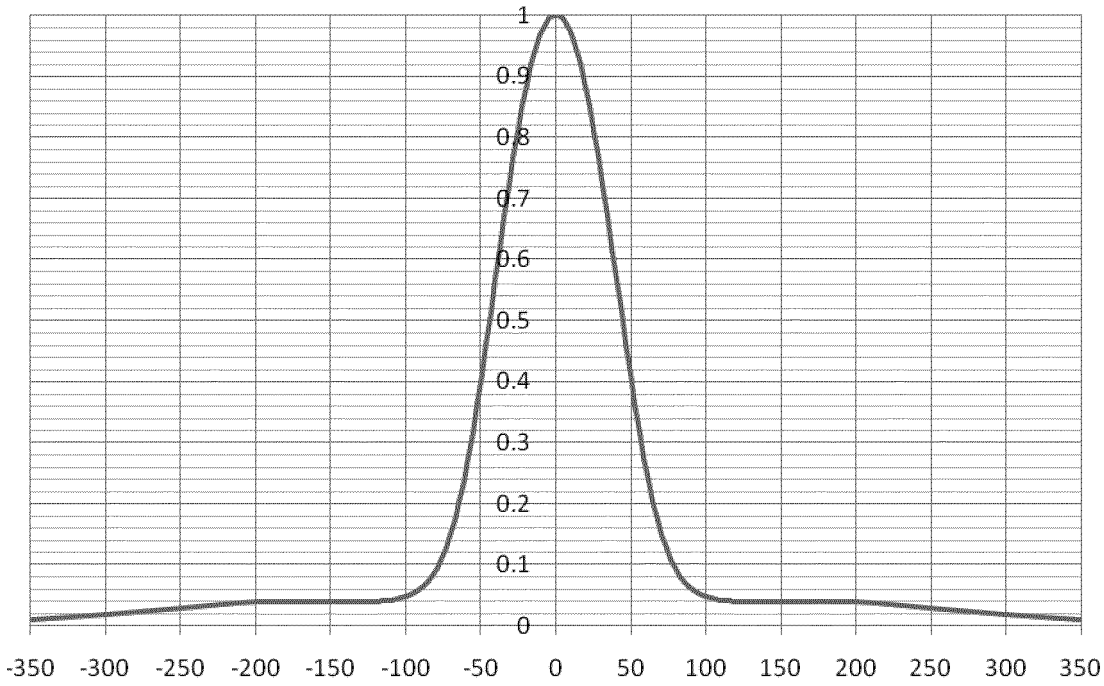
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-350
-300
-250
-200
-150
-100
-50
0
50
100
150
200
250
300
350

