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(54) ELECTRICAL SWITCH AND OPERATING METHOD

(57) An electrical switch comprising a button cap (40) is provided. The button cap (40) has an actuation part (41) configured to be actuated by a user and a flexible bellows (42) extending circumferentially around the actuation part (41), wherein the actuation part (41) and the bellows (42) each have at least one translucent portion. An electrical unit (50) of the switch comprises a switching element (51) and a light emitting device (52). The switch further comprises an optical waveguide component (20) that is arranged between the button cap (40) and the electrical unit (50) and that is in engagement with the button cap (40). The optical waveguide component (20) has a protrusion (25) configured to actuate the switching element (51). The optical waveguide component (20) is movable in an actuation direction (12) to mechanically transmit an actuation stroke from the button cap (40) to the switching element (51) via the protrusion (25). The optical waveguide component (20) further comprises a first portion (21) that extends in the actuation direction (12) towards the light emitting device (52) to receive light from the light emitting device (52) and a second portion (22) that extends towards the button cap (40) to emit light towards the button cap (40). The second portion (22) distributes received light at least towards the translucent portion of the actuation part (41) and the translucent portion of the bellows (42).

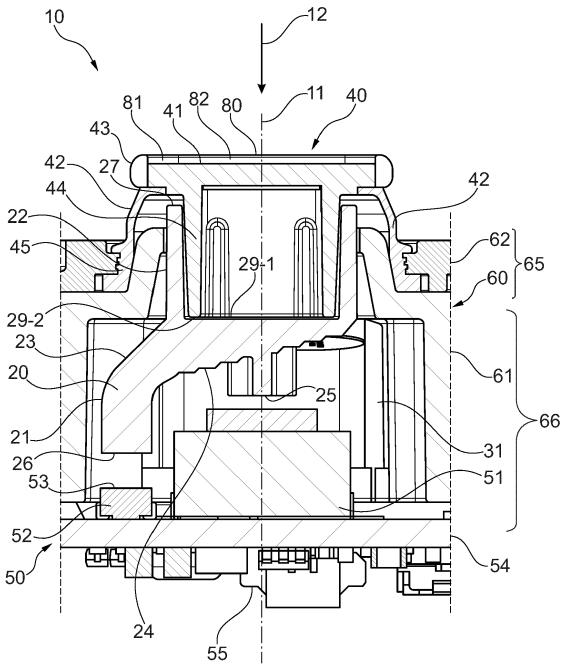

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an electrical switch, in particular for use in vehicles and mobile machinery employed in construction and agriculture. It further relates to a method of operating such electrical switch.

BACKGROUND

[0002] Construction or agricultural machinery often has control panels with a plurality of levers and switches, for example a multi-functional joystick and push buttons to control machine operation. Respective electrical switches do on one hand need to be robust and capable of being operated in harsh environments, and on the other hand must allow a reliable and secure operation by the user. As the user, such as a machine operator, will generally need to focus on the task at hand, it is desirable that such switches can be recognized easily and the switching state can be determined reliably.

[0003] The document DE 10 2021 104 812 B3 proposes a solution in which the user obtains tactile feedback when operating a switch in form of a push button. The operating stroke of the push button switch is increased so that even when vibrations are present, the user obtains reliable feedback on a successful actuation of the push button switch. This is achieved while keeping the space requirements of the push button switch low.

[0004] Another exemplary switch is disclosed in the document DE 10 2011 118 178 B3, wherein a silicon mat comprising domes is used to provide a restoring force and thus to provide tactile feedback.

[0005] It is desirable to reduce the complexity of such existing electrical switches. Furthermore, it is desirable to provide an electrical switch that can be operated safely and intuitively by the user of such agricultural or construction machinery even in harsh environments in which visibility and haptic abilities of the user are restricted.

SUMMARY

[0006] Accordingly, there is a need to mitigate at least some of the drawbacks mentioned above and to provide an improved electrical switch, in particular to reduce the complexity of the switch while allowing a reliable and safe operation.

[0007] This need is met by the features of the independent claims. The dependent claims describe embodiments of the invention.

[0008] According to an embodiment of the invention, an electrical switch comprising a button cap is provided, wherein the button cap has an actuation part configured to be actuated by a user and a flexible bellows (such as a folding bellows) extending circumferentially around the actuation part. The actuation part and the bellows each have at least one translucent portion. The electrical switch further comprises an electrical unit that comprises a switching element and a light-emitting device. The switch further comprises an optical waveguide component that is arranged between the button cap and the electrical unit and that is in engagement with the button cap. The optical waveguide component has a protrusion configured to actuate the switching element. The optical waveguide component is movable in an actuation direction to mechanically transmit an actuation stroke from the button cap to the switching element via the protrusion.

[0009] The optical waveguide component further comprises a first portion that extends in the actuation direction towards the light-emitting device to receive light from the light-emitting device and a second portion that extends towards the button cap to emit light towards the button cap. The optical waveguide component is configured to guide light from the first portion to the second portion, and the second portion is configured to distribute the light at least towards the translucent portion of the actuation part and the translucent portion of the bellows to illuminate the actuation part and the bellows.

[0010] Such configuration may achieve a compact electrical switch and that provides improved operability. As the waveguide component, which may also be termed "light guide", acts as a transmitting component that transmits the stroke to the switching element and at the same time guides the light towards the button cap, the number of parts is reduced and a compact and less complex assembly is achieved. The optical waveguide component further allows the use of a single light-emitting device to illuminate both, the bellows and the actuation part so that no additional components are necessary to illuminate both of these components. This further reduces complexity and the number of required parts. Even further, by illuminating both, the bellows and the actuation part, identification of the electrical switch is facilitated and the providing of optical feedback for the user may be improved. The light color may for example be changed to provide an unambiguous signal to the user whether the electrical switch is in an activated or deactivated state, which is easily recognizable due to the enlarged illumination area.

[0011] The actuation part of the button cap may be the part to which the user applies the pushing force when depressing the button cap; it may comprise an actuation surface to be pressed by the user. As the actuation part faces the user and is thus generally visible to the user, guiding light into the actuation part may increase the visibility of the switch.

[0012] In the present application, an electrical switch is to be understood as a generic term for all types of buttons and switches, such as for non-latching switches (e.g., switches that return to their initial mechanical and/or electrical (state after actuation), i.e. to a button in the narrower sense, and for latching switches (e.g., switches that maintain their mechanical and/or electrical state after actuation), i.e. switches in the narrower sense.

[0013] The second portion of the waveguide may in particular distribute light directly to the actuation part and the bellows, i.e. without intervening components. The actuation part may provide a top portion of the button cap, and the bellows may form side walls of the button cap. The top portion and the side walls of the button cap may thus directly receive light from the second portion of the waveguide. The respective translucent portions may be made of a translucent material, in particular of an optically transparent material. The whole bellows and/or the whole actuation part may be made of the respective translucent, e.g. transparent, material.

[0014] The optical waveguide component may consist of an integral single piece of material, in particular of the same material. The number of components of the switch may thereby be reduced and manufacturing may be facilitated. The switch may be made more robust and reliable.

[0015] The second portion of the optical waveguide component may extend between the bellows and a mounting portion of the button cap (e.g., as seen in a direction perpendicular to the actuation direction). This may allow an improved distribution of the light by means of the waveguide component, as the mounting portion may not disturb such distribution.

[0016] The second portion may for example extend towards an area in which the bellows meets the actuation part. A rim provided between the actuation part and the bellows may be located in this area. By extending into such area, the distribution of the light to different components of the button cap may further be improved.

