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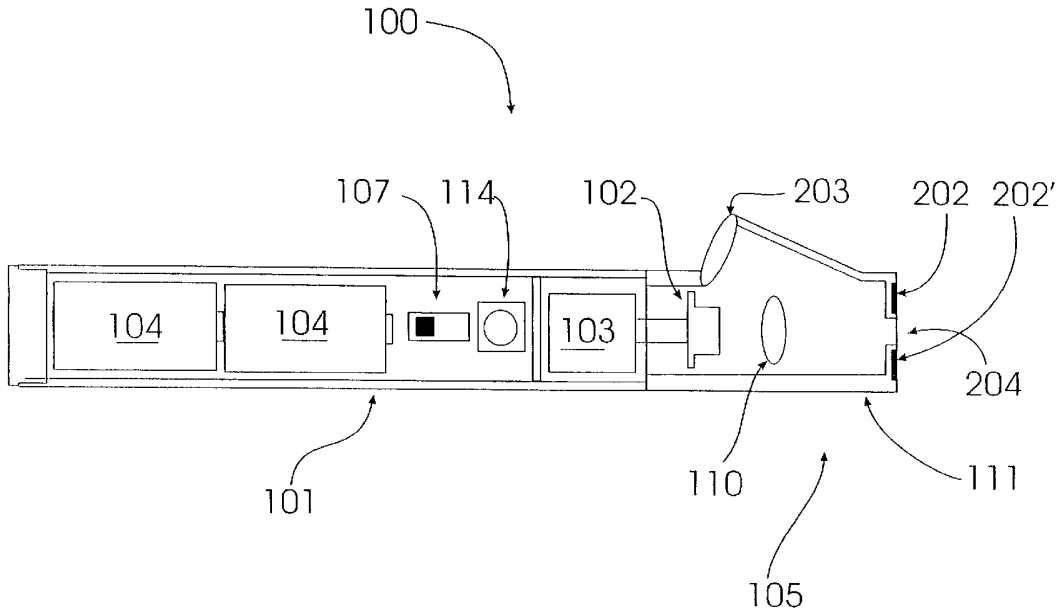
(54) Title: HAND-HELD APPARATUS FOR SKIN TREATMENT WITH INTENSIVE LIGHT



(57) Abstract: An apparatus for skin treatment comprising a casing of a size which is easily hand-held, a laser system or other intensive light system inside the casing including a light source with an electronic circuit, the light source arranged such that produced radiation from the light source exits the casing through an exit system of the casing, wherein the exit system comprises a safety device that only allows firing of the light source when the exit system is touching the skin to be treated and the direction of the radiation is directed onto the skin. Furthermore, the exit system is configured to create a substantially closed volume in combination with the surface of the subject to be treated in order to prevent the intensive light from the light source to escape from this volume.

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Hand-held apparatus for skin treatment with intensive light

FIELD OF THE INVENTION

The present invention relates to a hand-held laser apparatus, preferably for depilation.

BACKGROUND OF THE INVENTION

In order to permanently remove hair, it is well-known to damage the hair roots by laser radiation. In US patent no. 5 632 741 by Zavislan and Thomson, a depilation system is disclosed, where a hand piece is used for directing a laser beam into the root structure of a hair. The hand piece is connected to a large CO_2 laser generating pulses with pulse energy of 25-250 mJ thereby achieving a temperature of more than 100° C in the root of the hair.

Laser depilation apparatuses according to prior art are large and expensive and designed for use by physicians and not suitable for private use in the user's home. For example, the price for typical laser epilators starts at 50,000 US-dollars. It would be desirable to have a depilation apparatus, which is smaller and more affordable than the large systems described above. In this case, however, it has to be assured, that the system is safe even for users without a thorough education in using laser radiation, because the laser radiation necessary to remove hair has energy and a wavelength that may cause damage, if directed into an eye or onto dark skin.

Small hand-held lasers are generally known, for example as disclosed in US patent no. 5 697 700 by Huang for use as a handy pointer. A laser with a higher power is disclosed in US patent no. 6 370 173 by Martin, wherein the laser has a heat sink and a ventilator in order to dissipate the produced heat by the laser diode with one to sixty watts or more. The ventilation system and the rather high power of the system result in a heavy, not very handy device. For low level laser treatment (LLLT), especially for tissue healing at a tissue depth of several centimetres, a hand-held laser device is known from US patent no. 5 464 436 by Chadwick. Other hand-held lasers for acu-

puncture are commercially available from numerous companies, for example the Danish company Unilaser®. These lasers - not designed for hair removal – may accidentally be fired in directions other than the skin to be treated, which implies a high risk of injury to the user and bystanders, for example when laser light is directed towards the eye of a person either directly or via a reflecting surface. In addition, strong absorption of laser radiation in the skin may cause skin burns. Dark skin absorbs laser light more effectively than fair skin and it is, thus, desirable that the energy of the laser radiation is adjusted according to the pigmentation of the skin to be treated.

Most laser systems used for dermatological treatment are used by experts as mentioned above. Safety measures for these systems are primarily constructed to protect the expert during the professional handling of the device. Use of a laser system by private persons without any thorough instruction and eventually even with a person's tendency to experiment with laser light requires a much higher degree of safety.

For example, a safety arrangement as disclosed in Japanese patent application JP 2000 064455 by Yamazaki Iwao comprising two skin contacts, one on each side of the laser lens, would not be sufficient for thorough protection. For instance, at skin edges, for example near the eye lid, both sensors may touch the skin and allow firing of the laser, whereas part of the lens, which is larger than the detectors, may allow laser light to find its way around the edge of the skin edge. Furthermore, if the laser is not truly normal to the skin, laser light may escape, for example by reflection. Such situations may cause severe damage to the eye, as the laser light may have an intensity that is three orders of magnitude higher than the intensity of direct sunlight. It has also to be recognised as a further dangerous aspect that the wavelength of a laser for skin treatment may be invisible to the eye and would therefore not cause a closing of the eye during illumination.

DESCRIPTION OF THE INVENTION

It is the purpose of the invention to provide a handy laser apparatus for skin treatment that is easily affordable by private users and very safe in handling.

This purpose is achieved by an apparatus for intensive light treatment comprising a casing of a size which is easily hand-held, a light system with an intensive light source inside the casing arranged such that a produced light beam from the light source exits the casing through an exit system, a connection to an electrical power supply to provide power to the apparatus, a safety device functionally coupled to the light system and configured to allow or prevent firing of the light system, wherein a least three detection devices in a non-linear arrangement around the light beam at the exit system are coupled to the safety device, the at least three detection devices being capable of detecting the contact of the detection devices with the surface of the subject to be treated, wherein the safety device is configured to only allow firing of the light system when at least three detection devices are in contact with the surface of the subject to be treated. The exit system is configured to create a substantially closed volume in combination with the surface of the subject to be treated if the detection devices are in contact with the surface in order to prevent the intensive light from the light source to escape from this volume.

In the following, the surface of the subject to be treated may be understood as human skin, which solves the purpose of the invention. However, certain embodiments of the invention may be useful for improvements of new and existing light systems, for example laser systems, not only for treatment of human skin but also for other surfaces to be treated by intensive light, such as plastic, leather, wood and metal, the list, however, not being exhaustive. The application may, among others, be marking, engraving, cutting, or welding.

