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Ground Spring with Electrically Conductive Bristles

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ABSTRACT

Due to the relatively small size and shape of a knob, some portion of its internal circuitry is placed close to its external metal controller ring (bangle), making the circuitry vulnerable to electrostatic discharge (ESD). This disclosure describes techniques to establish a dedicated ESD pathway between electrical parts in relative motion (e.g., a controller bangle around a knob and the electronics housed within the knob) by using a spring-like metal structure comprising conductive bristles to receive electric charge from the bangle and to conduct it to ground via a trace on a printed circuit board (PCB) within the knob. ESD current is deflected from sensitive electronics and prevented from damaging it. The ESD current is carried away from the bangle to the PCB by conductive bristles, such that the smooth rotary movement of the bangle is unaffected and occurs without the production of unwanted noise or vibrations.

KEYWORDS

- Electrostatic discharge (ESD)
- ESD spring
- Conductive bristles
- Controller knob
- Thermostat knob
- Grounding cable
- Triboelectric charging

BACKGROUND

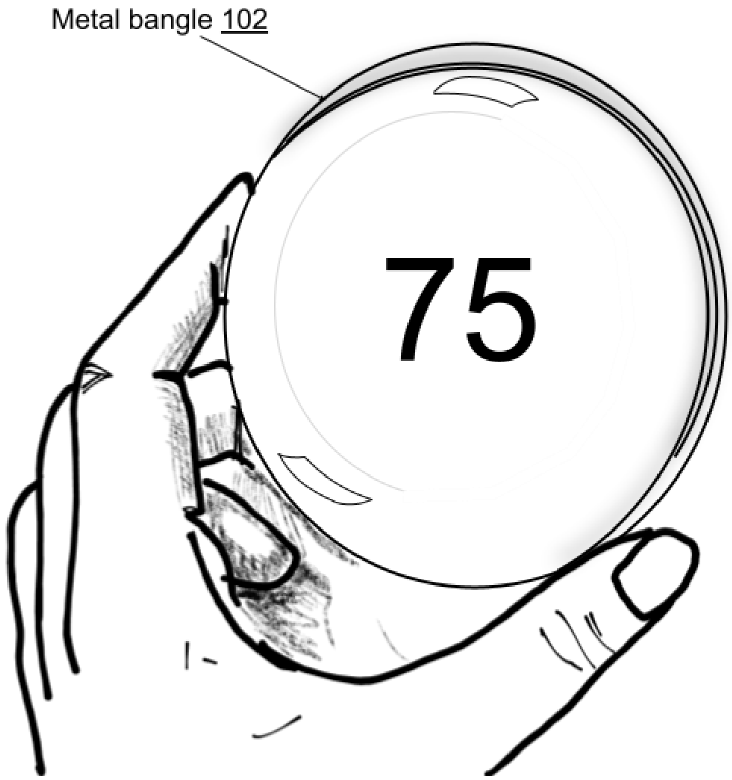

Fig. 1: A controller knob with a metal bangle

While the primary affordance of a knob on electrical equipment is to enable users to adjust parameters, knobs can themselves house a variety of sensitive electronic circuitry and sensors. For example, a controller knob for a thermostat, as illustrated in Fig. 1, can include temperature, pressure, and humidity sensors. For an attractive look, a polished metal ring or bangle (102) can encircle the knob. The user can adjust parameters or toggle between different features by rotating the bangle and selecting a certain feature by pressing the bangle.

Due to the relatively small size and shape of a knob, some portion of its internal circuitry may inevitably be placed close to the metal bangle, which makes the circuitry vulnerable to electrostatic discharge (ESD). This can happen because a user typically walks up to the device, potentially developing high amounts of electrostatic charge on their body through triboelectric charging, and then touches the metal bangle to rotate or press it. This delivers the charge to the bangle and to the nearby sensitive circuitry through secondary discharge, potentially damaging the circuitry permanently.