Fig. 4

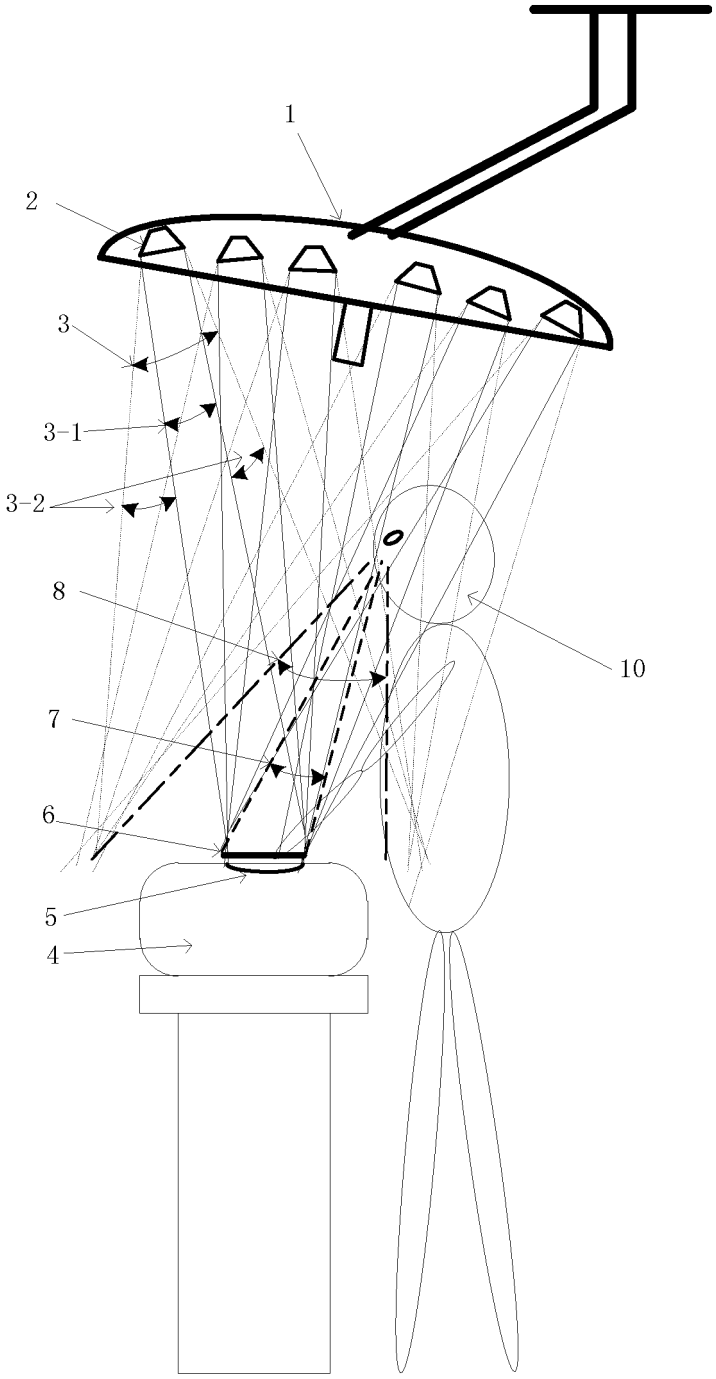

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/092381

A. CLASSIFICATION OF SUBJECT MATTER

F21S 8/06(2006.01)i; F21V 19/00(2006.01)i; F21W 131/205(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F21

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CPRSABS; CNABS; DWPI; SIPOABS; CNKI: 手术, 无影, 辅助, 周边, 周围, 外围, 补充, 补偿, 光, 照明, surgical, surger+, operat+, shadowless+, astral+, auxiliar+, assist+, compensa+, complement+, supplement+, light+, lamp+, illuminat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 203533332 U (MEDILAND (NANJING) MEDICAL EQUIPMENT CO., LTD.) 09 April 2014 (2014-04-09) description, paragraphs [0035]-[0042], and figures 1-5	1-15
X	CN 101257856 A (EMA CLOSE CO., LTD.) 03 September 2008 (2008-09-03) description, pages 1-4, and figures 1 and 2	1-15
A	US 2006109650 A1 (DRAEGER MEDICAL AG & CO. KGAA) 25 May 2006 (2006-05-25) entire document	1-15
A	CN 102927506 A (TIANJIN UNIVERSITY OF TECHNOLOGY) 13 February 2013 (2013-02-13) entire document	1-15
A	CN 201382284 Y (SANFENG MEDICAL APPARATUS CO., LTD.) 13 January 2010 (2010-01-13) entire document	1-15
A	CN 103791240 A (HEILONGJIANG UNIVERSITY OF SCIENCE AND TECHNOLOGY) 14 May 2014 (2014-05-14) entire document	1-15

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 March 2019	**02 April 2019**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/092381

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	203533332	U	09 April 2014	None			
CN	101257856	A	03 September 2008	DE	602006014432	D1	01 July 2010
				BR	PI0621250	A2	06 December 2011
				EP	1938768	B1	19 May 2010
				US	2008273317	A1	06 November 2008
				US	7922347	B2	12 April 2011
				EP	1938768	A4	17 December 2008
				EA	200702090	A1	28 April 2008
				WO	2007086770	A1	02 August 2007
				CN	101257856	B	13 October 2010
				EA	011462	B1	28 April 2009
				ES	2344803	T3	07 September 2010
				EP	1938768	A1	02 July 2008
				PT	1938768	E	16 July 2010
				AT	468079	T	15 June 2010
US	2006109650	A1	25 May 2006	DE	102004055839	A1	01 June 2006
				US	7401944	B2	22 July 2008
				DE	102004055839	B4	16 June 2011
CN	102927506	A	13 February 2013	CN	102927506	B	08 April 2015
CN	201382284	Y	13 January 2010	None			
CN	103791240	A	14 May 2014	CN	103791240	B	08 June 2016

Form PCT/ISA/210 (patent family annex) (January 2015)