

Marine Searchlight Powered by Laser Diodes

Field of Invention

[001] The present invention relates to marine searchlights powered by laser diodes. These searchlights are suitable for use in marine vessels, for use in search-rescue operation, as safety beacons or as piracy deterrent tools.

Background

[002] Solid state lighting using light emitting diodes (LEDs) is popular for their long duty cycles, long lives and high electrical efficiencies. As LEDs are narrow-band emitters, the emitted light is usually wavelength up-converted and combined to give approximate white light output. Combinations of phosphors are often used for such wavelengths up-conversion. However, LEDs suffer from efficiency drop when they are driven to emit high intensity light. Also, under high intensity excitation, the phosphors deteriorate.

[003] Existing searchlights usually use high intensity discharge lamps, such as halogen and xenon, and metal halide arc lamps; these lamps have relatively short lives of about 300-600 hours.

[004] It can thus be seen that there exists a need for another type of searchlight that is efficient, compact, easily controlled and has a long life. Instead of using LEDs as light excitation sources, laser diodes will be used. A laser diode can also be incorporated for distance sensing and/or to enhance the UV component of the searchlight.

Summary

[005] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[006] The present invention seeks to provide high-power searchlights for marine lighting, search-rescue operation, safety beacon/signal or as a piracy deterrent tool.

[007] In one embodiment, the present invention provides a marine searchlight using two or more laser diodes as light excitation sources. Preferably, the searchlight output is a substantially white light beam or beams. Preferably, characteristics of the searchlight output are also adjustable. These marine searchlights are defined in claims 1-12.

[008] In another embodiment, the present invention provides a method for operating a marine searchlight. Steps for operating these searchlights are defined in claims 13-16.

Brief Description of the Drawings

[009] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0010] FIGs. 1A-1B illustrate a searchlight according to a first embodiment of the present invention;

[0011] FIG. 2 illustrates a searchlight according to a second embodiment of the present invention;

[0012] FIG. 3 illustrates a searchlight according to a third embodiment of the present invention; and

[0013] FIG. 4 illustrates a searchlight according to a fourth embodiment of the present invention.

Detailed Description

[0014] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0015] FIG. 1A shows a plan view of an arrangement of a high-powered marine searchlight 100 according to one embodiment of the present invention. As shown in FIG. 1A, the searchlight 100 has two or more laser diodes 110a, 110b as light excitation sources; the number of laser diodes are used for illustration and it can be 3 or more numbers. The laser beams are directed onto a transparent phosphor member 130. Preferably, in the phosphor member 130, the phosphor activators are embedded in a transparent glass or quartz to minimize thermal oxidation or deterioration of the phosphor activators. Depending on the divergence of the laser beams, a focusing lens 120 is employed to change a width of a respective laser beam so that the laser beam impinges (not necessarily focused) onto the phosphor member 130 at an intensity or range of intensities to excite emission of light of up-converted wavelengths. With two or more laser diodes 110 and two or more phosphors members 130, the up-converted wavelengths of emissions from the phosphor members 130 combine to give an approximate white light output. This white light emission from the phosphor members 130 is collimated by a lens 140 to give a strong white beam of searchlight with a predetermined angle of divergence and a predetermined illumination distance. In one embodiment, the illumination distance reaches to substantially 4 km. As shown in FIG. 1A, the lens 140 is integrally formed with a front face of the searchlight 100. The lens 140 can also be separately formed from the front face of the searchlight 100. Also as seen in FIG. 1A, the searchlight 100 is housed in a water-tight enclosure 150 of IP66 rating. At the rear, exterior end, heat radiators 160 are thermally connected to the laser diodes 110a, 110b through the enclosure 150 for external cooling. FIG. 2B shows a side view of the above searchlight 100 where a base 155 is connected to some actuators for remote control, for example as disclosed in US Patent No. 7,672,760 issued to Aptomar AS.