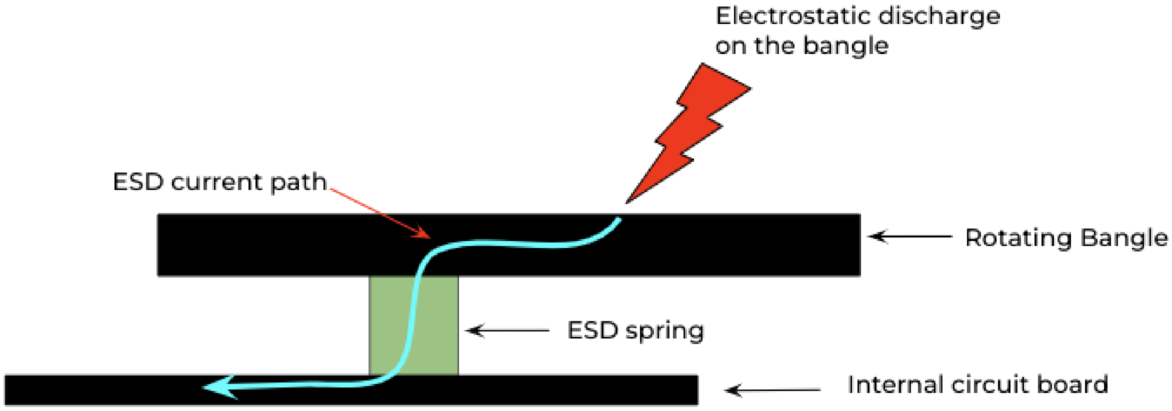

Fig. 2: An ESD spring to conduct electrostatic discharge between two moving parts

The problem of grounding a part (bangle) that is in motion relative to another part (PCB) for protection against either ESD or leakage current has been addressed previously. However, the solutions invariably result in a degraded user experience, e.g., a metallic grinding noise or unpleasant vibrations that arise when the parts are set in motion. For example, Fig. 2 illustrates a metal ESD spring that can be used between two parts in relative motion - a rotating bangle and an internal printed circuit board (PCB). The ESD spring establishes a current path that draws electrostatic charge away from sensitive electronics on the circuit board. Spring force maintains contact between the two parts to be grounded. However, relying on spring action to maintain contact between parts in relative motion results in grinding noises and vibrations, which, although a natural outcome of metals sliding against each other, result in a degraded user experience.

Another limitation of an ESD spring is that the continued use (by rotating) of the bangle by the user wears down the small spring part via friction. Not only can this result in the ESD spring losing electrical contact and failing to prevent electrostatic damage, metal shavings falling off the ESD spring can electrically short and damage the circuitry it is designed to protect.

DESCRIPTION

This disclosure describes techniques to establish a dedicated ESD current pathway by using a spring-like metal structure comprising conductive bristles to receive electric charge from the bangle and to conduct it to ground via a dedicated trace on the PCB. ESD current is thereby deflected from sensitive electronics and prevented from damaging it. The ESD current is carried away from the bangle to the PCB by conductive bristles, such that the smooth rotary movement of the bangle is unaffected and occurs without the production of unwanted noise or vibrations.

The bristle material can be any strong or partially conductive metal or composite such as iron fiber, carbon fiber, stainless steel, aluminum, copper, brass etc. The bristles can be held together by a combination of conductive glue, crimping, clamping, or soldering. The bristles touch the bangle and provide a soft contact, significantly reducing or eliminating grinding noises and vibrations. The base of the bristles, used to hold the bristles together, is made of electrically conductive metal. The base can be fixed to the circuit board using soldering, screws, etc.

