

DEVICE FOR DISCHARGING AN ELECTRICAL CHARGE FROM AN AIRCRAFT

This invention relates to a device for discharging an electrical charge from an aircraft. As such, this invention is useful for grounding or earthing an aircraft that is parked on ground. More particularly, but not exclusively, the invention is useful for grounding or earthing an aircraft that is parked next to a Passenger Boarding Bridge used for loading and unloading passengers onto the aircraft.

When an aircraft is bridged to a PBB at the airside apron, ground lightning strikes that hit the aircraft could pose a serious danger to personnel working under the aircraft or near it.

To mitigate this danger, earth straps that connect various parts of the aircraft (e.g. the aircraft's landing gear) have been used to discharge the lightning current to grounding points.

However, this is not ideal because this system is often subjected to the availability and condition of earth receptacles at the airside apron. In addition, operators may also forget to attach the earth straps especially during rushed schedules or bad weather.

A small spring coil device has also been used to contact the aircraft when it is interfaced with the PBB in order to discharge the lightning current into the structure of the bridge which is linked to the earth protection system. However, this is not an effective method as the contact area is too small to channel a large current and instead, causes burnt marks on the aircraft fuselage due to localized arcing. Such burnt marks damage the surface of the aircraft fuselage and may lead to greater concerns relating to the safety of passengers when the aircraft is in the air. In addition to that, the spring coil loses its rigidity after a short period of time and droops downwards and in many case, does not even contact the aircraft.

Hence, there is a need for a new device to effectively electrically ground an aircraft.

This invention provides a device used as a safety protection equipment installed on a PBB. The core purpose of this equipment is to create an electrically conductive path between a docked or parked aircraft and a PBB so that large currents can be safely discharged to the

earth protection system of the bridge when a lightning strike hits the aircraft at the airside apron.

As will be described in detail below, the device of this invention features several design attributes which are specifically catered to both the environmental and operational conditions of the aircraft when it is docked to the PBB.

In accordance with an aspect of the invention, there is provided a device for discharging an electrical charge from an aircraft, the device comprising: (a) a housing; (b) a rod having a first end and a second end, the first end is accommodated within the housing and an aircraft contacting member is disposed at the second end, the rod is adapted to slide along a longitudinal length between a first position and a second position; (c) a biasing member accommodated within the housing for biasing the rod in the first position; (d) at least one earth strap coupled to the aircraft contacting member for discharging the electrical charge to an earth grounding system, and the aircraft contacting member and the at least one earth strap are formed from an electrically conductive material.

In various embodiments, the device further comprises an insulating cap disposed intermediate the rod and the aircraft contacting member to electrically isolate the aircraft contacting member from the rod.

In various embodiments, the aircraft contacting member is a wheel.

In various embodiments, the wheel comprises a free rotating electrically conductive core and an axle coupled to the rod by a yoke, the at least one earth strap is coupled to the axle.

In various embodiments, the wheel further comprises at least 3 rings formed radially on the free rotating electrically conductive core, a first innermost ring disposed adjacent the free rotating electrically conductive core, a second ring disposed intermediate the first innermost ring and a third outermost ring, the second ring is made of a non-electrically conductive material.

In various embodiments, the second ring is made of a rubber material.

5 In various embodiments, the first and third outermost rings are made of an electrically conductive material.

10 In various embodiments, the first and second rings comprises a slot for allowing the third ring to extend into the slot and form a layer intermediate the first ring and the electrically conductive core of the wheel.

In various embodiments, the third ring is made from a material selected from the group comprising of aluminium, copper, tinned copper, stainless steel, a nickel-plated material and a silver-plated material.

15 In various embodiments, the wheel further comprises a bearing disposed between the free rotating electrically conductive core and the axle.

In various embodiments, the bearing is a copper bush.

20 In various embodiments, the outer surface of the aircraft contacting member that contacts the surface of the aircraft is covered with a non-scratching and electrically conductive material.

25 In various embodiments, a portion of the rod extends outside the housing to form an expose portion of the rod, the exposed portion of the rod is covered with a collapsible bellow.

In various embodiments, the device comprises two earth straps, each earth strap disposed on opposite ends of the yoke.

30 In various embodiments, the biasing member is a spring.

In various embodiments, the device further comprising a mounting means for attaching the device to a passenger boarding bridge.

In various embodiments, the electrically conductive material is stainless steel.

