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Design of a Multi-Functional Portable Lighting Device

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Abstract: In this study, we consider the ways to enhance the functionality of portable lighting devices which are increasingly used by human in his activities. We considered the influence of the light source used in it on the performance of such a light fixture. In particular, we have showed that the LED use as a light source allows expanding the functionality of a portable lighting device. We considered the options for improving their performance on the example of a portable lighting device with an extension cord. Taking into account the majority of the considered technical solutions, we developed a portable LED lighting device. We considered its structure and purpose of the component elements in detail. For practical verification of the concept proposed, we created a corresponding model of a portable LED lighting device and carried out some studies of its lighting characteristics. The studies have shown that the designed multifunctional portable lighting device provides the same luminous flux as a 60 W incandescent lamp which is usually used in portable lighting devices for local lighting while the light output of the developed lighting device is three times more than the light output of a portable fixture with incandescent lamp.

Key words: Portable lighting device, multifunctionality, LED lamp, prototype of a lighting fixture, activities, Russia

INTRODUCTION

Among all the variety of lighting devices used by human in his activity, attention should be paid to the portable Lighting Devices (LDs). Since, they allow expanding the scope of human activity. In this case, we consider the network portable LDs which are intended for the temporary local illumination of working surfaces when working in conditions of remoteness from a stationary light source and disconnected from the supply network when the LDs are moved. The assortment of such LDs is quite widein the lighting market. So, initially they used the Incandescent Lamps (ILs). The nomenclature of portable lighting fixtures is expanding with the development of light sources (Fig. 1). With the emergence of small-sized linear Fluorescent Lamps (FLs), portable lighting fixtures appeared on their basis (Ashryatov and Prytkov, 2014).

The development of energy-saving Compact Fluorescent Lamps (CFLs) made it possible to replace the incandescent lamps in portable lighting fixtures. The use of compact fluorescent lamps makes it possible to reduce their overall dimensions (Fig. 2).

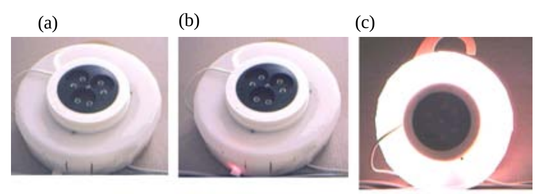

Fig. 1: Portable MOS for local lighting based on FLs of LBC 22 type: a) General form; b) The MSP location indicator lights next to the FL switch and c) MOS with extended hook

The use of high-performance LEDs further enhances the performance of portable lighting fixtures as the energy consumption and weight-size LD parameters decrease, the vibro and impact strength increases as well as the environmental safety and the absence of the need for special recycling of a lighting fixture (Anonymous, 2014). However, the existing Portable Lighting Devices (PLD) cannot be fully attributed to the multifunctional LDs.

Analysis of status and directions of multifunctionality development of portable lighting devices: As a rule, the PLDs are used in cases where temporary workplace lighting is required for any work. If any power tools are

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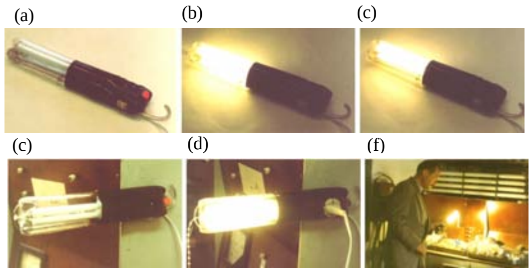

Fig. 2: Portable MOS for local lighting based on CFLs of KL9/TBC type: a) General form with a luminous MOS position indicator; b) MOS lighting without a reflector; c) MOS lighting with a reflector; d) MOS mounting to a flat metal surface using magnets; e) Connection to a MOS of another electrical device and f) Example of MOS operation with a reflector

used for the work production, the electrical extension cables should be used to connect it to the power supply network, that is an extended supply wire which has an electric plug at one end and an electrical outlet on the other end. In this case, on the one hand, it is necessary to have two stationary outlets for connecting the PLDs and an extension cord, on the other hand two feeding independent conductors they cause certain inconvenience in operation, since, the probability of their damage increases twice which may lead to the electric circuit closure or damage to the worker with supply voltage. Therefore, in order to increase the PLD functionality, it should also perform the function of an extension cord, that is at least one outlet should be provided in its design (Anonymous, 2010).

MATERIALS AND METHODS

The PLD with an extension cord should be equipped with a light source switch which will allow using it only as an extension cord. It is advisable to provide the switch with an indicator operating in a flashing mode which makes it easy to find the PLD connected to the power network with the light source turned off in a darkened room.

In order to increase the PLD functionality, it is necessary to provide the possibility of changing its light distribution at least providing two lighting functions: general and local lighting (Anonymous, 1994).