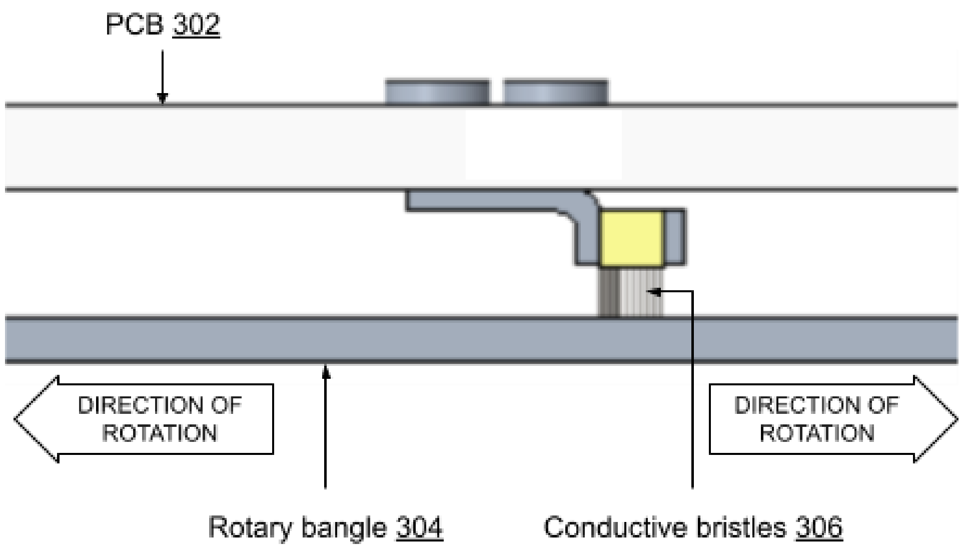

Fig. 3: Conductive bristles to direct ESD discharge from a rotary bangle away from sensitive electronics on a PCB

Fig. 3 illustrates conductive bristles (306) to direct ESD discharge from a rotary bangle (304) away from sensitive electronics on a PCB (302).

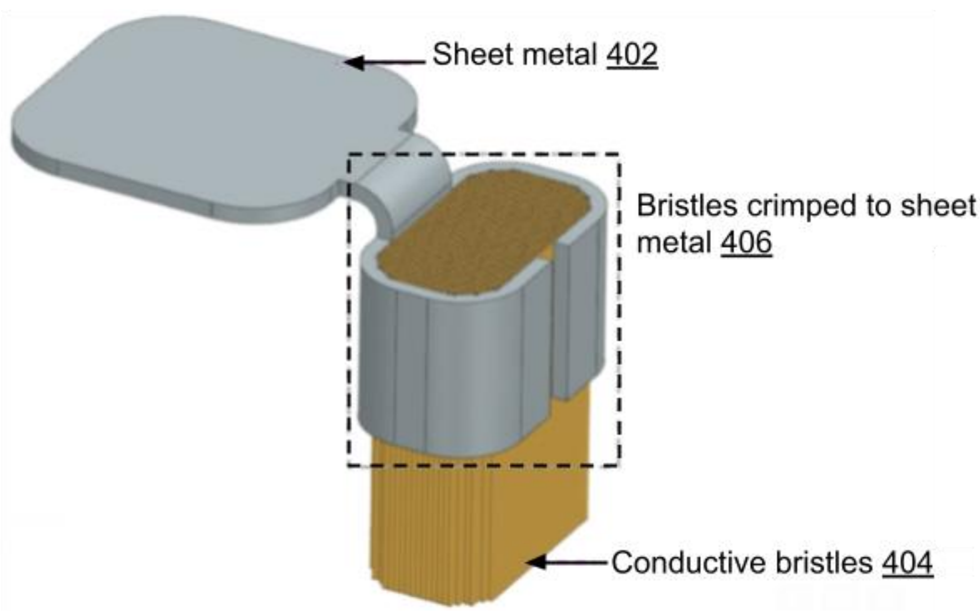

Fig. 4: Close-up view of conductive bristles and their mount to the PCB

Fig. 4 illustrates a close-up view of conductive bristles and their mount to the PCB. A sheet metal component (402) can be surface mounted on (soldered to) the PCB, thus establishing electrical contact between the PCB and the conductive bristles (404). The conductive bristles can be held together by crimping (406), the crimp being contiguous with the sheet metal.