By using three detection devices arranged in a non-linear manner, a much higher safety is obtained than if only two detection devices were used. Using only two detection devices defines a line of contact, such that there exist a danger that light from the intensive light source may escape from the area for treatment outside this line of contact, for example at edges of the skin like eye lids or eye brows. By using three detection devices in a non-linear arrangement, a plane of contact is defined, and the light from the light source is confined between the three detection devices. This results in a

controlled volume in front of the exit region, typically comprising an exit lens. By furthermore requiring that the exit system is configured to create a substantially closed volume in combination with the skin, light is confined within this volume and cannot escape from it.

An example for the arrangement of detection devices is a location of the detection devices in the most forward part of the apparatus, for example at the proximal end of a tube-like system, where this part has to touch the surface in order for the laser to fire. At the same time, this forward part closes the volume around the surface region to be treated and no laser light can escape uncontrolled from this volume. This reduces the risk for accidents and therefore implies a high degree of safety for the user even when not specially trained to use such devices.

Typically, the light system comprises a laser system, but a high intensity flash lamp system may be used as well. An advantageous laser diode or a laser diode array works at a wavelength of between 600 and 1100 nm because the colouring substance of hair, melanin, is especially absorbing in this wavelength region, whereas skin is not, at least if it is not very dark. A typical power of such a laser may be 1W.

Typical laser radiation for removal of hair is in the near-infrared or infrared region. For example, such an apparatus can be provided with a diode laser system involving a diode that emits laser radiation at a wavelength of 800 nm. The wavelength region of between 600 and 1100 nm is advantageous in that the laser radiation is transmitted through several mm skin without substantial heating of the skin. However, the roots of hairs or the hairs themselves absorb the laser radiation resulting in heating of the roots to an extent that the hairs fall out and further hair growth is prevented. The dermatological effect may be removal of hairs from the skin, which requires a temperature of the root of the hair of at least 60°C-70°C. In order to achieve this temperature, a laser power of 80 mW has proved to be sufficient, though, however, higher powers are preferred.

Possible applicable lasers are Rubin laser (ca. 690 nm), alexandrite laser (ca. 780 nm), titanium sapphire laser (ca. 800 nm), and neodymium YAG laser, ND:YVO at 1064 nm.

Alternative dermatological treatment may be removal of acne, tattoos, benign pigmented lesions (for example birthmarks), micro vascular malformations (for example port wine stains), vascular lesions (for example spider veins) or wrinkles. In these cases, it is not always necessary to have a wavelength in the near infrared. Essential is the absorption of the laser radiation at the point of material damage or material removal, such as tissue denaturation. For example, a black tattoo may be removed with any colour of laser radiation, whereas blue and green tattoo colours may best be treated with red laser light. For removal of acne, blue lasers are applicable, for example by blue diode lasers or frequency doubled infrared lasers. For removal of Spider veins, yellow or red lasers are suitable.

Laser radiation with such wavelengths and necessary intensity is dangerous if directed into the eye of a person or applied to dark skin. Therefore, the apparatus according to the invention foresees a safety device such that it is assured that the laser radiation is directed onto the skin and does not escape from the region of treatment.

In a concrete embodiment, the detection devices comprise mechanical pressure switches arranged to be activated when the exit system of the apparatus is pressed against the surface of the subject to be treated, and wherein the safety device is configured to only allow firing of the light source if at least three switches in non-linear arrangement are activated. As the skin of humans is rather soft, this is a simple and cheap embodiment to assure a confinement for the light rays, because the exit system has to be pressed against the skin in order to activate the pressure switches.

In a further embodiment, the detection devices comprise pressure sensors and the safety device is configured to only allow firing of the light system if the pressure exerted on the pressure sensors is higher than a predetermined level. Preferably, the pressure is in a direction substantially normal to the surface of the subject to be treated.

In a further embodiment, the detection devices comprise temperature sensors and the safety device is configured only to allow firing of the light system if the temperature at the surface of the surface of the subject to be treated as measured with the temperature sensor is within a predetermined range of temperatures.

In a further embodiment, the detection devices comprise resistivity sensors and the safety device is configured only to allow firing of the light system if the electrical resistance at the surface of the subject to be treated as measured with the resistivity sensor is within a predetermined range of resistance, for example between 10 k and 1 M .

In a further embodiment, the detection devices comprise conductivity sensors and the safety device is configured to only allow firing of the light system if the conductivity at the surface of the subject to be treated as measured with the conductivity sensor is within a predetermined range of conductivity.

In a further embodiment, the detection devices comprise pH sensors and the safety device is configured to only allow firing of the light system if the pH at the surface of the subject to be treated as measured with the pH sensors is within a predetermined range of pH.

In a further embodiment, the apparatus comprises electrodes configured to measure the impedance of the surface during contact with the surface for identification of the type of surface. This method is especially useful for determining, whether the illuminated surface indeed is human skin. In a preferred embodiment, such measurements of impedance are performed for at least two different AC frequencies and rather at three different frequencies. The impedance can vary among different persons, however, the ratio between impedances at different frequencies, for example at 1 kHz and 10 kHz, and eventually also including 100 kHz, is rather constant and a good measure for, whether the surface is human skin or not. For example, at least one electrode may be used for transmitting an AC signal to at least one other electrode. The signals are ana-

lysed, for example including band-pass filtering and processing in a microprocessor. The safety system may be configured to only allow light illumination, if the analysis reveals that the surface is part of human skin. The analysis may imply comparison to predetermined values of possible impedances for human skin.

The impedance of skin and the impedance of hair are different. Therefore, the impedance of skin in which hair is embedded is different from skin that does not have hairs. Therefore, in a further embodiment, the measurement of impedance includes evaluation for impedance changes due to presence of hair between the electrodes. In this case, the safety device may be configured only to allow firing of the light system in case that the evaluation system reveals the surface to be a surface of human skin and reveals the presence of a hair in the skin between the electrodes.

In a further embodiment, the apparatus comprises a light detector configured to receive light from the light source reflected from the surface, the light detector being functionally coupled to the safety device preventing the light system to fire when the intensity of the reflected light detected by the light detector is outside a predetermined range of intensity. The reflection of light from human skin is determined by the darkness of the skin, such that dark skin reflects less light and absorbs more. However, the increased absorption in the dark skin may cause damage to the skin. Therefore, the apparatus according to the invention uses the reflectivity of the skin to determine whether there is a risk for skin damage due to a skin colour that is too dark. In case that the skin is recognised as being too dark, the safety device will prevent firing of the laser or other high intensity light source.

In a further embodiment, the light detector device is functionally connected to an intensity adjustment device configured to automatically adjust the intensity of the light from the light source in dependence of the intensity in the light detector of the reflected light from the surface. As dark skin may be damaged more easily than light skin during laser irradiation due to the reduced reflectivity of radiation, an intensity adjustment device is increasing the safety of the device during use, as the intensity of the laser radiation is adjusted according to the pigmentation of the skin to be treated.

In practice, the apparatus is configured to treat the intensity of the reflected radiation as being indicative of the degree of pigmentation of human skin and the intensity of the laser radiation is automatically adjustable in relation to a predetermined relationship between degree of skin pigmentation and intensity of laser radiation. Such a predetermined relationship may be stored as a table or calculated during use in accordance with a mathematical model, for example an analytical mathematical expression.

In a further embodiment, the apparatus comprises an additional radiation source, preferably a light emitting diode or an additional laser, and a radiation detector system for detection of radiation from the additional radiation source reflected on the surface of the subject to be treated. The radiation detector system is functionally coupled to the safety device, which only allows the light source to fire when the intensity of the reflected radiation from the additional radiation is within a predetermined range of intensity. In this case, a wavelength of light may be chosen that is most suitable for reflectivity measurements.