[0017] The second portion may have an exit face at which light exits the optical waveguide component. The button cap may have a receiving face positioned at a fixed distance opposite to the exit face to receive light emitted from the exit face. This may improve the providing of light into the button cap, and in particular to the actuation part. Light leaving the exit face may further be scattered, deflected, and/or reflected, which may facilitate distribution to the bellows. Light may also leave the optical waveguide through the side surface to illuminate the bellows, such as through a side surface of the second portion (such side surface may be perpendicular to the exit face).

[0018] In an embodiment, the second portion of the optical waveguide component is formed as a sleeve, and the button cap may comprise a mounting portion that extends from the actuation part in a direction towards the switching element. The mounting portion may be arranged inside the sleeve of the optical waveguide component.

[0019] In the optical waveguide component, the light may in particular be distributed to a sleeve and may be emitted from a rim of the sleeve. A distribution of light over a relatively large area and thus a rather homogeneous illumination of the bellows and the actuation part may thereby be achieved. At the same time, the mounting portion may not disturb the distribution of light.

[0020] The mounting portion may be fixedly connected to the sleeve. No relative movement between the mounting portion and the sleeve may be possible when the button cap is depressed by a user. A compact configuration may thereby be achieved, and the light distribution may not be affected by depressing the button cap. The mounting portion may for example include two or more latches which may latch to the outer sleeve (e.g., one part may have a latch nose that engages a complementary hole of the other part). The mounting portion may form an inner sleeve or latches and the inner sleeve or latches may be latched to the outer sleeve. Preferably, holes are provided in the outer sleeve of the optical waveguide component.

[0021] The optical waveguide component may comprise a (further) exit face at which light exits the optical waveguide component, wherein the exit face is arranged in the actuation direction below the button cap (e.g. below a central region thereof) and is configured to emit light towards the button cap. For example, the optical waveguide component may comprise an intermediate portion arranged between the first portion and the second portion, and the exit face may be provided on a face of the intermediate portion that faces the button cap and that is preferably arranged inwardly (with respect to the axial direction defined by the actuation direction) of a structure formed by the second portion, e.g. inwardly of the abovementioned sleeve. Thus, also the central portion of the button cap can be illuminated in an efficient way by the optical waveguide component.

[0022] The exit face may for example comprise a first exit face provided in the actuation direction below the actuation part of the button cap and spaced apart therefrom, e.g. such that no further component is provided between the first exit face and the actuation part. Additionally or alternatively, the exit face may comprise a second exit face provided in the actuation direction below a mounting portion of the button cap, wherein the second exit face and the mounting portion of the button cap may be arranged and configured such that light exiting the second exit face enters the mounting portion. The mounting portion may comprise a respective light receiving surface at its axial end that faces the second exit surface. By allowing light emitted by the waveguide component to enter the mounting portion, it may be distributed efficiently within the button cap and illumination of the button cap may further be improved. The mounting portion may for example itself be configured to act as an optical waveguide and may guide the light efficiently to the actuation part of the button cap.

[0023] In an embodiment, the switch comprises a housing and the switching element is mounted stationarily with respect to the housing. Simplicity and compactness of the switch may thus further be improved. For example, the switch may comprise a circuit board, and the switching element and optionally the light-emitting device may be mounted to the circuit board. The circuit board may be mounted fixedly to the housing of the

electrical switch.

[0024] The optical waveguide component may be slidable in the housing of the electrical switch, in particular to transmit the actuation stroke.

[0025] In an embodiment, the switch comprises a housing having an upper part in engagement with the button cap (e.g., with a sealing edge of the bellows) and having a lower part in which the switching element is arranged. The optical waveguide component comprises a lower portion that extends in the lower part of the housing and the lower portion comprises one, two or more first guide elements, each being guided in a complementary second guide element provided in the lower part of the housing, such as in a wall of the housing. The compactness of the switch may thus be improved even further, since the optical waveguide component may thus also have a guiding function when transmitting the actuation stroke. By such guide elements, the jamming of the waveguide component in the housing may be prevented and the reliability of the switch may thus be improved. Further, the optical waveguide component and the button cap, which is fixedly mounted thereto, may by such configuration both be guided in axial direction in a unique and restricted manner, and may in particular be restricted to a one-dimensional movement in the axial direction. Thus, even if the user presses the button cap off-center, the button cap and the waveguide component are securely guided in axial direction and will thus trigger the switching element.

[0026] Upper part or upper portion, as used herein, refers to the part of the switch towards the side from which the switch is actuated by the user; lower part or lower portion refers to the portion in the direction of the switching element is located, in particular where a circuit board on which the switching element may be provided is located. It should be clear that this does not refer to any absolute coordinates, and that the switch may be mounted in any orientation.

[0027] The first guide elements may be ribs or ridges, and the second guide elements may be recesses or channels, wherein the first guide elements are in engagement with the second guide elements in a slidable manner. The configuration may also be reversed. Preferably, at least two guide surfaces of the ribs or ridges are engaged in a formfitting manner with complementary guide surfaces of the second guide elements.

[0028] The switch may comprise a return unit configured to return the button cap to its initial position (e.g., equilibrium position) after the button cap has been depressed by a user. The return unit may comprise or consist of the bellows. A simple configuration may thus be achieved in which no additional part needs to be provided for returning the button cap to its original position. The user may for example apply a push force through the actuator part, upon which the button cap slides together with the optical waveguide component and thereby compresses the bellows (the bellows may bulge outwardly). As the push force is removed, the bellows may release the stored energy and may push the button cap and thus the optical waveguide component back into its original position, i.e. the equilibrium position; the bellows may thus apply a respective restoring force and thereby act as a return.

[0029] The second portion of the optical waveguide component may be formed as a sleeve, such as a polygonal sleeve, e.g. a rectangular sleeve, and the optical waveguide component may comprise an intermediate portion that extends between the first portion and the second portion. Preferably, the intermediate portion has a tapered shape to distribute light from the first portion to the sides (preferably to all sides; for example to each sidewall, e.g. to all sides of a single circular wall or of plural rectangular walls) of the sleeve. A surface of the tapered shape that faces the switching element is preferably stepped. The distribution of light from a single light-emitting device to the second portion and thus to both, the actuation part and the bellows, may thereby be improved. The stepped surface may for example comprise at least four, preferably at least six steps that extend from the first portion to the second portion. The number of steps may be increased further, e.g. in dependence on the size of the component. The first portion may further have a width that is smaller than a width of the sleeve, and the intermediate portion may also be tapered to provide a transition between the width of the first portion and the width of the sleeve. The protrusion (which actuates the switching element) may be provided on the stepped surface.

[0030] The steps of the stepped surface may comprise a first face that is oriented substantially perpendicular to the actuation direction and a second face that is inclined by less than 45° with respect to the actuation direction. Such shape may improve the efficiency of the transport of light and the distribution to the second portion.

[0031] The first portion of the optical waveguide component may comprise a section that extends in the actuation direction towards the light-emitting device, wherein the section has a receiving end face (for example circular, oval, or polygonal, e.g. rectangular) that is arranged at a variable distance opposite to the light-emitting surface of the light-emitting device. The distance may for example vary when the button cap is depressed. The receiving end face may have an area sized so as to capture at least 40%, preferably at least 60%, of the light emitted by the light emitting device. An efficient transfer of light into the optical waveguide may thereby be achieved. The area of the receiving end face of the first portion may for example correspond to an area of the light-emitting surface.

