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(54) **HAND-HELD OPHTHALMIC ILLUMINATOR**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Jan. 24, 2001**

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Related U.S. Application Data

(63) Continuation-in-part of application No. 09/175,796, filed on Oct. 20, 1998, now abandoned.

(51) **Int. Cl.**[7] **A61B 3/10**
(52) **U.S. Cl.** **351/221**
(58) **Field of Search** 351/205, 206, 351/221; 315/362; 600/321, 431, 558

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Primary Examiner—George Manuel

(57) **ABSTRACT**

The invention provides an ophthalmic illuminator, including a battery, an electrical resistor, an electrical switch and an LED. The battery is in circuit with the battery; and the electrical switch is in circuit with the resistor, where electrical energy flows through the circuit when the switch is in the closed position. The light emitting diode is in circuit with the switch and generates blue light energy which in turn causes fluorescence in a fluorescien dye administered to the patient's eye when the switch is in the closed position. An optical element (e.g, a lens or reflector) can be disposed between the diode and the eye to increase blue light energy reaching the eye. The energy can be "pulsed" such that the diode generates the blue light at a predetermined frequency. A user of the illuminator, e.g., a physician, can hold the system by hand to operate the switch (e.g., through a button). A magnifier coupled to the system provides a magnified image of the patient's eye, if desired. Preferably, an annular housing integrates the LED (or a plurality of LEDs) together such that a button activates and generates the blue light energy, and a user views through the center of the housing, through a magnifier therein, to view the patient's eye.