Thus, the use of LEDs as light sources in the PLDs allows designing the full-fledged multi-functional portable lighting devices. So, using LEDs with different LICs in the optical part of the PLDs by combining their switching on and adjusting the supply current, vary them within a wide range of LIDCPLD (Ashryatov and Prytkov, 2014). By adding RGBLEDs to the optical part of the PLDs, it becomes possible to use the PLDs as a light-signal device or to adjust the color emission of the PLDs. Given the relatively small weight of the component base, it becomes possible to mount the PLDs to the flat soft magnetic materials using the permanent magnets. Since, in the vast majority of cases the PLDs have an elongated structure, that is, the length of lighting fixture significantly exceeds its cross-section, it is advisable to have two hooks for suspending the PLDs which should be located at opposite ends of the lighting fixture. This will allow, if necessary, fastening the PLDs in a horizontal position. To reduce the overall dimensions of the PLDs, the hooks should be retractable (Eisenberg, 2006).

Taking into account most of the above recommendations, we developed a portable LED LD (Fig. 3), protected by a utility model patent. Storage and transportation of both the PLDs and the extension cord without a suitable device for winding the extension wire causes certain inconveniences. Therefore, as a basis for the PLD developed, we selected a coil 1, on which the feed wire 16 PLD with the electric plug 17 is unwound and the auxiliary elements are disposed in the cavity of its cylindrical core when stored: on the one hand switch 7 and output 8, on the other permanent magnets 15 and inside power driver 9 of LEDs 4.

Since, the LEDs 4 generate heat during operation, they are therefore, located on a flat heat conducting material 3 which is located at some distance from the pin 2 of the coil 1 to enable cooling air to move.

There are LEDs 4 which are covered by a diffuser 5 to reduce their glossiness, on the side of a switch 7, on the flat heat conducting material 3. There is a retractable hook 12 for the PLD suspension on the opposite side (Fig. 3b and c). The hook 12 is in the folded state in Fig. 3b and the hook 12 is extended in Fig. 3c. To prevent rolling of the coil, one of the pins 2 and the flat heat conducting material 3 is given the shape of the polyhedron. In this case, the PLD on a flat surface rests on the face of one pin 2 and on the circle of another 10, that is it rests on three points which ensures its stable position on the surface. In order to fix the required length of the supply wire 16, a special cut-out 18 with elastic elements fixing the supply wire 16 is placed on the circular pin 10 (Fig. 3c).