[0032] The optical waveguide component may have a lower portion including one or more sidewalls that extend in the actuation direction and at least partially surround the switching element when the button cap is depressed. The lower portion may further include a side face at which the first portion of the optical waveguide component is arranged. For example, three sidewalls and one open face with the first portion may be provided, or four side-

walls may be provided, wherein the first portion may be integrated into or adjacent to one of the sidewalls. Additionally or alternatively, a thickness of the one or more sidewalls may be smaller than a thickness of the first portion. A higher thickness of the first portion may improve the light-guiding characteristics of the first portion. Additionally or alternatively, the one or more sidewalls may extend in the actuation direction beyond an end face of the first portion via which the first portion receives the light from the light-emitting device. By such configuration, the end face may be prevented from contacting the light-emitting device when being depressed, while the sidewalls may provide a firm guidance of the waveguide component. The guide elements may for example be provided at two or three edges of the sidewalls.

[0033] A cross-sectional area of the first portion in a plane perpendicular to the actuation direction may be spaced apart from a projection of an area that is enclosed by the second portion and that is projected in the actuation direction into the plane. The first portion, and thus the light-emitting device, may accordingly be arranged not centrally, but on a side. A compact arrangement may thus be achieved. The cross-sectional area may be adjacent to an end face at which the first portion receives the light from the light-emitting device. The cross-sectional area of the first portion may be smaller than the projected area.

[0034] The actuation part and the bellows may be formed integrally, for example by multicomponent injection molding. The button cap may thus provide a secure sealing in harsh environments while being compact. In particular, such configuration may achieve a sealing class of up to IP6K9K. The bellows may have a circumferential rim or sealing lip that may be sealed between a first part and a second part of a housing of the electrical switch. It may for example be clamped between the first part and the second part of the housing. The second part may be a frame that frames one or plural electrical switches, such as a cover panel or cover plate that engages the first housing part. The first housing part may house the waveguide component and the electrical unit.

[0035] The actuation part may be made of a hard plastic material. The button cap and the switching element may be arranged concentrically. The protrusion may be arranged centrally and in actuation direction below the button cap, wherein the switching element may be arranged centrally and in actuation direction below the protrusion. The light-emitting device may be offset, from a central axis of the button cap extending in the actuation direction, in a lateral direction perpendicular to the actuation direction. In particular, the light-emitting device may be arranged adjacent to the switching element.

[0036] In some embodiments, the button cap comprises a rim encircling the actuation part. The rim may have a translucent portion (made of translucent material), wherein the second portion of the optical waveguide component may be configured to distribute light towards the translucent portion of the rim. By distributing light to three distinct elements by the single optical waveguide, compactness of the switch may further be improved while keeping complexity low. Illumination of three distinct components may further improve operational safety of the switch, as the reliability of identification of both switch location and switching state may be improved.

[0037] The actuation part may be made of a first material and the rim may be made of a second material that differs from the first material at least by its translucent properties. The rim may for example have different optical filtering property as the actuation part, so that they may be illuminated at different colors. Preferably, the actuation part, the rim and the bellows are formed integrally. For example, they may be formed by three component (3k) injection molding. Besides having a different transmission spectrum, the degree of translucency may be different for the rim and the actuation part.

[0038] The translucent portion of the actuating part and/or of the rim may be configured to transmit light of a predetermined color. Preferably, such color is different from a color at which the bellows transmits light. For example, the translucent portion of the bellows may be configured to transmit white light. In some embodiments, all three components (rim, actuation part, and bellows) are configured to transmit white light.

[0039] The button cap may comprise an indicator element, wherein the indicator element is configured to selectively pass light emitted by the second portion of the optical waveguide component. The indicator element may for example be a mask or template that passes light only in some areas, so that a symbol can be displayed on the actuation part, or may for example have differently colored portions so that a color pattern, which may likewise indicate a symbol, can be displayed. The actuation part may comprise a recess, and the indicator element may be a plate arranged in the recess, e.g. pressed, glued, or otherwise be mounted to the recess. The plate may comprise one or more portions transparent to light. The recess may be on an outer part of the actuation part so that the indicator element is pressed by user actuation. Translucent portions of the indicator element may act as a color filter.

[0040] The protrusion may be a plunger or piston. It may have a cross-shaped or circular cross-section.

[0041] The switching element may be a button, in particular a short stroke button. A button may in particular be a non-latching switch which may cause a temporary change of the state of an electrical circuit while being actuated, e.g. depressed. Such short stroke button may further improve the compactness of the switch.

[0042] The light-emitting device may be a light-emitting diode (LED), in particular a multi-color LED that is controllable to emit different colors of light.

[0043] According to an embodiment, the electrical switch further comprises a control unit configured to control the light-emitting device to emit light of a first color when the electrical switch is in a passive state and to set

the electrical switch into an active state upon detection of an actuation of the switching element. The control circuit may further control the light-emitting device to emit light of a second color that is different from the first color when the electrical switch is in the active state. The color of illumination may thus provide a safe indication of whether the electrical switch is in the passive or active state, for example in a disabled or enabled state. Operational safety may thereby be increased, as the machine operator can easily recognize the switching state of the electrical switch. For example, in a passive, e.g. disabled, state, the light-emitting device may be controlled to emit white light, e.g. at reduced intensity, which may correspond to a back-light illumination of the switch which facilitates identification of the switch even in dark or dusty environments, as well as under sunlight. In the active, e.g. enabled state, the control circuit may cause the light-emitting device to emit red or green light, for example with increased intensity. Recognizing the active state may thereby be facilitated.

[0044] According to a further embodiment of the present invention, a control panel of a mobile machine is provided, which comprises an electrical switch having any of the configurations disclosed herein. Plural such switches may be provided on the control panel. For example, two neighboring switches may be provided, and these neighboring switches may have a similar or a mirrored configuration. The compactness of such control panel may thereby further be increased.

[0045] According to a further embodiment, a mobile machine comprising such control panel is provided.

[0046] According to a further embodiment of the present invention, a method of operating an electrical switch having any of the configurations described herein is provided. The method comprises receiving at the first portion of the optical waveguide component light emitted by the light-emitting device; transmitting, via the optical waveguide component, the received light from the first portion to the second portion; and distributing, via the second portion of the optical waveguide component, the light at least towards the actuating part and the bellows. By such method, advantages similar to the ones outlined further above may be achieved.

[0047] In the method, the light may further be distributed to a rim encircling the actuation part.

[0048] In an embodiment, the method may further comprise distributing, via the optical waveguide component, light of a first color emitted by the light emitting device to the actuating part and the bellows; moving the button cap together with the transmission element towards the switching element upon a user applying pressure to the button cap; actuating the switching element by the protrusion of the transmission element; changing the color of the light emitted by the light emitting device to a second color; and distributing the light of the second color via the optical waveguide component to the actuating part and the bellows. A compact switch that facilitates recognizing the state in which the switch currently is may thereby be provided. The first color may be white and may correspond to a background lighting, and the second color may be a signal color, e.g. red or green, and may indicate an active/enabled state of the switch.

[0049] It is to be understood that the features mentioned above and those yet to be explained below can be used not only in the respective combinations indicated, but also in other combinations or in isolation, without leaving the scope of the present invention. In particular, the features of the different aspects and embodiments of the invention can be combined with each other unless noted to the contrary.

BRIEF DESCRIPTION OF THE DRAWINGS

[0050] The foregoing and other features and advantages of the invention will become further apparent from the following detailed description read in conjunction with the accompanying drawings. In the drawings, like reference numerals refer to like elements.

Fig. 1 is a schematic drawing showing a sectional side view of an electrical switch according to an embodiment.

Fig. 2 is a schematic drawing showing a distribution of light in the electrical switch of figure 1 according to an embodiment.