20 Claims, 6 Drawing Sheets

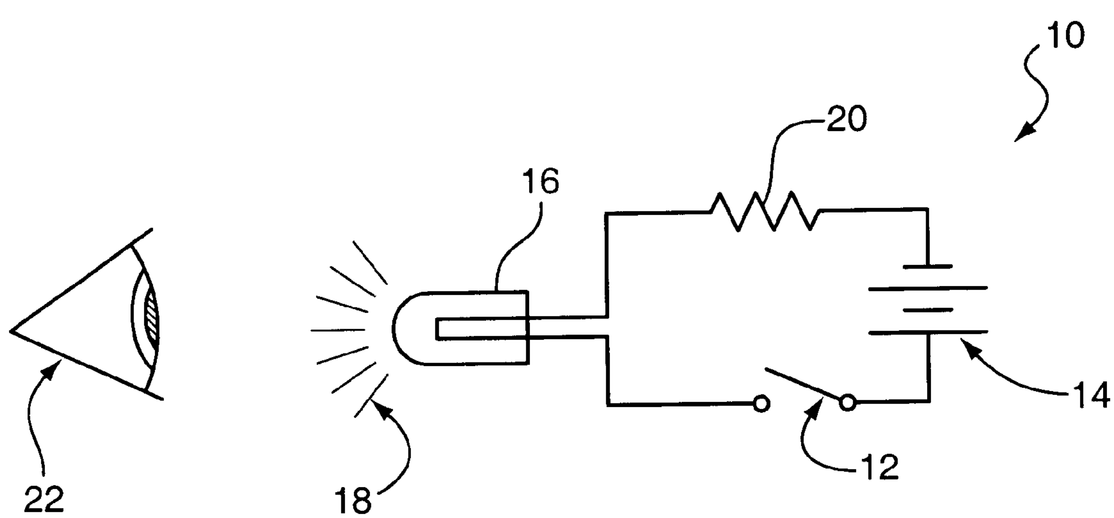


FIG. 1

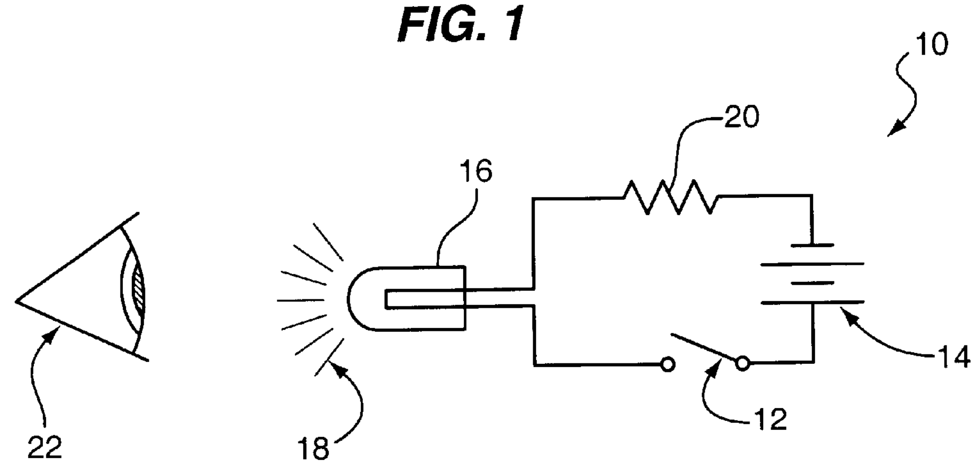