Especially relevant in this connection is the fact that absorption and reflectivity in human skin is dependent on the wavelength. Using different wavelengths, in other words, different colours, more certain identification may be achieved of whether the surface is human skin. Therefore, in a further embodiment, the radiation detector system is configured to detect and measure radiation with at least two different radiation frequencies. The apparatus may have means for calculating the relative intensities between the reflected radiations at the two different radiation frequencies for identification of the type of surface of the subject to be treated. The additional radiation source may emit light at two different frequencies or just white light. The detector system may contain two detectors for measuring two different wavelengths, for example by having corresponding colour filters. The ratio between the measured intensities at the two wavelengths, for example 400nm and 700 nm, may be calculated and compared to tabulated values before the light source is allowed to fire. This measurement also is suitable to determine, whether the skin is of a dark type having a higher risk for radiation damage.

In a further embodiment, the additional radiation source is configured to emit frequency modulated radiation and the radiation detector system is configured to detect this frequency modulated radiation in order to filter out background radiation. This is advantageous in order to reduce the influence from the high intensity light source.

Advantageous, the radiation source and the radiation detector system are configured to use an individual modulation frequency for each of the different radiation frequencies. In this case, colour filtering may be avoided and a single radiation detector may be sufficient for mutual discrimination of the two colours.

Wavelengths suited for such kind of measurements are for example 500nm, 550nm and 650 nm. Blood has a high absorption at 550nm. Therefore, a comparison with the relatively low absorption at 560nm reveals, whether the surface indeed is skin with an intact blood circulation. Also, it should be emphasised that blood vessels in skin are more concentrated around hair roots. This method may therefore also serve for identification of regions containing hair.

Alternatively, wavelengths around the absorption resonances of water may be used. For example, measurements may be performed at 2940nm and compared to reflectivity at 2500nm and 3500nm. The ratio between the reflectivity at different wavelengths reveals, whether the surface contains water.

If a transparent medium, like a prism, transport light under an angle larger than the angle for total internal reflection, an evanescent wave will occur along the outside of the medium. If this medium, for example a prism, is in contact with the skin of a human, the difference between the indices of refraction is reduced and light can leak out of the prism. By this, the internal reflection is reduced, which can be detected by a detector. This method can therefore also be used for determining, whether the prism – and by that the apparatus – indeed touches the skin. Therefore, in a further embodiment of the invention, the detection devices comprise a further light source, a prism configured to be in contact with the surface of the subject to be treated, and a photodetector, wherein the further light source is arranged to transmit light through the

prism under an angle in excess of the critical angle, wherein the detector is coupled to the safety device, the safety device being configured to prevent firing of the light source if the intensity of the reflected part detected by the photodetector is not reduced due to leaking light out of the prism at the contacted surface of the subject to be treated.

The apparatus according to the invention may be powered through a cord by an external power supply, for example connected to the public electricity system. However, for simplicity, the power supply is preferably a battery system inside the casing, because this is the most convenient configuration for users, especially under travelling conditions.

In order to achieve a well-defined conductivity, resistivity, pH or reflectivity on the surface of the subject to be treated, preferably skin, the surface may be exposed to a certain liquid, for example sprayed on the surface or applied to the surface by a dispensing pen. This way, the certain liquid acts as an additional safety factor, because application of the liquid is necessary for laser irradiation. However, it has to be assured that the liquid only in combination with the skin results in parameter ranges that are required for allowing the light source to fire. Such a liquid may be coloured in order to mark the region to be illuminated. The liquid may also be provided with substances that have a cooling effect, which may be felt as pleasant by the user. Further dermatologically advantageous ingredients may be contained in such a liquid for optimum convenience for the user.

For example such a liquid may be used in a kit for treatment with a laser or other intensive light system, the kit comprising an apparatus as described above and a liquid for application to the surface of the object to be treated, wherein the liquid has at least one from the group consisting of a preselected marking colour, conductivity, resistivity, pH or reflectivity, or a cooling effect, when applied to human skin and measured in combination with human skin.

The laser may be a laser diode, but the light source is not restricted to laser diodes. The laser system may comprise a single laser diode resulting in a single laser spot or a laser diode array for creating a line of radiation, which on the one hand is easier to handle for the user and on the other hand involves a faster result due to the larger spot. In case a laser source with a spot-like, for example circular, beam profile is used, a line focus may be obtained by focusing with for example a cylindrical lens, anamorphic prisms or diffractive optics.

In case the laser is mounted close to the surface of the subject to be treated, the direct spot from the laser may be used for the dermatological treatment. However, it is preferred that the depth of the region to be treated can be set prior to the treatment, because different kinds of dermatological treatment may require different depths. Therefore, it is preferred that a focusing lens is arranged in front of the laser, typically in the exit system. Using a focusing lens has an intrinsic security aspect. As the laser radiation is largely divergent after the focus near the exit region, the light power per area decreases as the square of distance from the focus. This implies that already after a relatively short distance from the apparatus, the danger from the laser radiation is decreased substantially.

For hair removal, the focus of the laser may be adjusted to 0.5 - 5 mm below the skin surface. If the laser treatment is used for hair of the beard, the required depth may be as large as 5 mm, though typically the adjusted focus depth in the skin is 1-4 mm, preferably 3 mm. However, the depth of the focus may be chosen in dependence of the wavelength, because the effect of scattering in the skin leading to broadening of the laser beam is dependent on the wavelength.

In a further embodiment of the invention, the focusing lens - or focusing lens system - may be adjustable such that the focus can be varied within a range of depth in the subject to be treated. Alternatively, the focusing lens system may be exchangeable, eventually in combination with an exchangeable exit system.

The apparatus according to the invention may for some embodiments cover the illuminated spot such that the user is not able to see the treated region clearly. In order to take this aspect into account, the invention in a further embodiment foresees a magnifying lens attached to the casing and directed towards the surface spot for laser treatment. The magnifying lens may be coated with a film or dyed with a colour such as to prevent or strongly attenuate the transmission of reflected laser light.

It is important that the strong laser light is not accidentally directed into eyes, which as a result may be damaged leading to blindness. Therefore an extra security feature may be incorporated. This security feature being an additional switch being arranged resiliently with counter force such that the switch may be pressed but not locked in the pressed state, wherein the apparatus is configured only to be able to fire the light source when the additional switch is pressed. Thus, the user has to press the finger on the switch in order to use the apparatus according to the invention. As soon as the finger is released, the switch returns by the resilient force back to the original position where no laser irradiation or other intensive light irradiation is possible.

In order to signal the powered state of the apparatus, it may have a main switch for the main power supply and a main control lamp, which lights up when the main switch is turned on.

Apart from the main control lamp, which indicates the general power state, the apparatus may comprise a light source control lamp, which is illuminated when the light source is firing. For example, the light source control lamp may be a Teflon tip in the exit system, the Teflon tip confining the light near the treatment spot on the surface. Thus, the tip in the exit system is illuminated by the light source or laser radiation and indicates clearly to the user, that the light source is firing and also where the illuminated spot is.

When not in use, the exit lens and at least part of the apparatus may be protected against dust and dirt by a cover. By covering the exit system, laser radiation or other intensive light is prevented from exiting the exit system, which is a further safety fac-

tor. Preferably, the cover is locked to the apparatus with a locking mechanism, such that the cover is only demountable after unlocking of the locking mechanism. Such a locking system may advantageously comprise an alphanumerical code lock or a code lock based on push buttons of different colours.