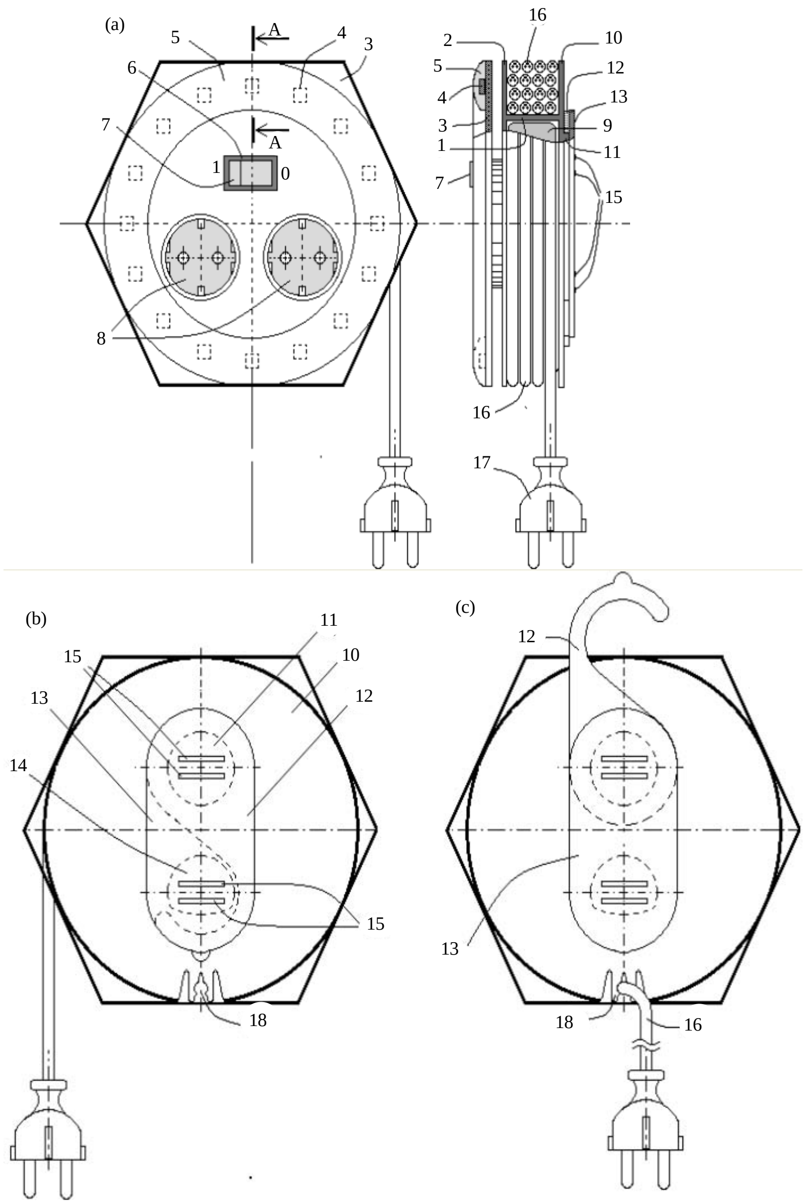

Fig. 3: a-c) General form of a multifunctional portable LD

RESULTS AND DISCUSSION

Experimental studies of a prototype model of a multifunctional portable lighting device: For practical verification of the proposed concept, we created a corresponding prototype model of the PLD (Fig. 4). We used 12 modules MX3AWT-A1-0000-000BE5-SQ with Cree XLamp MX-3 LEDs as light sources. The power of the series-connected LEDs was provided by a driver ELP18X1CS. When feeding the PLDs from the AC mains with a frequency of 50 Hz and a voltage of 220 V, the power consumption was 18 W, the current 92 mA and the power factor -0.9.

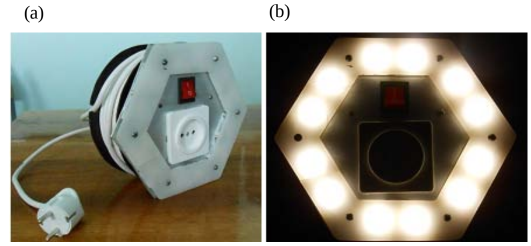

Fig. 4: a, b) General form of the prototype model of a multifunctional PLD

Estimating the stabilization time of light characteristics has shown that this process lasts about

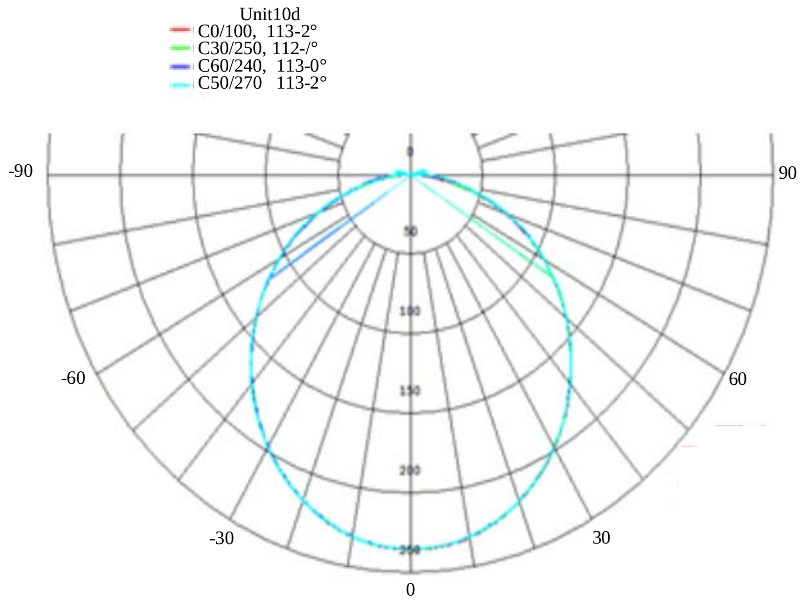

Fig. 5: LIC of the prototype model of the LED portable LD

25 min while the luminous flux of the lighting fixture decreases by 10% and reaches 690 Lm and the light output is 38 Lm/W. The Light Intensity Curve (LIC) of the lighting fixture is similar to the LED LIC and has a cosine type (Fig. 5).

Since, the PLD also performs the function of an extension cord which involves using it to power various power tools, the important characteristic of this lighting fixture is the value of the ripple factor. To measure K_p, we used a light meter-pulsometer "TKA-PKM" (08). The measurement of K_p showed that at a supply voltage of 220 VK_p = 35% with an increase in the supply voltage to 240 VK_p decreases to 33.8% and with a decrease in the supply voltage to 200 VK_p increases to 36.4%. The results show that this driver is suitable for this lighting fixture. In this case, it is required a driver which should provide K_p value close to 0%. This is necessary in order to exclude the possibility of a stroboscopic effect when using a power tool with a rotating working body (Anonymous, 1994, 2010, 2014).

Summary: Thus, the use of LEDs in the design of multifunctional portable lighting devices offers ample opportunities to increase their functionality.

CONCLUSION

The results show that the designed multifunctional portable lighting device provides the same luminous flux as a 60 W incandescent lamp which is usually used in portable lighting devices for local lighting while the light output of the developed LED PLD is three times more than the light output of the IL. When designing such multifunctional PLDs, special attention should be paid to selecting the appropriate component base.

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