[0016] FIG. 2 shows a searchlight 100a according to another embodiment of the present invention. The searchlight 100a differs from the above searchlight 100 in that each of the transparent phosphor member 130 is arranged in front of the contiguous laser diode 110c. Depending on the phosphor activators inside the phosphor member and the excitation wavelength, there may be a gang of two or three laser diodes and phosphor members. Depending on the output intensity of searchlight required, two or more gangs of the laser diodes 110c are used. These gangs of laser diodes 110c can also be selectively turned on according to the output intensity required.

[0017] FIG. 3 shows a searchlight 100b according to another embodiment of the present invention. The searchlight 100b differs from the above searchlight 100 in that the phosphor member 130a is reflective. As in the above embodiment, two or more laser diodes as light excitation sources emit laser beams. Each laser beam is reflected by a mirror 170 onto the phosphor member 130a. Divergence of each laser beam may be adjusted by a focusing lens 120, whilst the white light emission from the phosphor member 130a is collimated by a lens 180. In another embodiment, the front face of the searchlight 100b can also be profiled as a lens and additively cooperates with the lens 180 to adjust divergence or shape of the searchlight beam. It is also possible to mount the lens 180 on an actuator for remotely controlling the illuminating distance of the searchlight 100b.

[0018] The phosphor member 130a of the searchlight 100b can be identical to the phosphor member 130 of the searchlight 100 or 100a but is only mounted on a reflective support. In addition, the front and/or rear surfaces of the above phosphor members can also be deposited with an anti-reflection coating to minimize reflection losses.

[0019] FIG. 4 shows a searchlight 100c according to yet another embodiment of the present invention. The searchlight 100c differs from the above searchlight 100, 100a, 100b in that the searchlight 100c uses a reflector 190 to focus or shape the output beam of the searchlight 100c. Divergence of laser beams from the laser diodes 110a, 110b may be adjusted by the respective focusing lens 120 and be directed through predetermined apertures 192, 194 formed on the reflector 190. With the phosphor member 130a disposed at the focal point of the reflector 190, white light emission from the excited phosphor member 130a is projected from the searchlight 100c as a collimated beam so that a distant

target is illuminated at a designed light intensity. Preferably, the reflector 190 is of a parabolic shape and the phosphor member 130a is located at the focal centre of the parabolic reflector.

[0020] In FIG. 4, an additional laser diode 210 is provided to project a distance sensing beam 212 through an aperture 196 on the reflector 190. The distance sensing beam 212 passes through a half-mirror 215; upon the searchlight beam falling on a distant target, the distance sensing beam 212 is reflected back to the searchlight 100c but at the half-mirror 215, the reflected beam is reflected onto a photodetector 225. Distance of the distant target can be determined by two methods: (1) by time of flight of a short string of pulses of the distance sensing beam being emitted from the laser diode 210 and reflected back to the photodetector 225; or (2) by comparing the intensity of the reflected distance sensing beam with calibration chart of the searchlight 100c power against distance.

[0021] In the above searchlight 100b, 100c, the phosphor member 130a is described as reflective. It is possible that the phosphor member 130a is made from the transparent phosphor member 130 but has a reflective back support. In addition, the back surface of the transparent phosphor member 130a may be deposited with a reflective optical broad-band coating to reflect the white light emission of the phosphor member 130a; in addition, the front surface of the transparent phosphor member 130, 130a may be deposited with a narrow-band anti-reflection coating to minimize reflection losses.

[0022] The above searchlights 100, 100a, 100b, 100c using laser diodes as light excitation sources have long and reliable lives, compared to halogen, xenon or metal arc lamps. Advantageously, the laser diodes are operable at low voltages, such as 12V, which is readily available on small boats. These laser diodes are small in sizes and the searchlights are thus lighter and more compact in design and shape. It is also possible that the searchlight is made detachable as a portable light source for use with a portable battery pack.