Fig. 3 is a schematic drawing showing an optical waveguide component of the electrical switch of figure 1 according to an embodiment.

Fig. 4 is a schematic drawing showing a bottom view of the electrical switch of figure 1.

Fig. 5 is a schematic drawing showing a perspective explosive view of a particular implementation of the electrical switch of figure 1.

Fig. 6 is a schematic drawing showing a perspective view of an embodiment of the electrical switch of figure 1, wherein an illuminated rim and an indicator element are provided.

Fig. 7 is a flow diagram illustrating a method of operating an electrical switch according to an embodiment.

DETAILED DESCRIPTION

[0051] In the following, embodiments of the invention will be described in detail with reference to the accompanying drawings. It is to be understood that the following description of the embodiments is given only for the purpose of illustration and is not to be taken in a limiting sense. It should be noted that the drawings are to be regarded as being schematic representations only, and

elements in the drawings are not necessarily to scale with each other. Rather, the representation of the various elements is chosen such that their function and general purpose become apparent to a person skilled in the art. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprising," "having," "including," and "containing" are to be construed as openended terms (i.e., meaning "including, but not limited to,") unless otherwise noted.

[0052] Fig. 1 schematically illustrates an electrical switch 10 that includes a button cap 40 with an actuation part 41, an electrical unit 50 with the switching element 51 and an optical waveguide component 20 arranged between the button cap 40 and the electrical unit 50. Upon depressing the button cap 40 by a user in actuation direction 12, the optical waveguide component 20 transmits the actuation stroke via a protrusion 25 onto the switching element 51, thereby actuating the switching element 51. Switch 10 further comprises a housing 60 housing the components of the switch. Switching element 51 may be a button, in particular a short stroke button, and a control circuit 55 of electrical unit 50 may change a switching state of switch 10 upon detection of a respective actuation (e.g., from passive/disabled to active/enabled). Any type of switching element 51 may be employed, and a switch 10 may operate according to any known switch configuration.

[0053] Waveguide component 20 accordingly has a transmitting function and transmits the actuation stroke to the switching element 51. Electrical unit 50 further comprises a light-emitting device 52, in particular a multi-color LED. Waveguide component 20 has a first portion 21 arranged opposite to a light-emitting area 53 of LED 52 to receive light therefrom. It further has an intermediate portion 23 that guides and distributes the received light to a second portion 22. Second portion 22 may be sleeve-shaped, as shown in Fig. 3, and includes an exit face 27, where the light leaves the optical waveguide component 20. Button cap 40 has a flexible bellows 42, and the second portion 22 distributes the light, e.g. via exit face 27, to the actuation part 41 and the bellows 42. Exit face 27 may be a continuous circumferential surface, as shown in Fig. 3, which may make the distribution more homogeneous; in other implementations, it may be sectioned. The intermediate portion 23 is tapered, as shown in Fig. 1. In particular, it increases in width (perpendicular to the actuation direction 12) and provides a transition from a cross-sectional area of the first portion 21 to the larger area enclosed by the second portion 22. Intermediate section 23 is configured to increase the homogeneity of the light distribution to second portion 22. Intermediate portion 23 comprises a stepped surface 24 facing downwardly, i.e. towards to the switching element 51. Stepped surface 24 is visible in the bottom projective view of Fig. 4, which shows switch 10 without the electrical unit 50 viewed in a direction opposite to the actuation direction 12. The projection 25 may be a cross-shaped or cylindrical plunger that is provided on the stepped surface 24. The sectional views of Figs. 1 and 2 show that the steps have a surface perpendicular to the actuation direction 12 and a surface inclined, at an acute angle, with respect to the actuation direction 12, e.g. smaller than 45 or 30°. Light guidance properties of the intermediate section 23 and the distribution to the second portion 22 may thereby be improved.

[0054] The intermediate portion 23 may further comprise a first exit face 29-1 and/or a second exit face 29-2 that are configured to emit light towards the button cap 40. The first exit face 29-1 emits the light towards the actuation part 41, in particular to a central region thereof. As no further component is provided between the first exit surface 29-1 and the central region of actuation part 41, the light can directly enter the actuation part 41 (after crossing the spacing between these two elements), and illumination of the button cap 40 may thereby be improved. The second exit face 29-2 emits light towards the mounting portion 44 of the button cap 40. Mounting portion 44 may act as an optical waveguide and may comprise a receiving face at its end that faces the intermediate portion 23, that in particular faces the second exit face 29-2. Light can thus enter the mounting portion 44 and can be transferred efficiently via mounting portion 44 to the actuation part 41. Thus, illumination of the actuation part 41 can further be improved by second exit surface 29-2.

[0055] The distribution of the light from the LED 52 via the optical waveguide component 20 to the actuation part 41 and the bellows 42 is shown schematically in Fig. 2.

[0056] Actuation part 41 and bellows 42 are formed integrally, for example by multicomponent injection molding. Button cap 40 optionally comprises a circumferential rim 43 that extends around the actuation part 41, in particular around an actuation surface thereof which the user pushes directly or indirectly (e.g. via the indicator element mentioned below). It may be made of a material that differs by its optical properties from material of the actuation part 41; it may have a different translucency, e.g. transmit light of a different color. Rim 43 is formed integrally with part 41 and bellows 42, for example by 3K injection molding. Whereas actuation part 41 may be formed of a hard plastic material, bellows 42 is formed of a flexible material, such as rubber, silicone rubber etc.. Two or three materials may thus form a single integral piece of button cap 40, which may improve sealing of switch 10. All three components may have translucent portions or may be completely translucent. By using such different types of materials, these three components may transmit light of a different color, thus facilitating identification of switch 10. Second portion 22 is configured to distribute light also to rim 43, if present.

[0057] An indicator element 80 may optionally be provided on the actuation part 41. It can be adhered to or pressed into a recess on actuation part 41. Indicator element 80 is preferably a separate component, and may be a mask or optical filter. It includes an area 81

having a first optical property (e.g. non-translucent) and an area 82 having a second optical property (e.g. translucent), which allows the indication of a graphical symbol on switch 10. An example in which the indicator element is provided as a respective mask is shown in Fig. 6. In other implementations, the areas 81, 82 may transmit light of a different color, or only one area or further additional areas having different optical properties may be provided. Indicator element 80 may facilitate identification of a function of switch 10 and may thus improve operational safety.

[0058] Turning back to Fig. 1, the button cap 10 has a mounting portion 44 by which it is fixedly mounted to the second portion 22 of optical waveguide component 20. Second portion 22 is arranged between the mounting portion 44 and bellows 42 so that the distribution of light is not disturbed by mounting portion 44. Mounting portion 44 may include latches, locking tabs, or a circumferential sleeve arranged inside second portion 22. Mounting portion 44 and second portion 22 may be latched together so that they do not move relative to each other when the button cap 40 is actuated by a user. A latching member 28, as shown in Fig. 3, may be provided, e.g. in form of a hole or a latching nose, which engages a complementary engagement member (nose or hole) on the mounting portion 44. A compact and simple arrangement can thereby be achieved.

[0059] A central axis of button cap 40 and switching element 51 in actuation direction 12 define a central axis 11 of the switch 10. Light-emitting device 52 is offset laterally (perpendicular to the actuation direction 12) from the central axis 11. First portion 21 is thus likewise offset from central axis 11; as shown in Fig. 1, it is in particular spaced apart from a projection of the second portion 22 in the actuation direction 12 (i.e., the projections of portions 21, 22 into a plane perpendicular to direction 12 will not intersect). By such offset arrangement, a compact configuration is achieved.