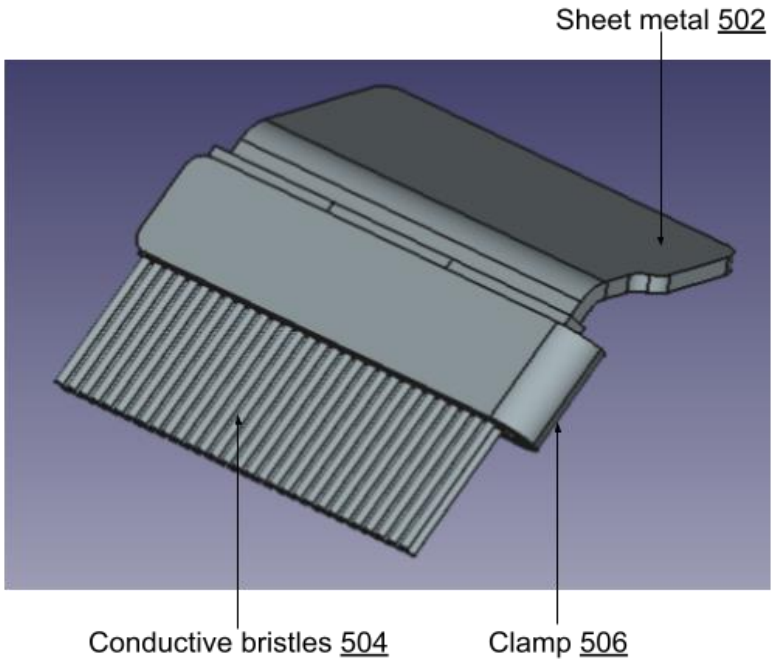

Fig. 5: Another example of conductive bristles and their mount to the PCB

Fig. 5 illustrates another example of conductive bristles and their mount to the PCB. In this example, conductive bristles (504) are held together with a clamp (506) that is contiguous with the sheet metal (502) that can be surface mounted onto a PCB.

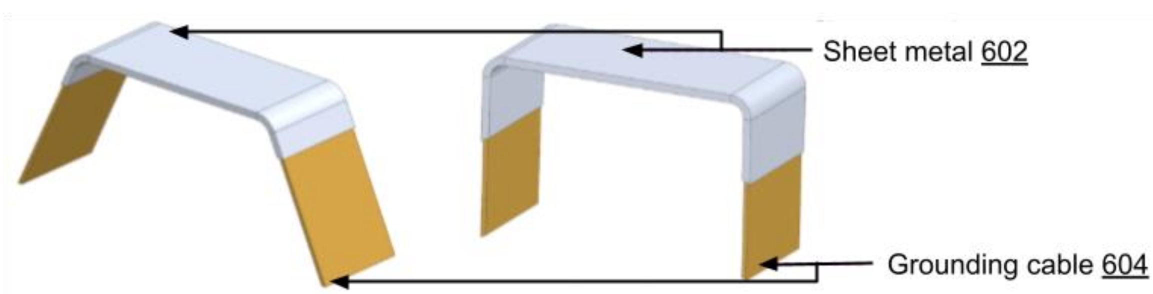

Fig. 6: Example connections of the grounding cable to the PCB

Fig. 6 illustrates examples of connections of the grounding cable to the PCB. Sheet metal (602) can be surface mounted (soldered) to the PCB and also be connected to a flexible, compliant grounding cable (604), which in turn connects with the metal enclosure of the thermostat (or other electrical equipment with a knob). ESD received through the conductive bristles travels through the sheet metal and grounding cable to the metal enclosure to get grounded, e.g., to pass harmlessly around the sensitive electronics enclosed within the electrical equipment.

The described techniques of using conductive bristles to ground electric charges are generally applicable in any situation where two electrical parts are in motion relative to each other and there is a need to ground those parts (either for electrostatic discharge purposes or for leakage-current grounding) without degrading user experience (e.g., without producing metallic grinding noise or vibrations) when the parts are set in motion.

CONCLUSION

This disclosure describes techniques to establish a dedicated ESD pathway between electrical parts in relative motion (e.g., a controller bangle around a knob and the electronics housed within the knob) by using a spring-like metal structure comprising conductive bristles to receive electric charge from the bangle and to conduct it to ground via a trace on a printed circuit board (PCB) within the knob. ESD current is deflected from sensitive electronics and prevented from damaging it. The ESD current is carried away from the bangle to the PCB by conductive bristles, such that the smooth rotary movement of the bangle is unaffected and occurs without the production of unwanted noise or vibrations.