FIG. 2

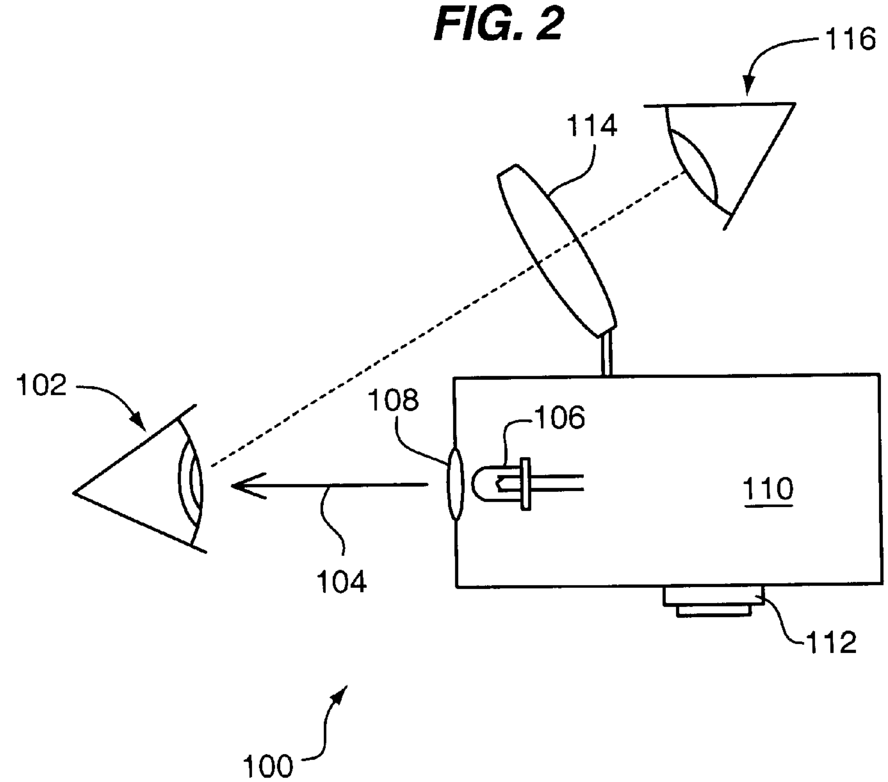


FIG. 3

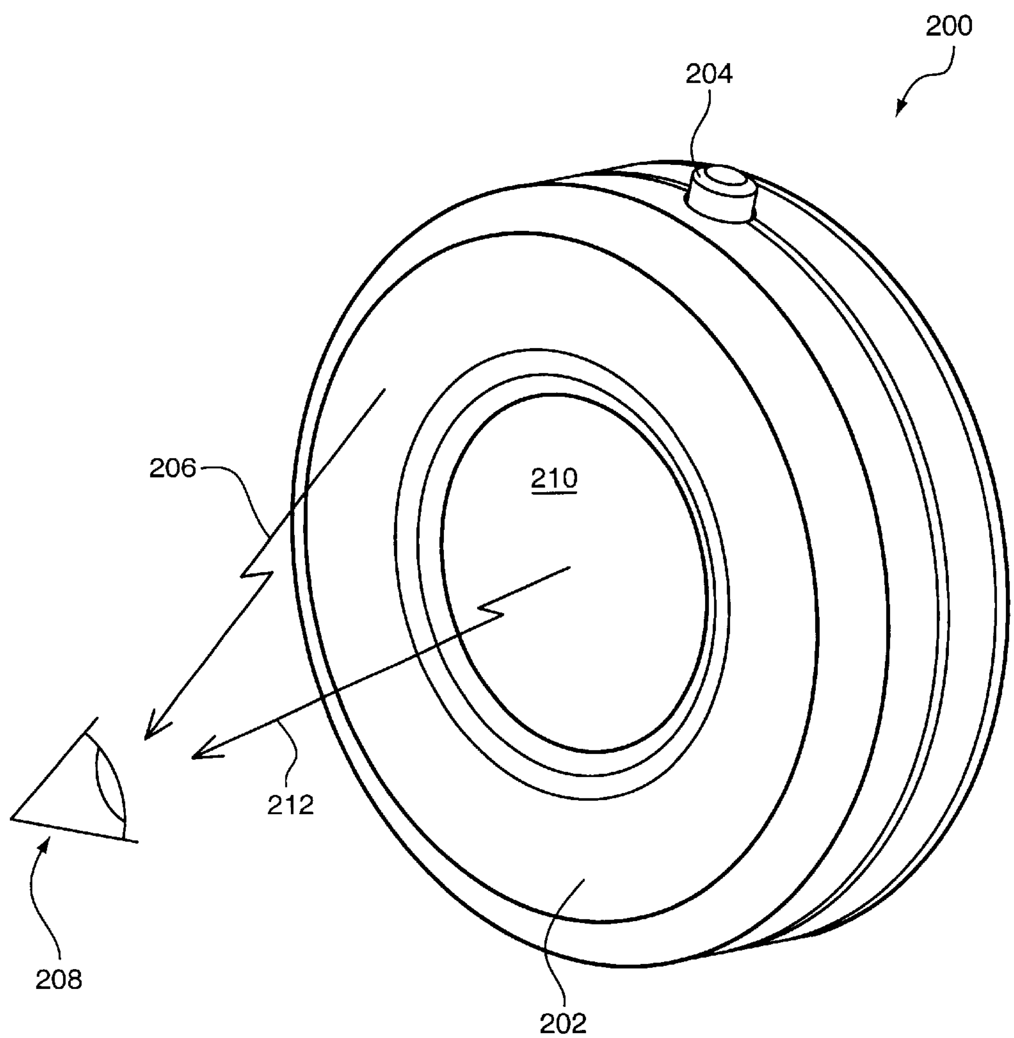