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Advantageously, the invention provides for a device that (when installed) can deployed automatically and then be used effectively to discharge an electrical charge or current from an aircraft in the event the aircraft is hit by lightning. The device bonds the aircraft and the PBB to overcome any potentially lethal lightning hazard of voltage difference at the interface of the aircraft fuselage and PBB to prevent injury to persons who may be bridging this interface gap. Such situations include persons walking across the interface during entry and exit of the aircraft to/from the PBB. Other situations include airside operations involving contact between the aircraft and interfacing ground service equipment (GSE) in which case this bonding device should be installed to bond the aircraft and the interfacing GSE to overcome the potentially lethal voltage difference between them.

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Advantageously, the material used to coat or cover the aircraft contacting member, the free rolling wheel which is the aircraft contacting member and the suspension offered by the biasing member to the rod all work together to allow the device the invention to contact an aircraft automatically and effectively discharge any electrical charge or current from the aircraft without damaging the surface fuselage of the aircraft.

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The aircraft contacting member (and its constituent make up) working together with the rod that is loaded with a spring mechanisms are some of the technical features of the invention that offer said advantages. These will be described in detail below. Importantly, the device of the invention can accommodate or self-compensate to the difference curvatures of the various aircraft (wide and narrow bodied aircraft) or changes in height due to the variation in weight (when load is added to or taken off the aircraft) by the act of the biasing member (in various embodiments, the biasing member is the spring mechanism) together with the wheel (the aircraft contacting member) rolling smoothly on the surface of the fuselage. The conductive canvass (which will be described later) will ensure that electrical conductivity is

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maintained even during the rolling motion and will always serve as the first area of contact with the aircraft during the interface.

In order that the present invention may be fully understood and readily put into practical effect, there shall now be described by way of non-limitative examples only preferred embodiments of the present invention, the description being with reference to the accompanying illustrative figures.

In the Figures:

Figure 1 shows the device according to an embodiment of the present invention;

Figure 2A show a cut-out of the housing according to an embodiment of the present invention;

Figure 2B shows an exploded view of the housing and the rod according to an embodiment of the present invention;

Figure 3A shows a side view of the wheel according to an embodiment of the present invention;

Figure 3B shows a cross-sectional view of line AA of Figure 3A;

Figure 4 shows a cross-sectional view of the wheel according to an embodiment of the present invention;

Figure 5 shows an exploded view of the wheel according to an embodiment of the present invention;

Figures 6A and 6B show various examples of a mounting member according to an embodiment of the present invention;

Figure 7 shows the device in use according to an embodiment of the present invention;

Figure 8 shows the path of an electrical charge or current when the device is in use according to an embodiment of the present invention; and

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Figures 9 and 10 show the device in use according to an embodiment of the present invention.

Figure 1 shows a general view of the device 5 according to an embodiment of the invention. The device 5 is a safety equipment and may be used to discharge an electric current or charge from an aircraft in the event the aircraft is struck by lightning. The electric current is discharged safely into the ground by a connecting the device 5 to a structure that allows for such safe grounding.

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The device 5, when installed on a PBB, can be deployed automatically. In other words, the device 5 can contact the fuselage 105 of an aircraft when a PBB approaches and connects with said aircraft for allowing the boarding or disembarking of passengers. When in contact with the fuselage 105 of the aircraft, the device 5 creates an electrically conductive pathway to discharge lightning current through the PBB.

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With reference to Figure 1, the device 5 comprises a housing 10 for accommodating a rod 15 or a portion of length of a rod 15 (the rod 15 can be clearly shown in Figures 2A and 2B). In other words, the rod 15 has two ends – a first end 15a and a second end 15b. The rod 15 may be made of any sturdy material (for example, any metals may be used) and may be of any suitable length. Ideally, it would have a suitable length to reach the fuselage 105 of an aircraft when it is installed or mounted on the PBB. The rod 15 may be of any suitable length. In various embodiments, the length of the rod 15 may be between 370mm to 680mm in length.

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The first end 15a of the rod 15 is accommodated within or in the housing 10, while the opposite second end 15b is attached to an aircraft contacting member 20. The aircraft contacting member 20 may take the form of any shape and structure so long as it is suitable for contacting the surface of an aircraft's fuselage 105.

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The rod 15 is elongate and is able to slide along its longitudinal length along the longitudinal cavity of the housing 10. Such movement allows the rod 15 to adapt to varying distances between the PBB and the aircraft, and allowing it to act like an arm for allowing contact with the aircraft.