[0023] Another advantage of the present invention is the versatile control on the output characteristics of the searchlight 100, 100a-100c. For example, the power of the searchlight can be controlled by changing the driving frequency or pulse rate of exciting the laser diode

110, 110a-110d. Two or more than two gangs of each laser diode may be provided so as to provide modular and selective power control on the searchlight output, for example, at high power for distance illumination/search-rescue operation or low power for short distance illumination/on-board lighting. The laser diodes can also be pulsed at a lower frequency for using the searchlight as a safety beacon or signal light when a need arises. These laser diodes can also be Q-switched to output wavelengths of half, third or quarter harmonics; a select gang of laser diodes may be Q-switched and the output, such as UV light, is combined with white light from another group of laser diodes for special modular operation in the marine or search-rescue environment.

[0024] The above marine searchlights 100, 100a-100c can also be used to safeguard security and safety of ships at night in high risk piracy areas by using the high intensity output beams to temporarily “blind” pirates or deter pirates/intruders from coming on-board. This high intensity output beams can be adjusted in power, mode (continuous brightness or flashing) and lighting characteristics (by Q-switching the laser diodes), thus making these searchlights as a useful security tool.

[0025] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the present invention. For example, the front face of the searchlight may be laterally broad in dimension to allow two beams of searchlight to project onto the distant target.

CLAIMS:

1. A marine searchlight apparatus comprising:
 - two or more laser diodes, which are operable to emit two or more laser beams of predetermined wavelengths;
 - a transparent phosphor member comprising phosphor activators to up-convert each of the predetermined laser wavelengths and the up-converted emissions are combined to produce a substantially white light output; and
 - a collimating means to project the white light output into a beam of a predetermined divergence, shape and illuminating distance.
2. The marine searchlight apparatus according to claim 1, wherein the two or more laser diodes are optically aligned in axes with the associated phosphor member.
3. The marine searchlight apparatus according to claim 1, wherein the two or more laser diodes are disposed on axes offset from an axis of the white light output but the axes of the laser diodes and white light output are connected by a mirror.
4. The marine searchlight apparatus according to any preceding claim, further comprises a reflector and the phosphor member is located near a focal centre of the reflector.
5. The marine searchlight apparatus according to claim 4, wherein the reflector is parabolic in shape.
6. The marine searchlight apparatus according to any one of the preceding claims, wherein the phosphor activators are embedded in a transparent glass or quartz.
7. The marine searchlight apparatus according to claim 6 when dependent on claim 3 or 4, further comprises a reflective support disposed on a rear surface of the phosphor member to maximise reflection of white light.

8. The marine searchlight apparatus according to any one of the preceding claims, wherein a front and/or back surfaces of the transparent phosphor member is/are deposited with narrow-band anti-reflection coatings to minimize reflection losses of the laser beams.
9. The marine searchlight apparatus according to any one of the preceding claims, wherein the laser diodes are operational as a gang, and two or more gangs of laser diodes are provided.
10. The marine searchlight apparatus according to claim 9, wherein a gang or gangs of the laser diodes is/are selectively turned on for modular control of the white light output power.
11. The marine searchlight apparatus according to claim 9 or 10, wherein one or more of the laser diodes or a gang of laser diodes are Q-switched so as to alter characteristics of the search light output.
12. The marine searchlight apparatus according to any one of the preceding claims, further comprising a measuring laser diode, a half-mirror and a photodetector, wherein the measuring laser diode is operable to produce a distance sensing beam and the half-mirror is orientated to reflect a reflected distance sensing beam to the photodetector.
13. A method of operating a marine searchlight, the method comprising:
 - exciting a phosphor member with two or more gangs of laser beams from laser diodes so that emissions from the phosphor member additively produce an approximate white light output;
 - collimating and shaping the white light output to produce a beam with a predetermined divergence and a predetermined lighting distance; and
 - turning on one or more gangs of the laser diodes to control power of the white light output and lighting distance.
14. The method according to claim 13, further Q-switching one or more of the laser diodes or a gang of the laser diodes to alter the characteristics of the search light output.

15. The method according to claim 13, further Q-switching the two or more gangs of laser diodes to alter the characteristics of the light output and turning on the output at a flashing speed as a beacon or a signal light.
16. The method according to claim 13, wherein the marine searchlight is used as a light blinding tool to deter pirates/intruders from coming on-board a marine vessel.