[0060] A lower portion 30 of waveguide component 20 includes one or more sidewalls 31 that extend substantially in the actuation direction 12 (Fig. 3). Although lower section 30 has a rectangular cross-section with three sidewalls 31, other configurations, such as providing of two sidewalls, a circular or oval sectional sidewall, or the like is also possible. As shown in the bottom view of Fig. 4, a side face 33 of lower portion 30 is open, and the first portion 21 is arranged in or at the side face 33. In other implementations, a further fourth sidewall 31 may be provided. The open side face 33 with the first portion 21 is also visible in Fig. 5.

[0061] In either implementation of lower portion 30, two or more guide elements 32 (Fig. 3) are provided to guide the movement of light wave component 20 in actuation direction 12. Guide elements 32 are provided as protrusions or ridges that are guided in complementary guide elements 67 (Fig. 4) of housing 60. Lower portion 30 is arranged in the lower part 66 of housing 60 and guide elements 67 are provided in the walls of lower housing part 66. Guide elements 67 may be slots or recesses in housing part 66, as shown in Figs. 4 and 5. At least two sides of a guide element 32 engage corresponding two sides of a guide element 67 slidingly and in a formfitting manner. Lateral movements may thus be avoided and a secure movement in actuation direction without jamming of waveguide component 20 may be ensured. Optical waveguide component 20 may thus provide at least three functions, namely the transmission of the actuation stroke, the guiding of the light to the button cap, and mechanical guidance within the housing. Since button cap 40 is fixedly connected to optical waveguide component 20, the movement of button cap 40 is likewise guided with minimum play. Compactness is thus further increased.

[0062] Electrical unit 50 may include a circuit board 54 to which switching element 51 and LED 52 are fixedly mounted. It may further include a control circuit 55, which may change an operating state of switch 10 according to an actuation of switching element 51 and may further control the light color of LED 52. Circuit board 54 may be fixedly mounted with respect to housing 60.

[0063] Housing 60 includes a first part 61 in which the waveguide component 20 is guided and a second part 62. A sealing lip 45 of bellows 42 is secured or clamped between housing parts 61, 62. Circumferential ridges and recesses on sealing lip 45 and the flexible material of bellows 42 may ensure an effective and secure sealing of bellows 42 to housing 60. Further, as bellows 42 is injection-molded with the actuation part 41, the sealing can be made very effective and switch 10 can be used in harsh environments. Second housing part 62 may be a frame as shown in Fig. 5, or may be a cover panel or cover plate that covers the first housing part of plural switches 10, as schematically indicated in Fig. 6. Only the second housing part 62 and the button cap 40 with its integrated actuation part 41, bellows 42 and optional rim 43 may thus be exposed to the harsh environment.

[0064] Bellows 42 further provides the return for switch 10 after switch 10 has been depressed. Bellows 42 may be deformed, in particular folded, upon depression of button cap 40, and the return force of bellows 42 may restore the button cap 40 into its initial equilibrium position upon release of the pressure. No additional return component is thus necessary, thereby further reducing complexity and improving compactness of the switch.

[0065] In other implementations, an additional return device may be provided. By displacing the first portion 21 and the light-emitting device 52 from the central axis 11, it becomes possible to centrally provide such additional return device, e.g. as a spring around the central axis 11 or the like. The reliability of returning switch 10 into its original position may thereby be improved.

[0066] The bellows 42 may be configured to provide a tactile feedback on a switching point of switch 10. The structural configuration of bellows 42 may be such that when the button cap 40 is depressed sufficiently to actuate the switching element 51, a (sudden) change in

actuating force may provide a respective tactile feedback.

[0067] Fig. 7 illustrates a method that may at least partially be implemented by the control circuit 55 of the electrical unit 50 of switch 10. In step 701, the switch is operated in a disabled mode with background lighting. Circuit 55 may control LED 52 to emit light of a first color which is distributed via waveguide component 20 to the actuation part 41, in particular to an actuation surface thereof, and bellows 42, and optionally to rim 43. In such state, the switch 10 may for example be in a logical 0 switching state. In step 702, the button cap 40 is depressed by a user, wherein the optical waveguide component 20 transfers the actuation stroke to the switching element so that the switching element 51 is actuated via the protrusion 25. Upon release of the pressure by the user, button cap 40 returns to its original position as described above. Switching element 51 may give out an electrical signal upon being actuated, i.e. by electrically connecting its input and output terminals for the duration of the actuation.

[0068] Control circuit 55 detects the actuation and operates the switch in an enabled mode, which may correspond to a logical state of 1. Circuit 55 may further control LED 52 to emit light of a second color that is different from the first color. As the light is distributed by the waveguide component 20 to the elements of the button cap 40, the user can readily recognize whether the switch 10 is in the logical state 0 or 1, i.e. whether it is disabled or enabled. As an example, white light at lower intensity may be used as background lighting, and in the enabled mode, the light color may be switched to a signal color, such as green, red, or the like. Operational safety may thereby be increased as the operator can recognize the switch state even when focusing on the task at hand and being disturbed by vibration, harsh conditions and the like. Further, as the bellows 42, the rim 43, the actuation part 41 and optionally the indicator element 80 may have different optical properties, such as a different degree of translucency or different color-filtering properties, the switch 10 allows the different parts of button cap 40 to be illuminated in different colors, which may improve the operability of switch 10 and facilitate recognizing its function and/or state.

[0069] It should be clear that upon a further depression of a button cap 40 and thus actuation of switching element 51, control circuit 55 may cause switch 10 to return to the initial disabled state, or to enter into a further enabled state, which may be indicated by even a different color. For example, repeated actuation of switch 10 may cycle through different operation modes of switch 10, and control circuit 55 may cause light-emitting device 52 to indicate the respective operating mode by a different color. Versatility of switch 10 may thereby also be improved.

[0070] While specific embodiments are disclosed herein, various changes and modifications can be made without departing from the scope of the invention. The present embodiments are to be considered in all respects as illustrative and non-restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

List of reference signs

[0071]

10	electrical switch
11	central axis
12	actuation direction
20	optical waveguide component
21	first portion
22	second portion
23	intermediate portion
24	stepped surface
25	projection/plunger
26	receiving end face
27	exit face
28	latching member
29-1	first exit face of intermediate portion
29-2	second exit face of intermediate portion
30	lower portion of waveguide component
31	side wall of waveguide component
32	guide element
33	side face
40	button cap
41	actuation part
42	flexible bellows
43	rim
44	mounting portion
45	sealing lip of bellows
50	electrical unit
51	switching element
52	light emitting device
53	light emitting area
54	circuit board
55	control circuit
60	housing
61	first housing part
62	second housing part
65	upper part of housing
66	lower part of housing
67	guide element of housing
80	indicator element/mask
81	area of first optical property
82	area of second optical property
701-703	method steps

Claims

1. An electrical switch, comprising:

- a button cap (40), wherein the button cap (40) has an actuation part (41) configured to be actuated by a user and a flexible bellows (42) extending circumferentially around the actua-

tion part (41), wherein the actuation part (41) and the bellows (42) each have at least one translucent portion;
- an electrical unit (50) that comprises a switching element (51) and a light emitting device (52); and
- an optical waveguide component (20) that is arranged between the button cap (40) and the electrical unit (50) and that is in engagement with the button cap (40),
wherein the optical waveguide component (20) has a protrusion (25) configured to actuate the switching element (51), the optical waveguide component (20) being movable in an actuation direction (12) to mechanically transmit an actuation stroke from the button cap (40) to the switching element (51) via the protrusion (25),
wherein the optical waveguide component (20) further comprises a first portion (21) that extends in the actuation direction (12) towards the light emitting device (52) to receive light from the light emitting device (52) and a second portion (22) that extends towards the button cap (40) to emit light towards the button cap (40), the optical waveguide component (20) being configured to guide light from the first portion (21) to the second portion (22), wherein the second portion (22) is configured to distribute the light at least towards the translucent portion of the actuation part (41) and the translucent portion of the bellows (42) to illuminate the actuation part (41) and the bellows (42).