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Within the housing 10 resides a biasing member 25. Again, the biasing member 25 may be seen in Figures 2A and 2B. In an embodiment, the biasing member 25 is a customised spring mechanism made of stainless steel. The biasing member 25 can include any other guidance member (for example, a guidance pin 27 and clamp 28 shown in Figure 2A) for guiding the movement of the rod 15 within the housing 10. The biasing member 25 acts like a suspension mechanism allowing the rod 15 said movement. As such, the biasing member 25 allows the rod 15 to slide along its longitudinal length between a first position and a second position. The biasing member 25 biases the rod 15 in the first position. When the PBB (with the device 5 mounted on it) approaches an aircraft, the biasing member 25 allows the rod 15 to move to accommodate the distance between the aircraft and the device 5 so that the fuselage 105 is not damaged. Without the biasing member 25, the rod 15 will not have any give and such rigidity will either prevent the PBB from full connection with the aircraft or damage the surface of the fuselage 105. Therefore, the first position of the rod 15 may be the position when the device is not in contact with the aircraft while the second position of the rod 15 may be the position when the device is in contact with the aircraft, i.e. some resistant or compression of the biasing member 25 when the aircraft is pushed against and in contact with the aircraft contacting member 20. The biasing member 25 thus provides a good, light but firm contact force when it is used with different fuselage curvatures. It maintains a light but sufficient pressure on the body of the aircraft, thus providing a good electrical contact to it in order to channel any current from a lightning strike at the aircraft to the earth protection system of the PBB.

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The device 5 further comprises at least one earth strap 30. In the Figures, a pair of earth straps 30 are shown. However, any suitable number may be used to allow for the safe discharge of the electrical charge. The earth strap 30 is coupled to the aircraft contacting member 20 so that it forms a passage for an electrical charge to pass from the aircraft contacting member 20 to an earth ground system. The axle 45 and yoke 50 arrangement of the wheel 20 may

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include a clamping surface 58 for coupling or connecting the earth strap 30 to the PBB. Such an arrangement allows the earth strap 30 to form an electrical conduit with the axle 45 of the wheel 20. An insulating spacer ring 59 may be disposed intermediate the clamping surface 58 and the free rotating electrically conductive core 40 to serve as an insulator. As such, the opposite end of the earth strap 30 may be coupled to the PBB or any other device that is used for grounding. Therefore, for the effective passage of electrical charge, the aircraft contacting member 20 and the earth strap 30 are formed from an electrically conductive material. Each earth strap 30 may be 25mm in width and 3mm in thickness and approximately 800mm in length. The straps are made from braided tinned copper material which serve to conduct the lightning current from the wheel 20 to the steel structure under the PBB when the device 5 will be installed or mounted.

In various embodiments, the rod 15 may be electrically isolated from the aircraft contacting member 20 by an insulating cap 35 that is disposed intermediate the rod 15 and the aircraft contacting member 20. Advantageously, the insulating cap 35 prevents any high load of current travelling from the wheel 20 through to the housing 10 which houses the biasing member 25 which can damage the device 5 and causing the rod 15 to malfunction, for example not being able to slide about a distance within the housing 10.

In various embodiments, the aircraft contacting member 20 may be a wheel. Figures 3A, 3B and 4 show details of the wheel 20. From here onwards, we will refer the aircraft contacting member 20 to the wheel 20. With reference to these Figures, the wheel 20 comprises a free rotating electrically conductive core 40 and an axle 45. The wheel 20 is coupled to the rod 15 by a yoke 50 that is attached to the axle 45 of the wheel 20. As shown in Figure 1, the earth strap 30 is coupled to the wheel 20 by a connection or attachment with axle 45 and yoke 50. At its opposite end, the earth strap 30 may be coupled to any device that is connected to a grounding system. For example, the earth strap 30 may be coupled to the PBB directly, or as shown in Figure 6A, may be coupled to the mounting means 100 shown at 104. The axle 45 comes with 2 stepped ends with M10 metric threads. The steps are flushed against the outer surface of the yoke 50 and is in direct contact with the earth strap 30. This serves to channel the lightning current from the copper bush to the earth strap 30 so that it may flow to the steel structural beams under the PBB for safe discharge.