FIG. 4

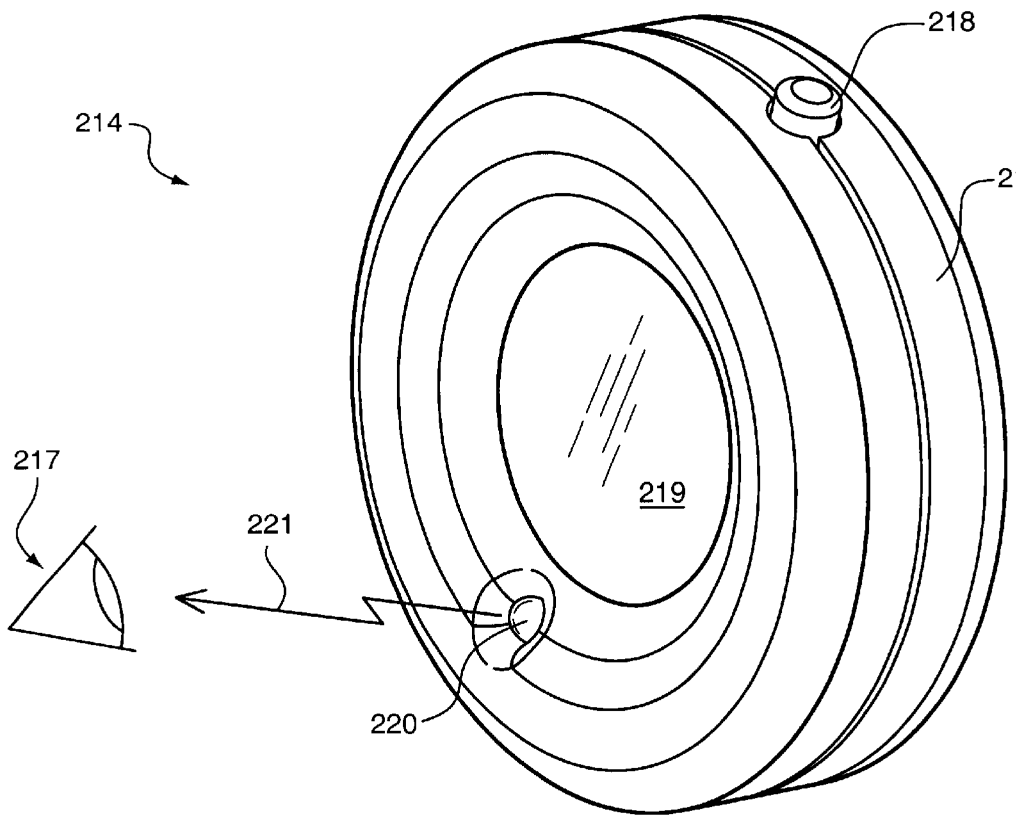


FIG. 5

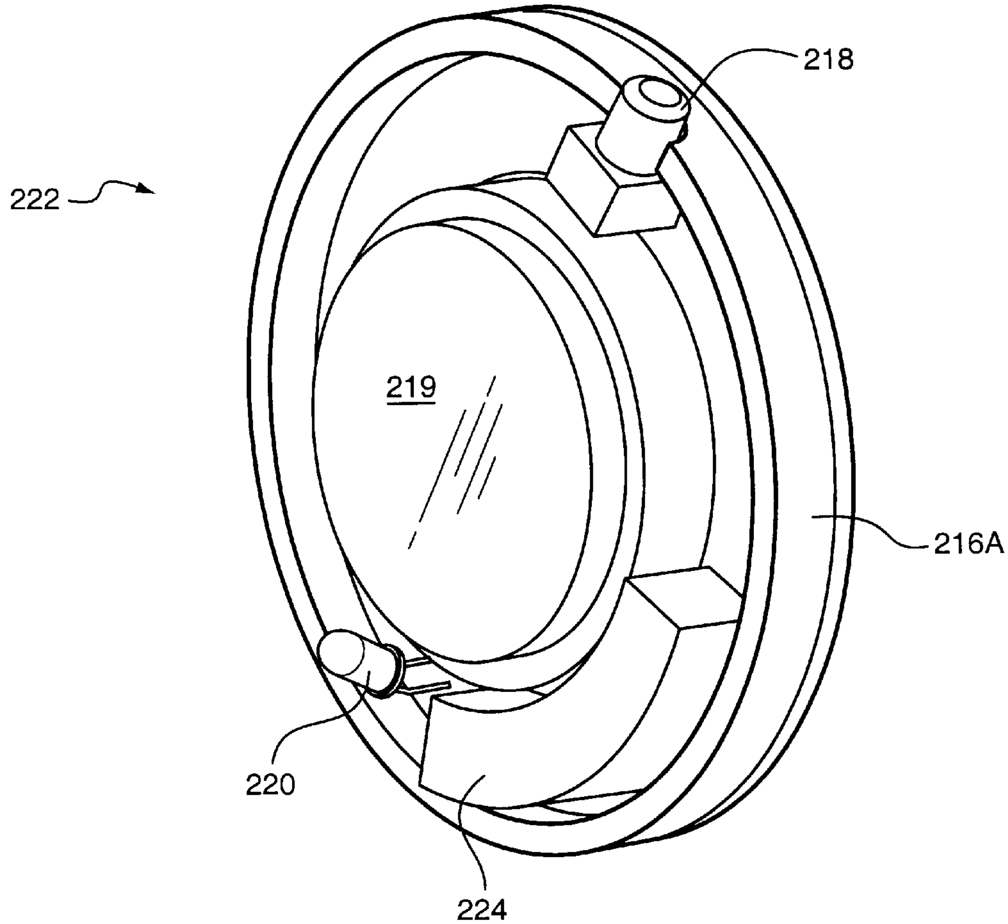