2. The electrical switch according to claim 1, wherein the second portion (22) extends between the bellows (42) and a mounting portion (44) of the button cap (40).

3. The electrical switch according to claim 1 or 2, wherein the second portion (22) of the optical waveguide component (20) is formed as a sleeve, and wherein the button cap (40) comprises a mounting portion (44) that extends from the actuation part (41) in a direction towards the switching element (51), wherein the mounting portion (44) is arranged inside the sleeve of the optical waveguide component (20).

4. The electrical switch according to claim 2 or 3, wherein the mounting portion (44) is fixedly connected to the second portion (22).

5. The electrical switch according to any of the preceding claims, further comprising a housing (60), wherein the switching element (51) is mounted stationarily with respect to the housing (60).

6. The electrical switch according to any of the preceding claims, wherein the electrical switch comprises a housing (60) having an upper part (65) in engagement with the button cap (40) and having a lower part (66) in which the switching element (51) is arranged, wherein the optical waveguide component (20) comprises a lower portion (30) that extends in the lower part (66) of the housing (60), wherein the lower portion (30) comprises one, two, or more first guide elements (32), each being guided in a complementary second guide element (67) provided in the lower part (66) of the housing (60).

7. The electrical switch according to any of the preceding claims, wherein the electrical switch (10) comprises a return unit configured to return the button cap (40) to an initial position after the button cap has been depressed by a user, wherein the return unit comprises or consists of the bellows (42).

8. The electrical switch according to any of the preceding claims, wherein the second portion (22) of the optical waveguide component (20) is formed as a sleeve, and wherein the optical waveguide component (20) comprises an intermediate portion (23) that extends between the first portion (21) and the second portion (22), wherein the intermediate portion (23) has a tapered shape to distribute light from the first portion (21) to the sides of the sleeve, wherein a surface (24) of the tapered shape that faces the switching element (51) is stepped.

9. The electrical switch according to any of the preceding claims, wherein the optical waveguide component (20) has a lower portion (30) including one or more side walls (31) that extend in the actuation direction and at least partially surround the switching element (51) when the button cap (40) is depressed, wherein the lower portion (30) further includes a side face (33) at which the first portion (21) of the optical waveguide component (20) is arranged, and/or wherein a thickness of the one or more side walls (31) is smaller than a thickness of the first portion (21), and/or wherein the one or more side walls (31) extend in the actuation direction (12) beyond an end face (26) of the first portion (21) via which the first portion (21) receives light from the light emitting device (52).

10. The electrical switch according to any of the preceding claims, wherein a cross sectional area of the first portion (21) in a plane perpendicular to the actuation direction (12) is spaced apart from a projection of an area that is enclosed by the second portion (22) and that is projected in the actuation direction (12) into said plane.

11. The electrical switch according to any of the preceding claims, wherein the button cap (40) comprises a rim (43) encircling the actuation part (41), the rim (43)

having a translucent portion, wherein the second portion (22) of the optical waveguide component (20) is configured to distribute light towards the translucent portion of the rim (43).

12. The electrical switch according to claim 11, wherein the actuation part (41) is made of a first material and the rim (43) is made of a second material that differs from the first material at least by its translucent properties, wherein the actuation part (41), the rim (43), and the bellows (42) are preferably formed integrally.

13. The electrical switch according to any of the preceding claims, further comprising a control circuit (55) configured to control the light emitting device (52) to emit a light of a first color when the electrical switch (10) is in a passive state, and to set the electrical switch (10) into an active state upon detection of an actuation of the switching element (51), wherein the control circuit (55) is configured to control the light emitting device (52) to emit a light of a second color that is different from the first color when the electrical switch (10) is in the active state.

14. A control panel of a mobile machine comprising an electrical switch (10) according to any of the preceding claims.

15. A method of operating an electrical switch (10) according to any of the preceding claims, wherein the method comprises:

- receiving at the first portion (21) of the optical waveguide component (20) light emitted by the light emitting device (52);
- transmitting, via the optical waveguide component (20), the received light from the first portion (21) to the second portion (22); and
- distributing, via the second portion (22) of the optical waveguide component (20), the light at least towards the actuating part (41) and the bellows (42).

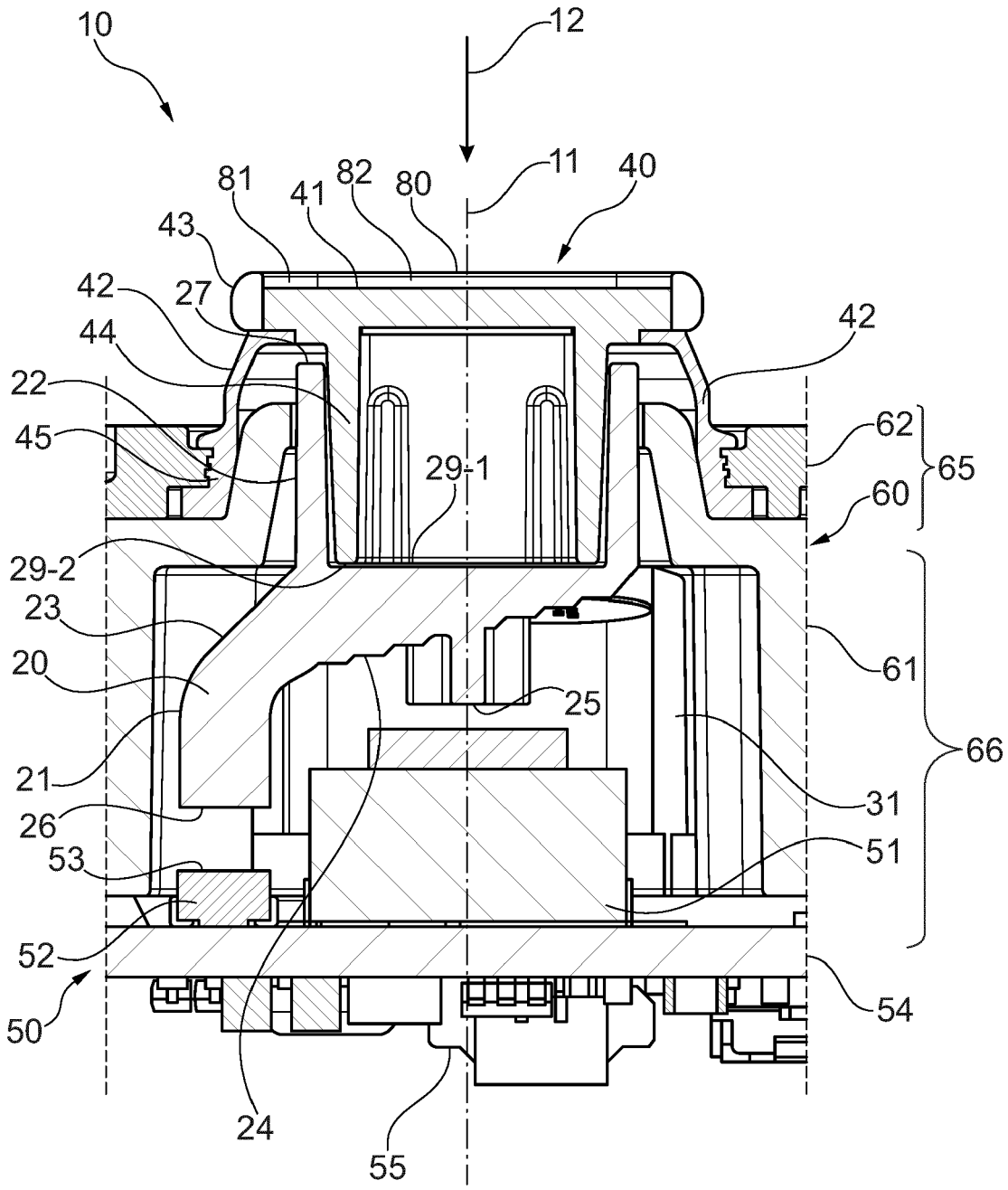
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Fig. 1

