The New Structure Design and Simulation of Anti-electric Shock Multi-jacks Socket

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Abstract: The design to meet consumer demand for safe, durable, attractive appearance and easy to use of socket, is an improvement and innovation in appearance and structure of the multi-jacks socket from anti-electric shock, multi-functional, intelligent, environmental protection and others. The new multi-jacks socket has the properties of anti-electric shock, automatically incorporating wires, jacks different direction, beautiful appearance, and it can be the decoration of home space.

Keywords: Anti-electric shock, multi-jacks socket, structure design, simulation, mathematics analysis.

1. INTRODUCTION

Socket is a very common power connection. It is because of commonplace, we often easily overlook its potential security risk. According to "China Statistical Yearbook fire" and other relevant information, electrical fires occurred in China each year accounted for more than 30% of the total annual fires, which caused as a result of poor quality switches and sockets account for a large percentage.

With the improvement of the condition of the family, the increasing use of household appliances, many families prefer multi-jacks socket because of its multi-purpose. But the jacks of multi-jacks socket are generally not all be used simultaneously, the spare jacks will be a threat to the child at home. Because the children are born good move and have a desire to explore for everything. They will maybe put the nail or finger into the spare jacks and cause electric shock. The lengthy wires of multi-jacks socket can provides the convenience of use, but it can also cause problems, for example, the jumbled wire not only impedes the cleaning, but also it is placed difficulty. In addition, the existing multi-jacks socket space is designed unreasonably, when we insert a large plug into a jack, the large plug will occupy the adjacent space and the adjacent jack will can not be used. This adaptive innovation design based on TRIZ theory [1] is to solve the above problems.

2. APPEARANCE DESIGN OF NEW MULTI-JACKS SOCKET

2.1. Appearance Shape of New Multi-Jacks Socket

Fig. (1) illustrates the overall appearance shape of new multi-jacks socket. It is similar to starfish with six horns.

2.2. Appearance Color of New Multi-Jacks Socket

Color is an important factor for appearance design, because color can directly affect the purchase intent of consumers or users [2]. In order to match the psychological needs of customers and adapt to the color of the home space, the new multi-jacks socket is designed fresh and bright colors. In this article, the color is described by CMYK. As shown in Fig. (1), main color of the new multi-jacks socket is white (C:0,M:0,Y:0,K:0); translucent protective cover is blue (C:99,M:77,Y:0,K:0, Transparency:50%); rounded platen and master switch are red purple(C:49,M:71,Y:0,K:0).

3. STRUCTURE DESIGN AND SIMULATION OF NEW MULTI-JACKS SOCKET

New multi-jacks socket is mainly composed of switch, rounded platen, winding plate, translucent protective cover, socket cap, anti-electric shock device and back cover. The assembly of these structures follows modular design principle and can be realized DIY disassembly or assembly [3].

3.1. Structure of Anti-electric Shock Device

As shown in Fig. (2), anti-electric shock device is mainly composed of spring 1, spring 2, jib 3, stent 4, conductive connection block 5, conductive strip 6. The operation principle of anti-electric shock device is: when an object like a nail
or other conducting object is inserted into a hole of jack, due to contact with point between object and jib, the object is easy to slip and cannot contact with the conductive strip. The object cannot be charged. Even without slipping, since there is a unilateral force on jib, jib will be rotated to the upper plastic body of conductive strip and be forced to stop. The jib can motion neither downward nor rotation. The conductive connection block could not contact with the conductive strip, so the object can not be charged too. When two objects like nails or other conducting objects are inserted into the two holes of jack in the same time, due to the unstability of a child holding small items like nails, the two jibs of anti-electric shock cannot move down at the same speed, in the same direction and in the same time, it means the stent will be inclined. At this time, the jibs will bounce back under the action of the elastic force of the spring 1, so the objects cannot be contacted with the conductive strip and electric shock accident can not occur. However, when a plug is inserted into the jack, because of that the movement of plug is restricted by jack shape, the plug will can only move down and not offset. So, two metal strips of plug will stably move down along the jibs to contact with conductive connection block until the elasticity of spring 2 reaches the maximum. Then, the two jibs will rotate in the opposite direction to respectively contact with conductive strips and the plug is electrified, as Fig. (3) is shown. Since the conductive connection block is inserted and fixed on jibs and through jibs, so when the jibs connect with the conductive strips, it is the conductive connection blocks that contact with conductive strips directly. When plug moves away from outlet, due to elasticity of the spring 1 and spring 2, jibs will revert to the initial state.

Fig. (2) shows that there is a certain inclination angle and distance between conductive connection block and conductive strips. If the downward movement process of plug does
not reach the predetermined depth, the plug is not energized. That is to say, we will not be shocked even if we pull or insert the plug directly holding the metal strips of plug. It is very convenient and safe for those who like to operate plug using a single hand.