A code lock may also be used in connection with a start-up procedure for the laser or other intensive light source, such that a code has to be entered in order to fire the light source. As an additional safety measure, the apparatus according to the invention may be configured to require re-entering of the code in case that the apparatus has been lifted away from the skin and not been fired during a predetermined time interval, for example one minute. The latter ensures that the apparatus is not staying in a ready state, where, eventually, children may accidentally find the apparatus and use it for playing and accidentally get injuries.

The apparatus according to the invention may be equipped with a display for displaying the current status, eventual alarm messages or other relevant messages to the user.

Optionally, the apparatus according to the invention may be equipped with a computer interface for programming an internal microprocessor in the casing of the apparatus. The interface may also be used for read out of digital data, for example in connection with maintenance and repair of the apparatus. Such a microcontroller may be used for the above mentioned control of different ranges as well as surveillance of the functioning of the apparatus generally. For example the microcontroller may be used for controlling and monitoring power for the laser, monitoring temperature of the apparatus in order to prevent overheating, monitoring humidity.

SHORT DESCRIPTION OF THE DRAWINGS

The invention will be explained in more detail with reference to the drawing, where

FIG. 1 shows an apparatus according to the invention,

FIG. 2 shows an alternative embodiment of an apparatus according to the invention,

FIG. 3 shows a diagram of a safety circuit.

DETAILED DESCRIPTION / PREFERRED EMBODIMENT

In FIG. 1, an apparatus 100 according to the invention is shown. It comprises a casing 101 of a size that is easily hand-held. Such a size may typically be between 1 cm and 5 cm in diameter and with a typical length of between 5 cm and 30 cm. The casing 101 contains a diode laser system including a laser diode 102 with an electronic circuit 103. The electronic circuit may as well be part of the safety device and contain the aforementioned microprocessor. As an electrical power supply to provide power to the apparatus, a battery 104, for example rechargeable, is enclosed in the casing 101 and fixed by a fixing arrangement 109. Alternatively, the power may be supplied from an external power supply connected to the apparatus 100 through an electrical cord.

The casing 101 is closed at the back end by a rear cover 106 that is screwed into the casing 101. In order to activate the laser, a main switch 107 has to be activated. When activated, a power indicator 108, for example a light emitting diode, indicates that the power has been switched on.

The laser 102 is arranged such inside the casing 101 that produced laser radiation from the laser 102 exits the casing 101 through an exit system 105. A laser used in the apparatus can be a continuously firing diode laser as well as a pulsed laser, for example with pulse duration of 5-100 ms.

The exit system comprises an optical lens system 110 for focusing the laser radiation from the laser 102. After being focused by the lens system 110, the laser radiation traverses a safety tube system 111. The safety tube system 111 is coupled to a number, for example four, of conductivity switches 112, which are activated when the exit system 105 is pressed against the surface of the subject to be treated. A fourfold detector system positioned around the laser radiation 116 is illustrated in a side view and a front view in in FIG. 4. Activation of the conductivity switches 112, as illustgrated in FIG. 1, results in powering of the laser system such that the laser 102 is only able to emit radiation when the exit system 105 is touching the surface of the subject to be

treated, where all sensor pads of the conductivity switches 112, situated around the laser beam exit aperture 113, have to simultaneously touch the surface of the subject to be treated thus assuring an orientation of the apparatus 100 such that the laser radiation is directed towards the surface, for example normal to the surface.

As an alternative to the conductivity switch 112, the safety tube system 111 may be used in connection with temperature sensors, pH sensors, mechanical pressure switches, pressure sensors, a resistivity sensors or impedance sensors coupled to a safety deivce only allowing the laser to fire when the measurements by the sensors are within a predetermined range all sensors are contacting the surface of the subject to be treated.

In order to provide the laser 102 and the electronics 103 with power, an additional switch 114 has to be activated, which is an additional safety aspect for preventing injuring mistakes during usage of the apparatus. Such an additional switch 114 may be arranged resiliently with counter force such that the switch 114 may be pressed but not locked in the pressed state. This switch assures that the user indeed has to deliberately activate the apparatus for firing the laser.

Once the measurements with the sensor or sensors are within the predetermined range, and/or the mechanical additional pressure switch 114 is activated, the laser may fire. Since the laser radiation is entirely encapsulated by the safety tube 111, the user is unable to see the radiation and eventual accidents are prevented. Therefore a further light emitting diode 115 or other indicator is used to indicate when the laser 102 is actually firing.

An alternative embodiment is shown in FIG. 2. The apparatus 100 comprises two batteries 104 inside the casing 101 and a non-latching switch 114 in addition to a main switch 107 for power supply.

The lens system 110 may be constructed adjustable in order to be able to vary the distance from the exit system 105 to the focus of the laser radiation inside the skin of a patient, for example at a depth of 0.5 mm to 5 mm.

In the shown embodiment, the exit system 105 is equipped with at least three sensors 202, 202', which, for example, may be pressure sensors, temperature sensors, pH sensors, conductivity sensors, resistivity sensors, impedance sensors or a combination thereof. Having at least three sensors 202, 202' to touch the surface of the subject to be treated, it is assured that the apparatus 100 according to the invention is held in an orientation which is to a high degree normal to the surface, for example the skin of the user. The latter assures that the laser radiation is indeed directed onto the surface or into the subject, for example the skin, to be treated and confined within the volume around the area on the surface to be treated.

In order to illustrate the importance of at least three detector, a situation is illustrated in FIG. 5, where, due to a missing of a multifold detector system, the apparatus 100 is allowed to be tilted from the surface of the subject to be treated. Such situation may occur predominantly at edge regions 118 of the skin 119. In this case, as illustrated in FIG. 5, laser light may leak out of the volume 117 with the potential of causing injury, if not a detector system according to the invention is employed. In contrast to this fatal situation, due to the detector system according to the invention, where at least three detectors around the beam have to touch the skin of the human, the situation as illustrated on FIG. 5 would not be possible, because the laser would be prevented from firing.

The apparatus 100 may advantageously comprise a magnifying lens 203 attached to the casing 102 and directed towards the surface spot 204 for laser treatment. Through a magnifying lens 203 in the exit system 105, the user may observe the treatment spot 204. This facilitates the use of the apparatus 100, because the user in a more safe and convenient way may find the spot 204 on the surface of the skin, where a radiation treatment shall be applied, for example the removal of hair.

In FIG. 3, a diagram is illustrated for a safety arrangement. Between the two battery poles 301, 302, electrical power can be extracted – which is indicated with an arrow 303 - for the electronics 103 and the laser 102. However, this is only possible, if the transistor 304, for example a Darlington transistor, is open for current through the collector. In order to open for the collector current, a small emitter current has to flow, which is achieved when the additional switch 201' is closed while, simultaneously, the sensor 305 measures a parameter within a predetermined range. An emitter current of 1 microamp may trigger a collector current of 1 amp for the laser 102 and the electronics 103. A resistor 306 is preferably used for stability reasons, though this is not strictly necessary.

The exit system 105 of the apparatus according to the invention may in addition be equipped with a detector that detects reflected light from the surface at which the laser radiation is directed. Such a detector with corresponding electronics may be included in the safety system of the apparatus. For example, the detector may determine, whether the surface may indeed be the skin of a person. Thus, the reflected radiation has to be within a predetermined range for the laser to continue firing. For example, if there is no reflection at all, the laser is not pointing at a nearby reflective surface or not on a reflective surface with a convenient angle and the laser may be prevented from firing.