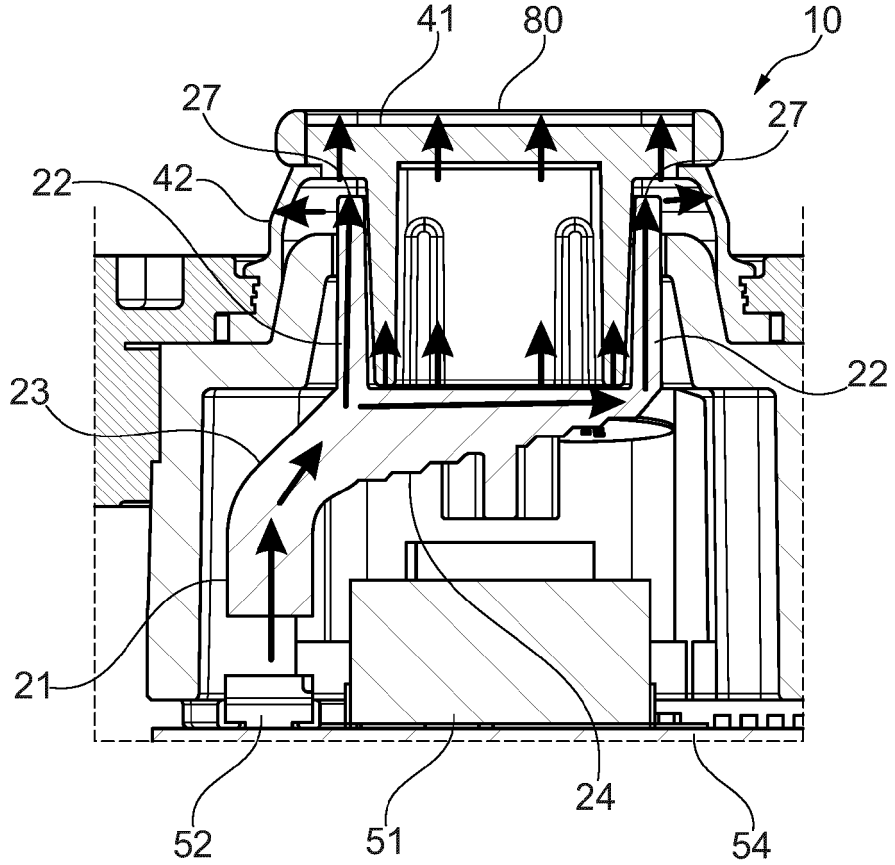

Fig. 2

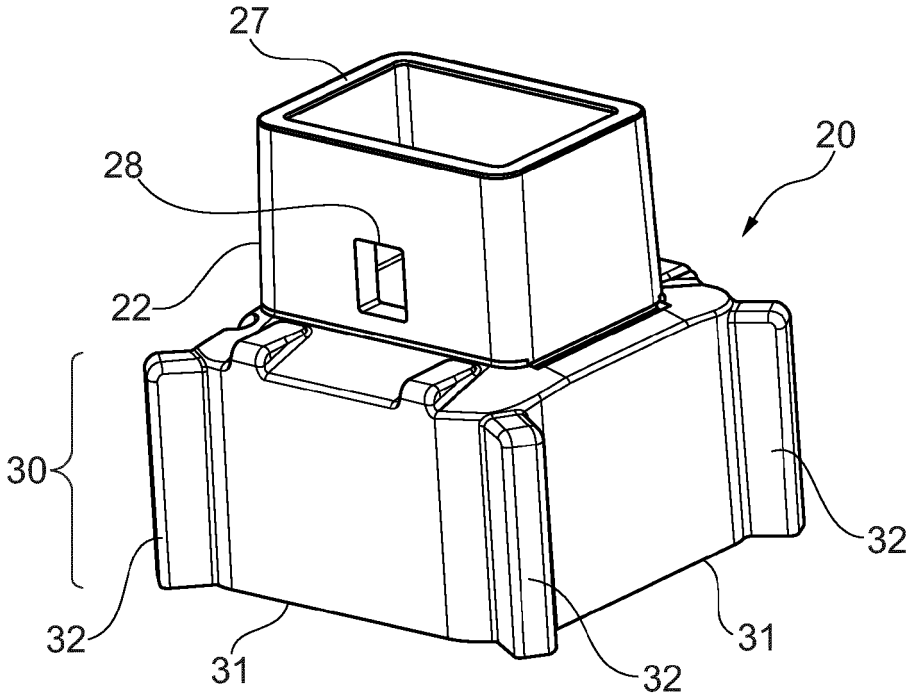

Fig. 3

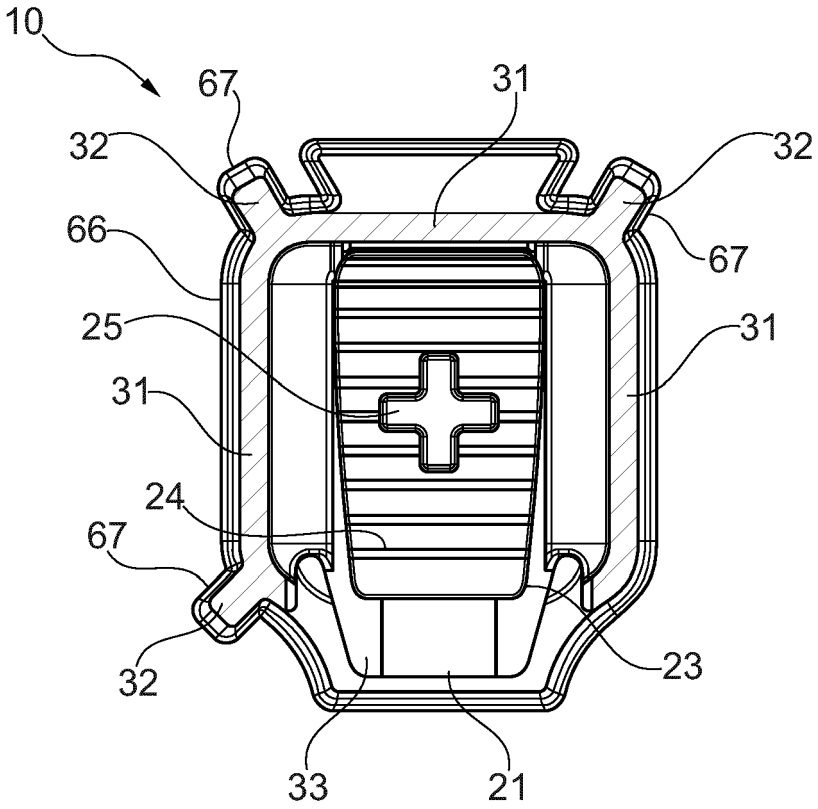
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Fig. 4