With reference to Figure 4, it can be seen that the wheel 20 comprises at least 3 rings formed radially on the free rotating electrically conductive core 40. The 3 rings are a first innermost ring 55 disposed adjacent the free rotating electrically conductive core 40, a second ring 60 disposed intermediate the first innermost ring 55 and a third outermost ring 65. In an embodiment, the second ring 60 is made of a non-electrically conductive material. In addition, it is preferred that the second ring 60 be made of a sturdy but soft material that can provide a dampening or cushioning effect. One such material that may be used is rubber. In various embodiments, the rubber is nitrile butadiene rubber. Any other suitable deformable but sturdy material that is resilient to the effects of UV, heat, dust and water may be used. The advantage of using such a material is that it provides the aircraft contacting member 20 with some dampening or cushioning characteristic so that, when it comes into an initial contact with the fuselage 105 of an aircraft, it does not damage the fuselage's surface. The second ring 60 provides a shock absorbent attribute through the soft and deformable compression of its body when the wheel 20 comes into contact of the fuselage 105. The slight deformation of the second rubber ring 60 also increases the surface area of contact between the conductive canvass 85 and the aircraft with some added traction force for the wheel 20 to turn.

The free rotating electrically conductive core 40 provides the basic structural support for the wheel 20 and acts as a medium for the electrical current to flow during a lightning strike. It can be machined down with side annular recesses and pockets to lighten its weight so that an optimised weight to strength ratio is achieved.

In order to provide the electrical passage necessary to fulfil the function of the device 5, the first 55 and third 65 outermost rings are made of an electrically conductive material. In addition, a slot 70 is cut into the first 55 and second 60 rings shown in Feature A in Figure 4 to allow the third ring 65 to extend into the slot 70 and form a layer 75 intermediate the first ring 55 and the electrically conductive core 40 of the wheel 20. The layer 75 may be coupled to the first ring 55 via a cap screw 77. In various embodiments, the third ring 65 may also be termed a wheel earth strap that allows an electrical current received on the surface of the third ring 65 to pass through the non-electrically conductive second ring 60 to the electrically

conductive core 40 of the wheel 20. This wheel earth strap 65 will help to share the load carrying capacity of the device 5. Therefore, even though the rubber material of the second ring 60 offers the dampening effect, the slot allows the electrical current to effective discharge from the third ring 65 into the core of the wheel 20 and through to the earth strap 30. As such, to be electrically conductive, the third ring 65 may be made from a material selected from the group comprising of aluminium, copper, tinned copper, stainless steel, a nickel-plated material and a silver-plated material. In various embodiments, the third ring 65 and earth strap 30 are made of the same material.

The wheel 20 wheel further comprises a bearing 80 that is disposed between the free rotating electrically conductive core 40 and the axle 45. The bearing 80 allows the wheel 20 to rotate freely. In order to improve the electrical conductivity of the device 5, the bearing that is used in the invention is a copper bush. This copper bush is not only excellently electrically conductive, but also increasing the contact surface area allow an electrical current to pass through the wheel 20 to the earth strap 30. The internal surface of the copper bush is highly polished with minimal surface roughness in order to prevent arcing across any small gaps at the boundary zone between the copper bush and the axle.

The outer surface (or a portion of the outer surface) of the aircraft contacting member 20, i.e. the exposed surface of the third layer 65, that contacts the surface of the aircraft may be covered with a non-scratching and electrically conductive material. Advantageously, together with the rolling action of the wheel 20, the material that contacts the aircraft will not scratch or damage the surface of the aircraft. Such a covering may be known as a conductive canvass 85. The conductive canvass 85 may be made by cutting from stock conductive material sheets which is electrically conductive with very low resistance and stitched together with 3 layers, followed by the pressing in of metal eyelets at the side of the wheel 20. The 3 layers adhere to each other with the use of conductive glue and thread stitching around the perimeter of the canvass 85. The combination of the 3 layers gives it excellent strength and will not tear easily under normal traction against the aircraft fuselage. The flaps on the sides of the canvass 85 are folded 90 degrees inwards before having the eyelets punched into them so that screws can be inserted to secure the conductive canvass 85 to the wheel 20. The conductive canvass 85 may be treated with a series of coatings made of any suitable material which can provide

good traction endurance, water resistance, UV stability and flame retardant properties. These additional coatings make it ideal for outdoor use under rain and sunlight. Advantageously, the conductive canvass 85 provides a non-scratching surface that would not damage or scratch the surface of the fuselage when the wheel 20 comes into contact with the fuselage but offers a conductive surface to carry the electrical charge from the aircraft through the wheel 20 and to the earth strap 30.