By detecting the radiation that is reflected from the skin of the treated person, the type of skin may be determined. A high reflectivity may indicate a skin of light colour, while a low reflection may indicate a darker tan in the skin. A darker skin will typically absorb more radiation than light skin and is therefore subject to a higher risk of damage by the radiation. Therefore suitably, once a detector has measured the reflection from the skin, this measurement may be used in the apparatus according to the invention to automatically calculate and adjust a laser intensity that is convenient for the treatment. However, in case that darker spots on a light skin, for example birthmarks, are to be treated, this function may be omitted.

As an alternative to measuring the intensity of the reflected radiation from the light source, and as illustrated in FIG. 6a, a further light source in the form of a further light emitting diode 601 and a photodetector 602 contained in the exit system 105 may be used for measuring the reflectivity of the skin 118 or other type of surface to be treated. The reflectivity of the surface, for example skin, is depending on the wavelength of the emitted light 603 from the diode 601 and can be used for discrimination of other frequencies in the detector 602, for example discrimination of light from the laser or flash lamp. This feature may be part of the safety system, only allowing the laser to fire, if the reflectivity corresponds to allowed values. The intensity of the reflected light may also be used for adjustment of the intensity of the laser or other type of light for surface treatment, such as a flash lamp.

In a further development, as illustrated in FIG. 6b, the light path from the emitter 601 to the detector 602 may be led through a prism 605. In this case, critical angle for internal reflectivity in the prism 605 may be involved in the measuring, whether the apparatus according to the invention actually touches the skin. For example, the safety device may be configured to prevent firing of the light source if the intensity of the reflected part detected by the photodetector 602 is not reduced due to light leaking out 604 of the prism 605 at the contacted surface 118 of the subject to be treated.

An applicable laser is a diode laser with a wavelength of 800 nm and a power of 80 mW. The radiation is typically directed onto a spot with a diameter of 0.1 mm. Equipped with such a laser, two commercially available batteries are sufficient for the apparatus to function for more than ten hours.

In order to ease the handling of the laser for depilation, the apparatus may have a laser array for a line focus, for example an array with 1000 mW may be used on a line focus for example of 0.5 mm x 2 mm. Such type of laser may have a very high efficiency and have only small heat production such that active cooling of the apparatus is not necessary.

A laser of this type has been used in test experiments and proved easy handling and efficient hair removal. Irradiation of the skin for as long as minutes has not shown any skin injury.

CLAIMS

1. Apparatus for intensive light treatment comprising
- a casing of a size which is easily hand-held,
- a light system with an intensive light source inside the casing arranged such that a produced light beam from the light source exits the casing through an exit system,
- a connection to an electrical power supply to provide power to the apparatus,
- a safety device functionally coupled to the light system and configured to allow or prevent firing of the light system,

c h a r a c t e r i s e d in that

a least three detection devices in a non-linear arrangement around the light beam at the exit system coupled to the safety device, the at least three detection devices being capable of detecting the contact of the detection devices with the surface of the subject to be treated, wherein the safety device is configured to only allow firing of the light system when at least three detection devices are in contact with the surface of the subject to be treated, wherein the exit system is configured to create a substantially closed volume in combination with the surface of the subject to be treated if the detection devices are in contact with the surface in order to prevent the intensive light from the light source to escape from this volume.

2. Apparatus according to claim 1, wherein the light system comprises a laser system.

3. Apparatus according to claim 1, where the light system comprises a high intensity flash lamp system.

4. Apparatus according to anyone of the claims 1-3, wherein the detection devices comprise mechanical pressure switches arranged to be activated when the exit system of the apparatus is pressed against the surface of the subject to be treated, and wherein the safety device is configured to only allow firing of the light source if at least three switches are activated.

5. Apparatus according to anyone of the claims 1-3, wherein the detection devices comprise pressure sensors and wherein the safety device is configured to only allow firing of the light system if the pressure exerted on the pressure sensors is higher than a predetermined level, the pressure being in a direction substantially normal to the surface of the subject to be treated.

6. Apparatus according to anyone of the claims 1-3, wherein the detection devices comprise temperature sensors and wherein the safety device is configured to only allow firing of the light system if the temperature at the surface of the surface of the subject to be treated as measured with the temperature sensor is within a predetermined range of temperatures.

7. Apparatus according to anyone of the claims 1-3, wherein the detection devices comprise resistivity sensors and wherein the safety device is configured to only allow firing of the light system if the resistivity at the surface of the subject to be treated as measured with the resistivity sensor is within a predetermined range of resistivity.

8. Apparatus according to anyone of the claims 1-3, wherein the detection devices comprise conductivity sensors and wherein the safety device is configured to only allow firing of the light system if the conductivity at the surface of the subject to be treated as measured with the conductivity sensor is within a predetermined range of conductivity.

9. Apparatus according to anyone of the claims 1-3, wherein the detection devices comprise pH sensors and wherein the safety device is configured to only allow firing of the light system if the pH at the surface of the subject to be treated as measured with the pH sensors is within a predetermined range of pH.

10. Apparatus according to any of the preceding claims, wherein the apparatus comprises electrodes configured to measure the impedance of the surface during contact with the surface for identification of the type of surface.

11. Apparatus according to claim 10, wherein at least one electrode is used for transmitting an AC signal to at least one other electrode, and wherein measurements of impedance are performed for at least two different AC frequencies.

12. Apparatus according to claim 11, wherein the measurements of impedance at the at least two frequencies are analysed in a microprocessor and compared to predetermined values of possible impedances for human skin.

13. Apparatus according to claim 12, wherein the measurements of impedance includes evaluation for impedance changes due to presence of hair between the electrodes, and where the safety device only allows firing of the light system in case that the evaluation system reveals the surface to be a surface of human skin and reveals the presence of a hair in the skin between the electrodes.

14. Apparatus according to any of the preceding claim, wherein the apparatus comprises a light detector device configured to receive light from the light source reflected from the surface, the light detector being functionally coupled to the safety device preventing the light system to fire when the intensity of the reflected light detected by the light detector is outside a predetermined range of intensity.

15. Apparatus according to claim 14, wherein the light detector device is functionally connected to an intensity adjustment device configured to automatically adjust the intensity of the light from the light source in dependence of the intensity in the light detector of the reflected light from the surface.

16. Apparatus according to any of the preceding claims, wherein the apparatus comprises an additional radiation source, preferably a light emitting diode or an additional laser, and a radiation detector system for detection of radiation from the additional radiation source reflected on the surface of the subject to be treated, the radiation detector system being functionally coupled to the safety device only allowing the light source to fire when the intensity of the reflected radiation from the additional radiation is within a predetermined range of intensity.

17. Apparatus according to claim 16, wherein the radiation detector system is configured to detect and measure radiation with at least two different radiation frequencies, and wherein the apparatus has means for calculating the relative intensities between the reflected radiation at the two different radiation frequencies for identification of the type of surface of the subject to be treated.

18. Apparatus according to claim 16 or 17, wherein the radiation source is configured to emit frequency modulated radiation and the radiation detector system is configured to detect this frequency modulated radiation in order to filter out background radiation.

19. Apparatus according to claim 18, wherein the radiation source and the radiation detector system are configured to use an individual modulation frequency for each of the different radiation frequencies.