FIG. 6

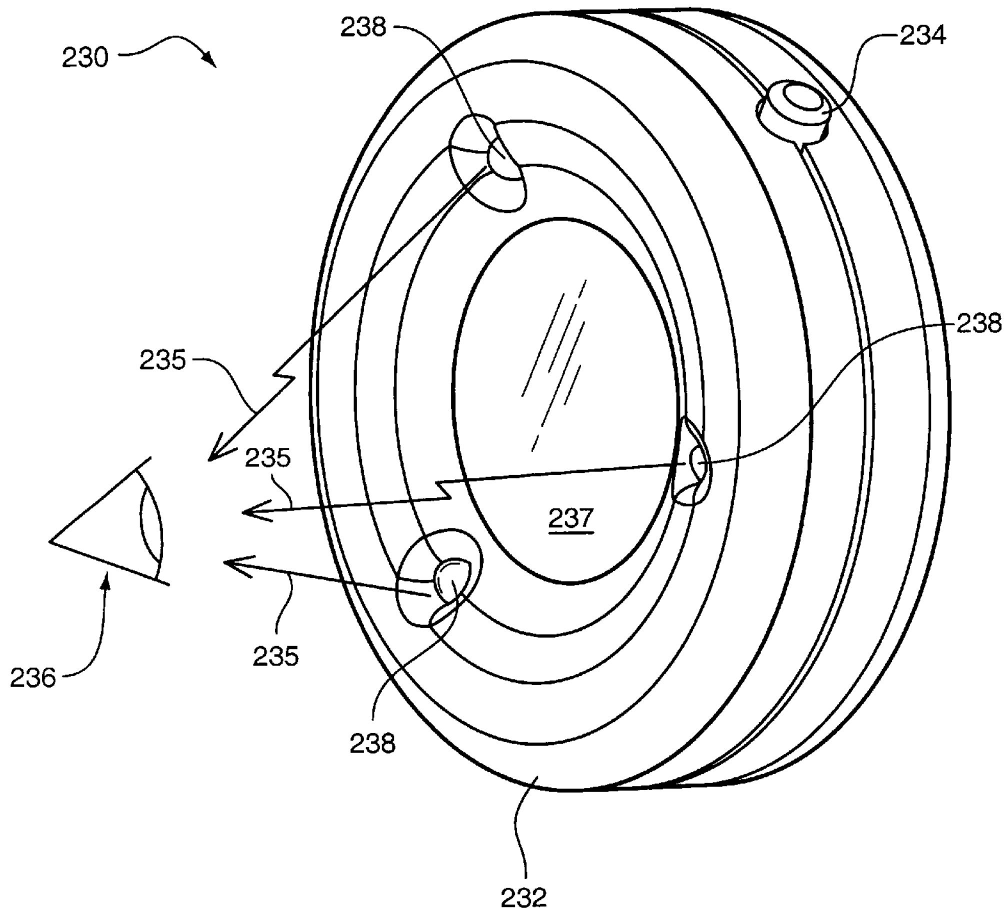
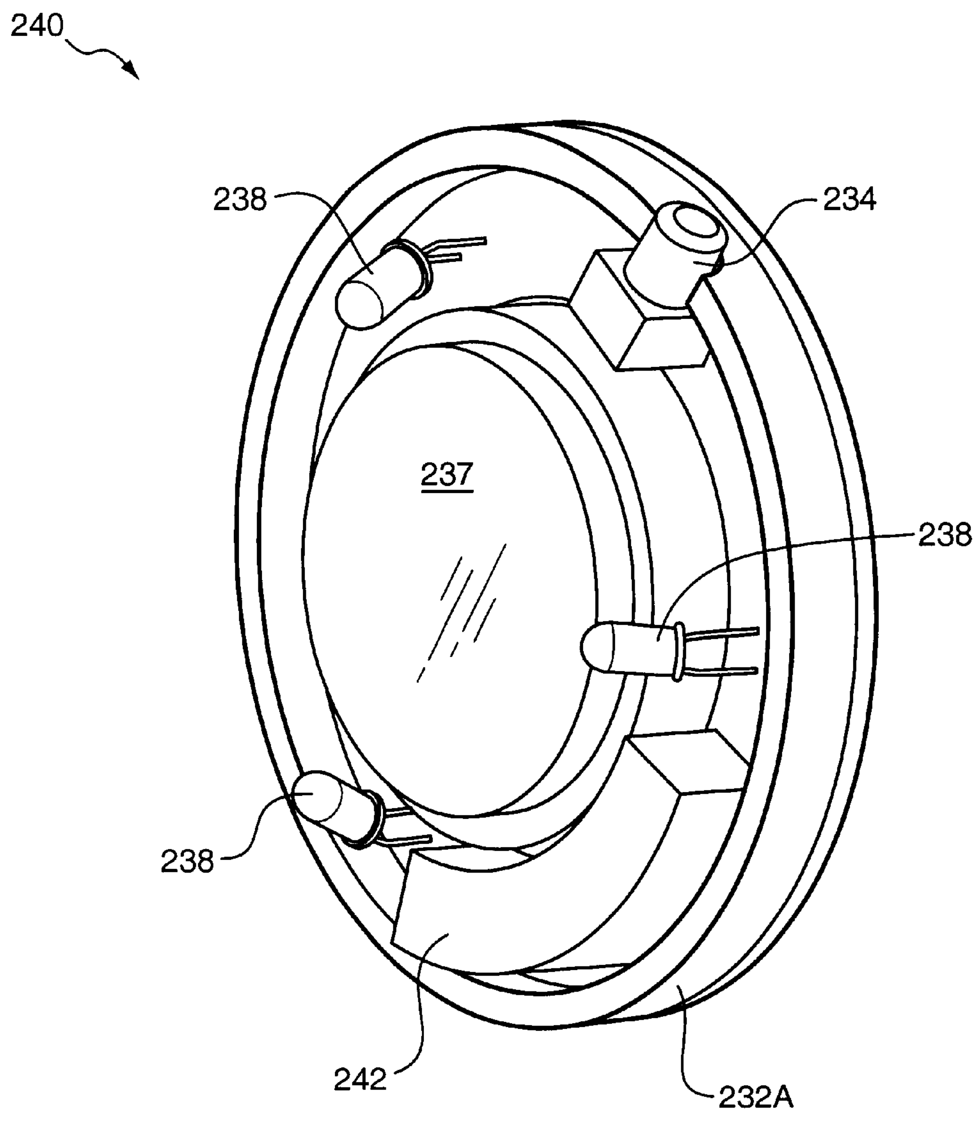