3.2. Structure of Winding Plate

Winding plate is located the center part of the new multi-jacks socket. Fig. (4) illustrates the structure of winding plate. It is mainly composed of reel 2, rounded platen 1, upper chassis 3, winding rods 4, bottom chassis 5 and electric brush 6. The function of winding plate is to automatically incorporate the wire. In Fig. (4), reel 2, which is made from metal and appressed upper chassis 3, will be energized and turned when electric brush 6 is pressed down and contacted with it by the rounded platen 1. The friction force on the upper chassis 3 of reel 2 will make the whole composed of upper chassis 3, winding rod 4, and bottom chassis 5 turn. Thus the power wire of new multi-jacks socket is rolled in the winding rods 4.

4. MATHEMATICAL MODEL OF THE PRESSURE DISTRIBUTION OF ANTI-ELECTRIC SHOCK DEVICE

In order to ensure the feasibility and stability of anti-electric shock device, it is necessary to analyze the forces on the device and make a mathematical analysis. The Fig. (5) illustrates the every force which acted on the anti-electric shock device. In order to make conductive connection block contact with conductive strip successfully, the stent must be always in the horizontal state, that is, in the process of inserting plug into the jack, the two jibs must move down in same
speed. So, spring 2 and spring 1 cannot start deforming at the same time. Spring 1 cannot work until the elasticity of spring 2 reaches the maximum. This requires the elasticity coefficient of spring 2 and spring 1 meets a certain proportion.

In Fig. (5), some symbols are expressed as follows:

- $F_1$ --- the elasticity of spring1, N;
- $F_3$ --- the elasticity of spring2, N;
- $F_2$ --- the force on the jibs, N;
- $F_n$ --- the force on the stent, N;
- $M_G$ --- the gravity of spring1, spring2, jib, stent, and conductive connection block, N;
- $\alpha$ --- the angle jibs and stent, Degree
- $\theta$ --- the angle between jibs and spring2, Degree;
- $L_1$ --- the distance from spring1 to stent, mm;
- $L_2$ --- the distance from the bottom endpoint of jibs to stent, mm.

Some of them can be expressed by equations, as follows:

$$F_2 \cdot \frac{L_2}{\cos \theta} = F_1 L_1$$  \hspace{1cm} (1)

$$2F_2 \cdot \sin \theta + M_G = F_3$$ \hspace{1cm} (2)

$$F_1 = k_1 \cdot X_1$$ \hspace{1cm} (3)

$$F_3 = k_3 \cdot X_3$$ \hspace{1cm} (4)

where,

- $k_1$ --- the elasticity coefficient of spring1;
- $k_3$ --- the elasticity coefficient of spring2;
- $X_1$ --- the stretched length of spring1, mm;
- $X_3$ --- the stretched length of spring2, mm.

Use of Equation (1)-(2), we have:

$$F_3 = 2 \cdot \frac{F_1 \cdot L_1}{L_2} \sin \theta \cdot \cos \theta + M_G$$ \hspace{1cm} (5)

Equation (5) shows that $F_2$ does not affect the function realization of the anti-electric shock device. It indicates that the quality of plug has no influence on the whole mechanism. Thus, the stability of anti-electric shock device can be guaranteed.

According to the condition which must be satisfied to realise the mechanism principle, and simulation in PRO/E software, we get some physical figures as:

$$M=0.96g, \ \theta = 30^\circ, \alpha = 45^\circ, L_2 = 7.3mm, L_1 = 2.5mm, \ X_1 = 0.7mm, \ X_3 = 1.9mm$$

Use equation (3)-(4) and put these figures into Equation (5), we get:

$$k_3 / k_1 = 11.3$$ \hspace{1cm} (6)

From Equation (6), we know that the function of anti-electric shock will be achieved as long as the coefficient ratio of spring 2 and spring 1 is 11.3.

**CONCLUSION**

Aiming at these problems such as poor efficiency of anti-electric shock, easily tucking in motion mechanism and conductive failure of existing multi-jacks socket, the design provides a new anti-electric shock multi-jacks socket based on respecting the children's behavior rule. The new multi-jacks socket is designed an innovative anti-electric shock device; increased a winding plate, which can automatically incorporate the wire; and added a LED light that its color can change with the power of electric equipment. From the above-mentioned content, the new anti-electric shock device has the operability and superiority. And by mathematical analysis and computer simulation, it is shown that the function of new multi-jacks socket is normal and stable so long as the coefficient ratio of spring 2 and spring 1 is 11.3.

**CONFLICT OF INTEREST**

The author confirms that this article content has no conflict of interest.
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