20. Apparatus according to any of the preceding claims, wherein the detection device comprises a further light source, a prism configured to be in contact with the surface of the subject to be treated, and a photodetector, wherein the further light source is arranged to transmit light through the prism under an angle in excess of the critical angle, wherein the detector is coupled to the safety device, the safety device being configured to prevent firing of the light source if the intensity of the reflected part detected by the photodetector is not reduced due to light leaking out of the prism at the contacted surface of the subject to be treated.

21. Apparatus according to any one of the preceding claims, wherein the power supply is a battery system inside the casing.

22. Apparatus according to any one of the preceding claims, wherein the light source is a laser diode or a laser diode array, preferably with a wavelength of between 600 and 1100 nm.

23. Apparatus according to any one of the preceding claims, wherein the apparatus comprises a magnifying lens attached to the casing and directed towards the surface spot for light treatment, the lens optionally being coated with a film or dyed with a colour such as to prevent or strongly attenuate the transmission of reflected light.

24. Apparatus according to any one of the preceding claims, wherein the apparatus comprises an additional switch, the additional switch being arranged resiliently with counter force such that the switch may be pressed but not locked in the pressed state, wherein the light system only can fire when the additional switch is pressed.

25. Apparatus according to any one of the preceding claims, wherein the apparatus is provided with a cover for covering the exit system for preventing the light to exit the exit system, the cover being locked to the apparatus with a locking mechanism wherein the cover is only demountable after unlocking of the locking mechanism, the locking mechanism preferably comprising an alphanumerical code lock.

26. Use of an apparatus according to any one of the preceding claims for intensive light treatment of hair roots, acne, tattoos, benign pigmented lesions, microvascular malformations, vascular lesions, or wrinkles.

27. A kit for intensive light treatment comprising an apparatus according to anyone of the claims 1-25 and a liquid for application to the surface of the object to be treated, wherein the liquid in combination with the skin has at least one from the group consisting of a preselected marking colour, conductivity, resistivity, pH or reflectivity, or a cooling effect.