FIG. 7



HAND-HELD OPHTHALMIC ILLUMINATOR

RELATED APPLICATIONS

This application is a continuation-in-part of, and claims priority to, commonly owned U.S. application Ser. No. 09/175,796, filed on Oct. 20, 1998 now abandoned and hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Ophthalmologists, optometrists and other medical doctors and health care professionals frequently are required to examine the cornea of the human eye for scrapes, abrasions, dirt or foreign bodies. The current technology utilizes a battery operated hand-held penlight illuminator in conjunction with a solution of Sodium Fluorescein. An example of an existing prior art device is the Solan Blu-Slit® manufactured by Xomed Surgical Products, Inc. of Jacksonville, Fla. The penlight illuminator typically uses conventional batteries as a power source and an incandescent or halogen light bulb. A cobalt blue filter attached over the lamp filters the white light emitted by the bulb to produce a blue beam. This blue beam is used to illuminate the patient's eye after application of the Sodium Fluorescein dye.

The fluorescein dye, which is typically impregnated in sterile paper, is administered by the physician in the following manner. The patient's upper eyelid is retracted and the sodium fluorescein impregnated paper applicator is made to contact the bulbar conjunctiva of the eye at the temporal side. The applicator is removed and the eyelid is opened and closed several times to allow diffusion of the dye over the entire conjunctival area and cornea.

The fluorescein dye tends to accumulate in epithelial defects of the cornea and illumination of the eye will cause the defect to fluoresce vividly. By using blue filtered light to illuminate the eye of the patient, which has been dyed with fluorescein, this fluorescence is most observable. The amount of fluorescence observable is proportional to the accumulation of the fluorescein or the magnitude of the defect. However, the magnitude of the fluorescence is also proportional to both the intensity and spectral purity of the light illuminating the patient's eye. In other words, a brighter and more spectrally pure beam will show more detail and thus is more desirable to the physician.

SUMMARY OF THE INVENTION

The subject of this invention is a device which is used to illuminate a patient's eye that has been administered with a fluorescent dye for the purpose of examining the eye for epithelial defects. The invention in its simplest form utilizes four components: a battery, an electrical resistor, an electrical switch and a blue light emitting diode.

BRIEF DESCRIPTION OF THE INVENTION

FIG. **1** depicts an electrical schematic of an ophthalmic illuminator utilizing a blue LED source, according to the invention.

FIG. **2** shows an alternative ophthalmic illuminator of the invention.

FIG. **3** shows a perspective view of a hand held eye illuminator constructed according to the invention.

FIG. **4** shows a perspective view of another hand held eye illuminator constructed according to the invention.

FIG. **5** shows a perspective interior view of the illuminator of FIG. **4**.

FIG. **6** shows a perspective view of another hand held eye illuminator constructed according to the invention.

FIG. **7** shows a perspective interior view of the illuminator of FIG. **6**.

DETAILED DESCRIPTION OF THE INVENTION

In schematic **10** of FIG. **1**, when the switch **12** is closed electrical energy from the battery **14** flows through the circuit **10** and causes the blue LED **16** to produce blue light **18**. The resistor **20** is used to limit the current that is applied to the LED **16** as per the manufacturer specifications which is typically 20 to 30 milli-amps. Certain LED's have an internal resistor **20** built into the LED package, as known in the art. Battery **14** voltage is typically four to twelve volts DC. The blue LED's are for example manufactured by both CREE and NICHIA and typically produce illumination on the order of 0.50 candle or more at a wavelength of 450 nano-meters with a typical bandpass of 50 nm. These LED's typically are comprised of Gallium Nitride on a Silicon Carbide substrate (NICHIA) or just Silicon Carbide (CREE). In one embodiment of the invention, resistor **20** is not required; rather, battery **14** serves as the resistor for circuit **10**.