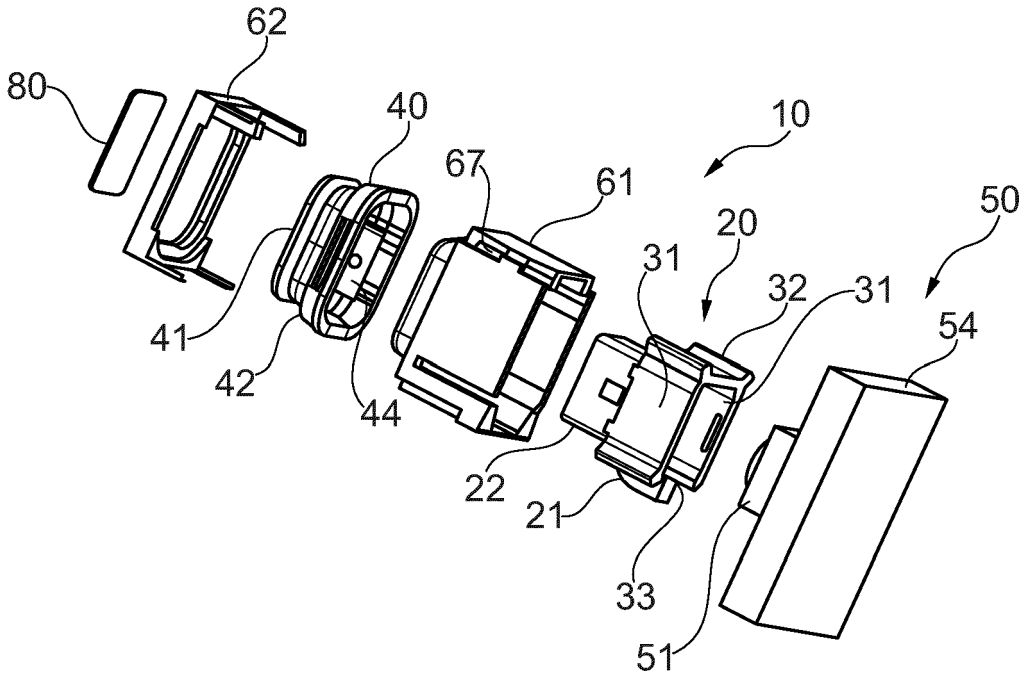
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Fig. 5

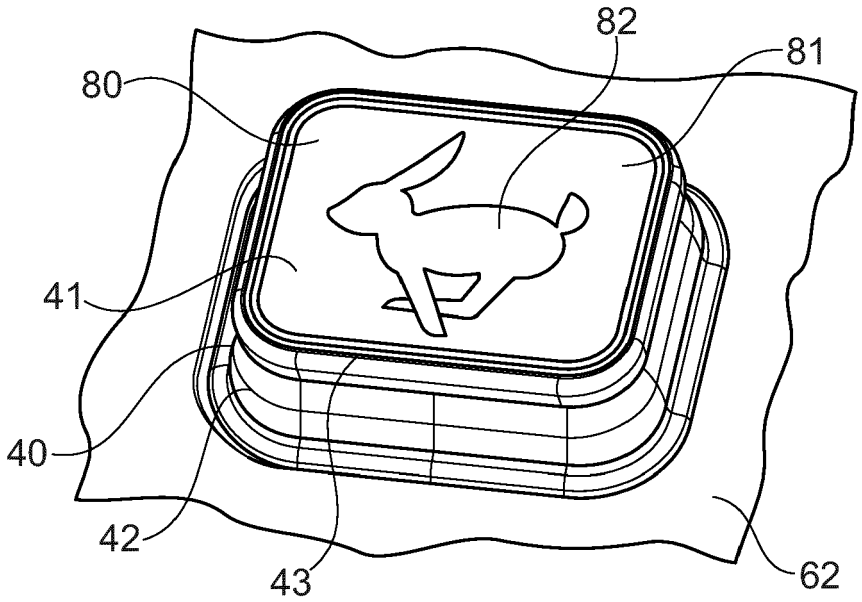
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Fig. 6

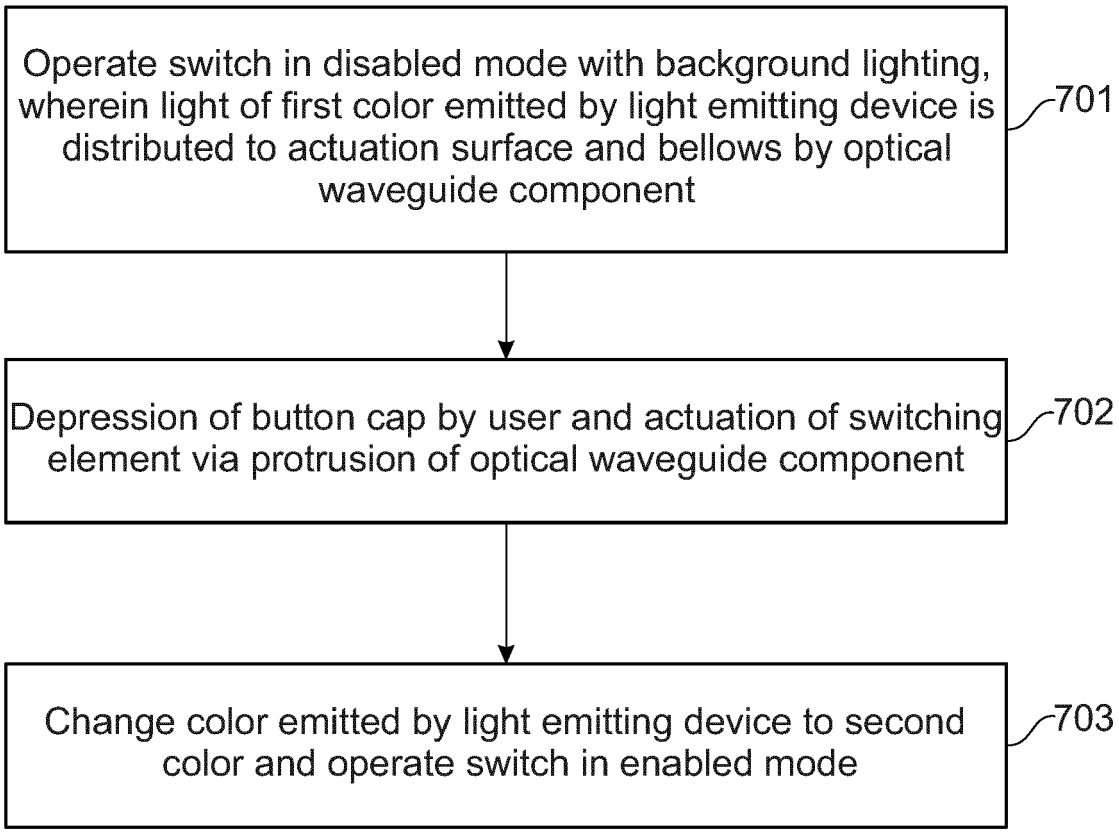
Operate switch in disabled mode with background lighting, wherein light of first color emitted by light emitting device is distributed to actuation surface and bellows by optical waveguide component
701
Depression of button cap by user and actuation of switching element via protrusion of optical waveguide component
702
Change color emitted by light emitting device to second color and operate switch in enabled mode
703

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 2500

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H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 January 2024	Glaman, C

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