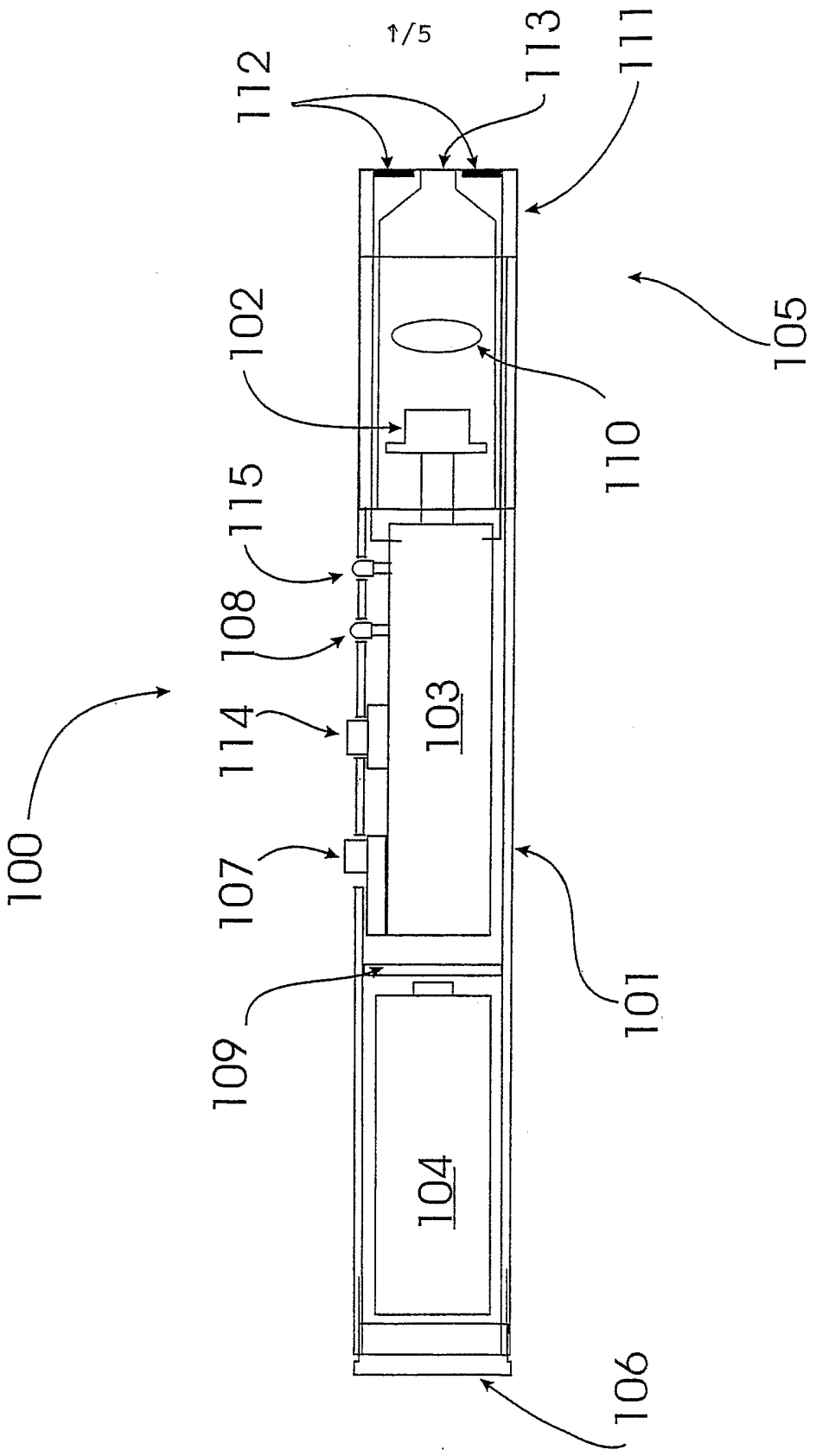

FIG 1

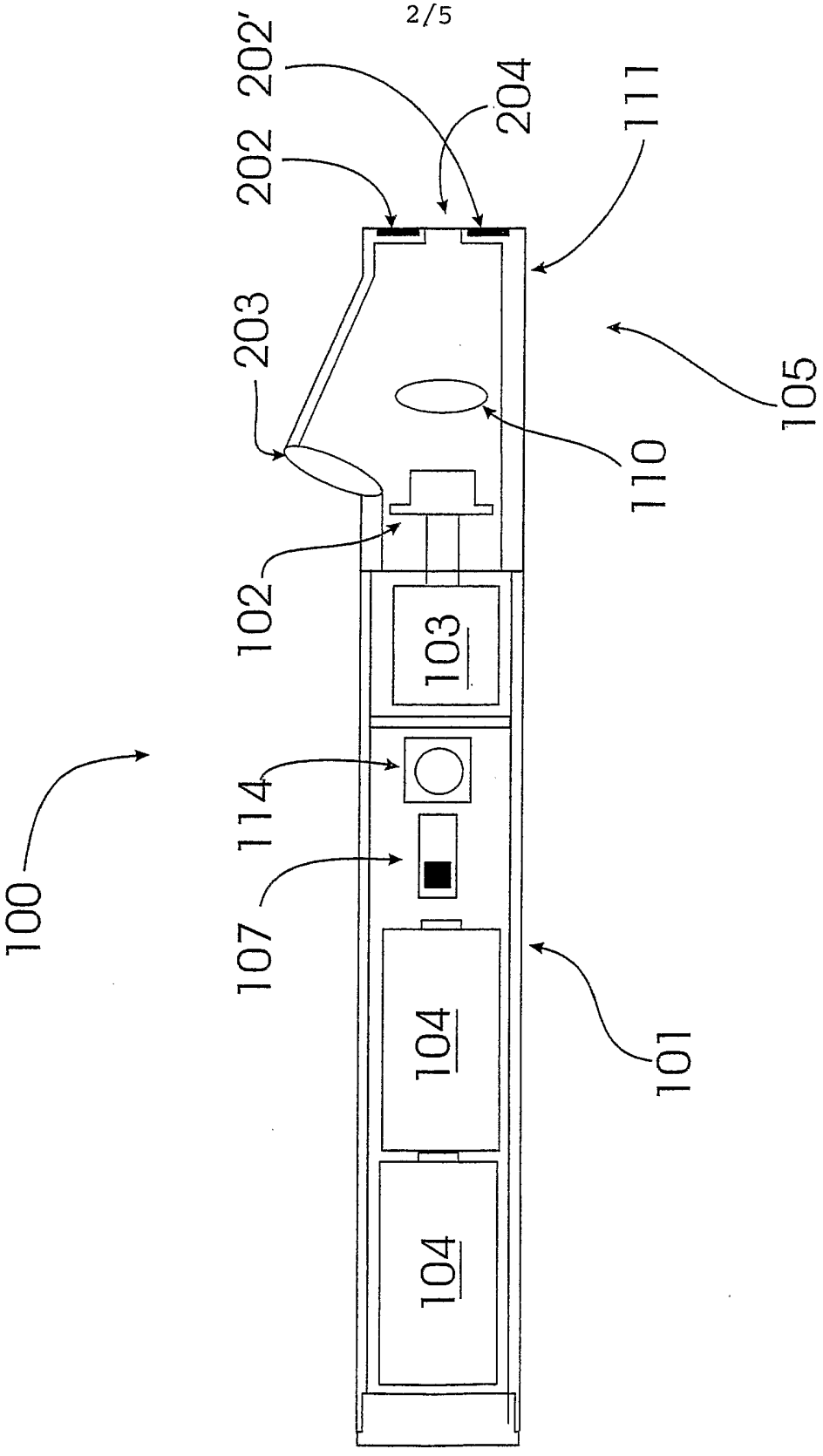

FIG. 2

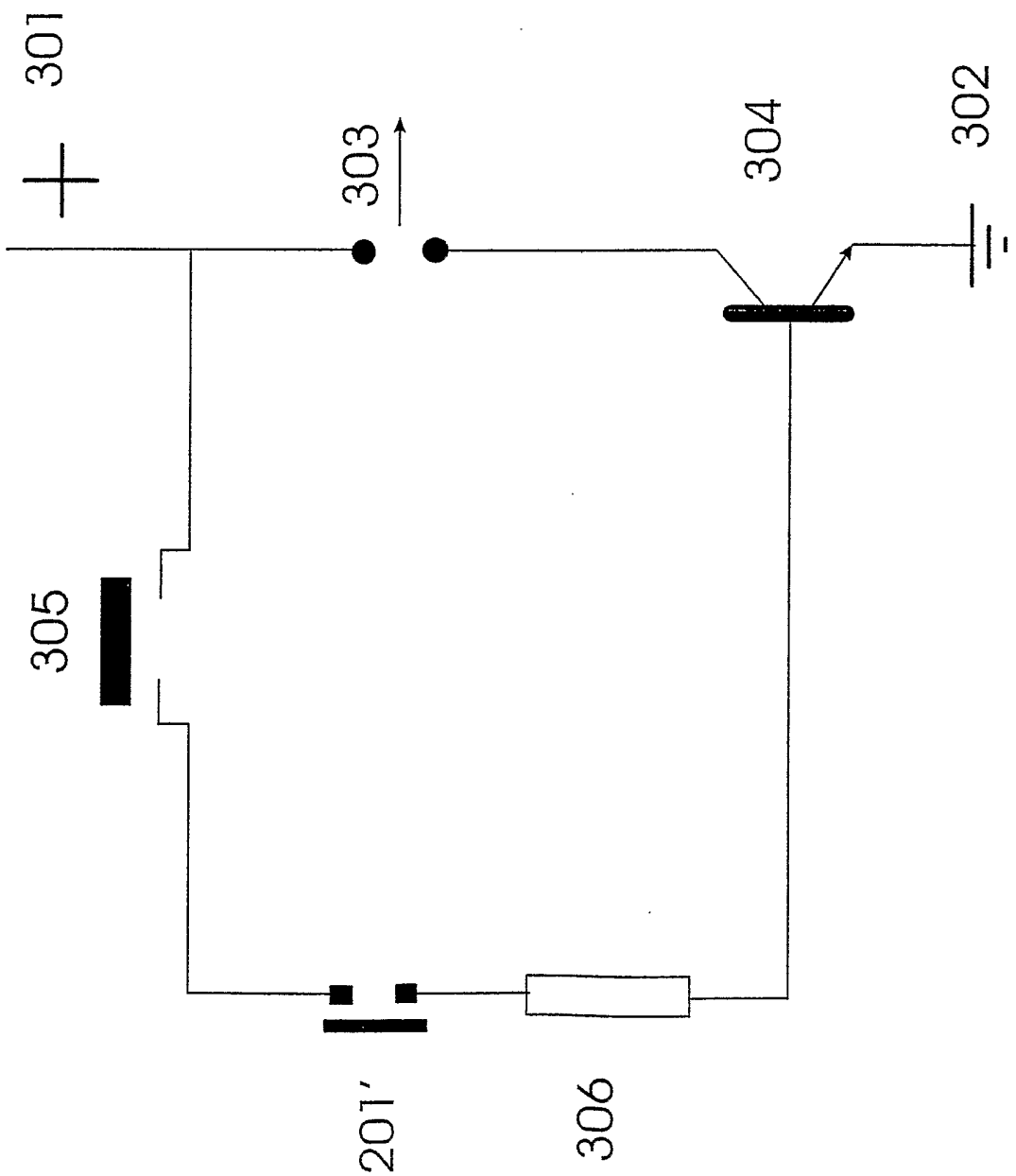

FIG 3

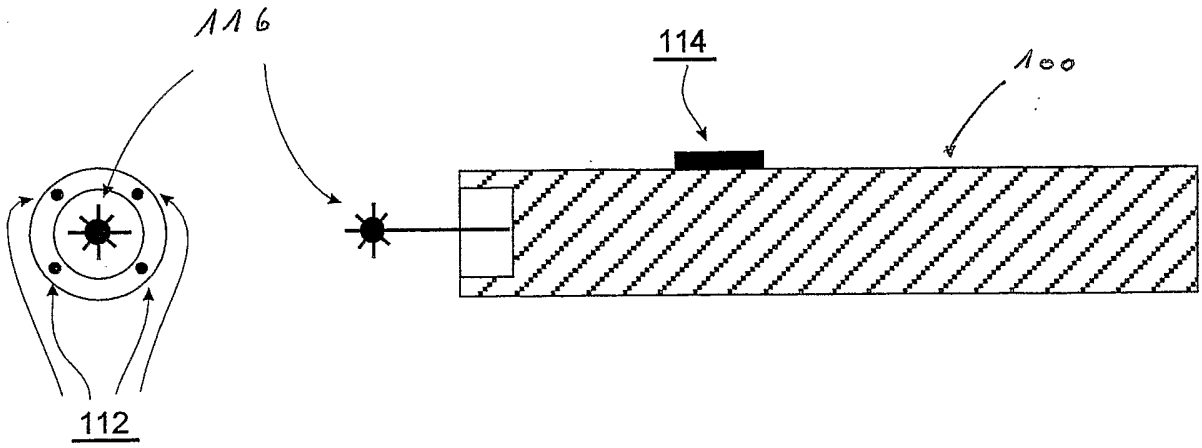

FIG.4

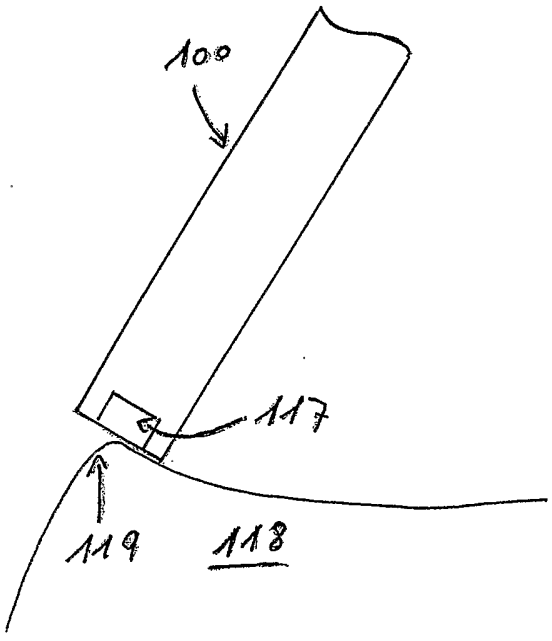

FIG.5

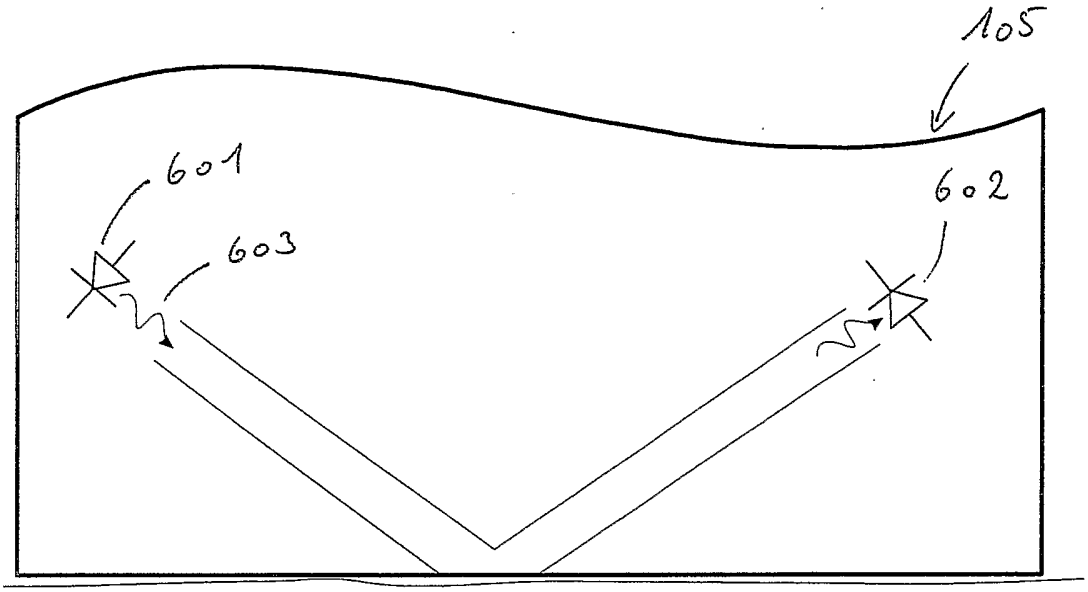

FIG. 6a

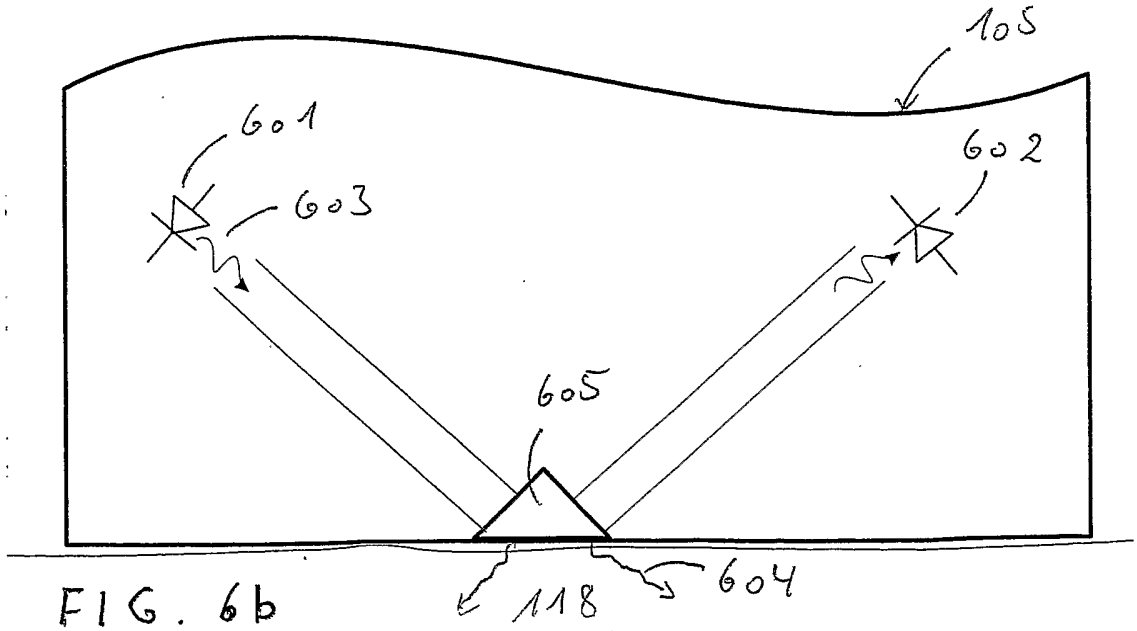

FIG. 6b

INTERNATIONAL SEARCH REPORT

PCT/DK 03/00482

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B18/20

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)
IPC 7 A61B

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 practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 26, 1 July 2002 (2002-07-01) & JP 2001 252363 A (YA MAN LTD), 18 September 2001 (2001-09-18) cited in the application	1-5,21, 22,24,27
Y	abstract	6-10,14, 16,23

P,X	WO 02 078559 A (KONINKL PHILIPS ELECTRONICS NV) 10 October 2002 (2002-10-10) column 7, line 28 -column 8, line 29; figure 2	1-3,7,8, 10,14, 16,17,22

Y	US 2001/007068 A1 (MUKAI HIDEO ET AL) 5 July 2001 (2001-07-05) paragraphs '0060!,'0071!,'0075!	6-10

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in 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 document 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
18 September 2003	24/09/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Mayer-Martenson, E

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INTERNATIONAL SEARCH REPORT

PCT/DK 03/00482

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 501 680 A (NARAYANAN KRISHNA ET AL) 26 March 1996 (1996-03-26) column 7, line 1 - line 64; figures 6-9	14,16
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INTERNATIONAL SEARCH REPORT

PCT/DK 03/00482

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 26
because they relate to subject matter not required to be searched by this Authority, namely:

Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

PCT/DK 03/00482

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