The ophthalmic illuminator as depicted in FIG. **1** is superior to the current incandescent technology for the following reasons: first, the blue LED **16** emits more illumination in the desired blue spectrum (425 to 475 NM) than the filtered incandescent lamp which results in more fluorescence of the fluorescein dyed eye **22** and thus has better sensitivity; second, the blue LED **18** uses less power than a blue optically filtered incandescent or halogen bulb so that the battery power source **14** should last significantly longer; third, the invention is simpler to the prior art technology in that there is no need for a blue bandpass optical filter.

There are a number of enhancements that can be made to the basic invention as shown in FIG. **1**. First, a lens **24** may be added close to the LED **18** between the LED **18** and the patient's eye **22** to maximize the light collection efficiency of the system. A reflector could be added separately or used in conjunction with a lens for the same purpose. Second, the electrical circuit **10** could be modified with a pulse means **13** to cause the blue LED **16** to operate in a pulsed mode instead of continuous mode. This would enable higher peak current to be applied to the blue LED **16** to produce the appearance of an even brighter beam and hence more fluorescence sensitivity to the physician. Third, a simple magnifier tens could be added to the device **10** to provide a magnified view of the patient's eye **22** to the physician or user (see FIG. **2**). The fixed magnification of this lens would typically be chosen to between 1.5× and 15×. Typically the magnifications are between 2× and 10×. A variable focal length zoom lens could also be substituted as the simple magnifier to provide a range of magnification for the physician user.

The invention described here can be manufactured as a stand-alone hand held device or incorporated into other ophthalmic diagnostic instruments such as a table-top or hand held slit lamp.

FIG. **2** shows an alternative system **100** of an ophthalmic illuminator constructed according to the invention. FIG. **2** also shows the patient's eye **102** illuminated by blue light **104** generated by the diode **106**. The light **104** is preferably coupled to the eye **102** through an optical lens (or reflector, known in the art) **108** to increase the blue light energy at the eye **102**.

System **100** preferably integrates to a common housing **110** such that a user can hold the system **100** during, treatment of the eye **102**. Although not shown, the circuit of FIG. **1** can reside within the housing **110**; and a button **112** can be used to operate the switch **12** (FIG. **1**) which in turn causes the generation of light **104**. The button **112** is for example operated by a physician's finger.

System **100** can also include a magnifier **114** coupled to the housing **110** such that the physician's eye **116** can view the patient's eye **102** with increased magnifier. A zoom lens (known in the art can replace the magnifier **114** such that selective control of that magnification is achieved.

FIG. **3** shows a hand held illuminator **200** constructed according to the invention. Illuminator **200** has an annular housing **202** that contains circuitry such as schematic **10** of FIG. **1**. A button **204** is arranged with housing **202** such that a user may press to generate light energy **206** to illuminate a patient's eye **208**. Button **204** for example functions as switch **12**, FIG. **1**. A user of illuminator **200** may then peer through aperture **210**, along path **212**, to conveniently view patient eye **208**. Aperture **210** may optionally include a magnifying lens, or zoom lens, according to preferred embodiments of the invention. Sources for generating energy **206** include a LED such as LED **16**, FIG. **1**. Sources may be integrated with housing **202** in various ways as illustrated below. In accord with the invention, energy **206** delivered from sources (e.g., LEDs) may be considered a transmit channel while path **212** may be considered a receive channel. In one embodiment of the invention, the energy is blue light that creates green fluorescence from the eye; and thus a lens in aperture **210** is preferably coated with a green filter thin film coating to filter light along the receive channel.

FIG. **4** shows a hand held illuminator **214** constructed according to the invention. Illuminator **214** has an annular housing **216** that contains circuitry such as schematic **10** of FIG. **1**. A button **218** is arranged with housing **216** such that a user may press to generate light energy **221** to illuminate a patient's eye **217**, as above. Button **218** for example functions as switch **12**, FIG. **1**. Illuminator **214** further has an optical magnifier in the form of a lens **219** for a user to peer through to conveniently view patient eye **217**. A LED **220** integrates with housing **216** to generate light energy **218**. LED **220** may optionally include a focusing lens, though one is not required.

FIG. **5** shows an interior portion **222** of illuminator **214**. Specifically, interior portion **222** shows further features of button **218** and LED **220**, each connected in circuit to internal battery **224**. Battery **224** for example operates as in battery **14**, FIG. **1**, to power LED **220**. Element **216***a* forms the back of housing **216**.

FIG. **6** shows a hand held illuminator **230** constructed according to the invention. Illuminator **230** has an annular housing **232** that contains circuitry such as schematic **10** of FIG. **1**. A button **234** is arranged with housing **232** such that a user may press to generate light energy **235** to illuminate a patient's eye **236**. Button **234** for example functions as switch **12**, FIG. **1**. Though not required, illuminator **230** further has an optical magnifier in the form of a lens **237** for a user to peer through to conveniently view patient eye **236**. A plurality of LEDs **238** integrate with housing **232** to generate light energy **235**. Each of LEDs **238** may optionally include a focusing lens, though one is not required. Although three LEDs **238** are shown, more or fewer LEDs can be used without departing from the scope of the invention.

FIG. **7** shows an interior portion **240** of illuminator **230**. Specifically, interior portion **240** shows further features of button **234** and LEDs **238**, each connected in circuit to internal battery **242**. Battery **242** for example operates as in battery **14**, FIG. **1**, to power LEDs **238**. Element **232***a* forms the back of housing **232**.

In addition to the advantages apparent in the foregoing description, the invention may have application in other fields outside of ophthalmology. For example, in the field of dermatology, an illuminator of the invention may be used to illuminate skin, along the transmit channel, and to view the skin along the receive channel.

In view of the foregoing,

What is claimed is:

1. An ophthalmic illuminator, comprising:

a battery;

an electrical resistor in circuit with the battery;

an electrical switch in circuit with the resistor;

at least one light emitting diode, in circuit with the switch, for generating blue light energy in response to activation of the switch; and

a fluorescein dye administered to a patent's eye, the dye being responsive to the energy to fluoresce.

2. An illuminator of claim **1**, further comprising an optical element disposed between the diode and the eye to increase blue. light energy reaching the eye.

3. An illuminator of claim **2**, wherein the element is one of a lens or a powered reflector.

4. An illuminator of claim **1**, further comprising electronics for cyclically energizing the diode, wherein the diode generates the blue light at a predetermined frequency in order to increase the illumination appearance of the energy.

5. An illuminator of claim **1**, further comprising a housing for integrating the battery, switch, resistor and diode into an integral package, the diode being positioned to generate blue light energy away from the package, and further comprising a magnifier lens coupled to the housing for providing a magnified image of the patient's eye to a user of the illuminator.

6. An illuminator of claim **5**, wherein the magnifier lens has a magnification between about 1.5× and 15×.

7. An illuminator of claim **1**, further comprising a housing for integrating the battery, switch, resistor and diode into an integral package, the diode being positioned to generate blue light energy away from the package, and further comprising a zoom lens coupled to the housing for providing a selective magnified image of the patient's eye to a user of the illuminator.

8. An illuminator of claim **1**, wherein the dye comprises Sodium Fluorescein.

9. An illuminator of claim **1**, wherein the diode comprises Gallium nitride.

10. An illuminator of claim **1**, wherein the diode comprises Silicon Carbide.

11. An illuminator of claim **1**, further comprising a substantially annular housing constructed and arranged with a button for operating the switch, a user of the illuminator viewing through an aperture in the housing to view the patient's eye.

12. An illuminator of claim **11**, further comprising a magnifying lens constructed and arranged with the aperture, for magnifying the patient's eye for the user.

13. An illuminator of claim **11**, further comprising a plurality of light emitting diodes, each diode responsive to activation by the button to generate the blue light.

14. An illuminator of claim **1**, further comprising a focusing lens constructed and arranged with at least one of the diodes to focus the blue light energy onto the patient's eye.

15. A method for illuminating a patient's eye for ophthalmic examination, comprising the steps of: administering a fluorescein dye to the patent's eye, illuminating the eye with blue light energy generated from one or more light emitting diodes, the dye being responsive to the blue light energy to fluoresce, and viewing the patient's eye, and viewing the eye while the dye fluoresces.

16. A method of claim **15**, wherein the step of administering a fluorescein dye comprises administering Sodium Fluorescein to the eye.

17. A method of claim **15**, wherein the step of illuminating the eye comprises pressing a button on an annular-shaped housing, and wherein the step of viewing the patient's eye comprises viewing through a center of the housing.

18. A method of claim **15**, wherein the step of illuminating comprises generating light from a plurality of light emitting diodes.

19. A method of claim **15**, wherein the step of viewing comprises viewing through a magnifying lens coupled with a housing that supports the diodes.

20. A method of claim **15**, further comprising the step of focusing the blue light energy onto the patient's eye.

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