The various layers of the wheel 20 may be made by a machining process, the rubber second ring 60 may be made by a molding process. Figure 5 shows an exploded view of the various parts of the wheel 20 that may be put together: the axle 45 slips through the copper bush 80, which form a sliding fit that allows rotation; the copper bush 80 is pressed-fitted into the free rotating electrically conductive core 40 so that these two components will rotate together; the rubber second ring 60 is slipped over the free rotating electrically conductive core 40; the third wheel earth strap ring 65 is wrapped-around the second rubber ring 60 with ends inserted through the slot 70 and secured to the inside of the wheel with screw fasteners; the conductive canvas 85 is slipped through the third wheel earth strap ring 65 and once it is in place, the sides of the conductive canvas 85 are folded down and aligned with the tapped holes on the free rotating electrically conductive core 40 and secured by screw fasteners. In an embodiment, the third wheel earth strap ring 65 may be approximately 25mm in width and 3mm in thickness and 630mm in length. It may be made from braided tinned copper material and it lies in direct contact with the conductive canvass 85. The second rubber ring 60 may be heat and UV stable.

In Figure 1, the device 5 also comprises a collapsible bellow 90 for covering any exposed portion of the rod 15. Such covering is useful in preventing dirt from entering the housing 10 and affect the smooth operation of the device 5. The airfield is generally a dusty environment with aircraft brake dust and other pollutants residing all over the infrastructure and equipment. As the dust and other pollutants settle on the exposed linear sliding rod, continual movement will cause the dust and other particles to be mixed with the lubricating oil film and gets lodged between the rod surface and the bushing holding it. This will shorten the lifespan of the bushing through excessive wear by abrasive contaminants.

Also, any suitable protective weather resistant covering or tubing (which may be made from a non-conductive material) may be used to cover the earth straps 30 to prevent any accidents should a person come into contact with an earth strap 30. In addition, such covering or tubing protects the earth straps 30 from mechanical abrasions and electrical leakage. In an embodiment, such a covering or tubing may be made of rubber and used as a sleeve to protect the earth straps 30. Such tubings used may be a flat shrink tubing or something thicker and stronger.

Figures 6A and 6B show a mounting means 100 for attaching the device 5 to a PBB. The device 5 may be mounted on any suitable position on the PBB. For example, the mounting means 100 shown in Figure 6A is for mounting on the underside of the PBB 110 as can be seen in Figure 9 where two PBBs 110 are used – one for the upper deck 112, and one for the lower deck 114 of the aircraft. A mounting fin 102 is disposed intermediate the mounting means 100 and the housing 10 of the device allowing the angle of the rod 15 to be adjusted to accommodate the curvature of the aircraft depending on whether the device 5 is intended for connecting the upper or lower deck of the aircraft. The upper deck embodiment will contact the top half of the circular cross section of the fuselage 105 in a horizontal fashion whereas the lower deck embodiment will contact the lower half of the circular cross section of the fuselage 105 at an angle. From the Figures, it can also be seen that the mounting means 100 may be made in such a way so as to accommodate the curvature of the fuselage 105.

In an alternative embodiment, the mounting means 100 may be configured such that the device 5 is mounted on the side of the PBB 110. This can be seen in Figures 6B and 10. Here, the device 5 is mound on the right side of the PBB 35 (i.e. if the person is standing at the exit of the PBB 110 facing the aircraft door) to provide a physical and firm electrical contact interface with the fuselage of a common aircraft parked at the airside apron. The side mounting of the device 5 will enable the wheel 20 to contact a wider span of aircraft with very different fuselages. In this embodiment, the device 5 does not require a mounting bracket for mounting the device 5 to the underside of the PBB 35), and as such, there is no need to customize different mounting apparatuses to accommodate different fuselage sizes. In the device described above, in order to accommodate different fuselage sizes, the mounting brackets will need to be adjusted or customized for every device installed.

Also, the device 5 can have a longer rod 15. In an embodiment, the rod 15 has a total travel length of 270mm. This length can allow the device 5 to accommodate the big variation of travel depth between very contrasting aircraft models.

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The device 5 is mounted to a secondary extension beam 30 (hollow section) installed at the side of the passenger loading bridge 35. This extension beam 30 actually brings the device forward to a suitable position where it can contact both very big and small aircrafts with the newly increased stroke length. The multiple holes 50 at the side mounting of the device 5 and
10 the extension beam 30 allows easy adjustment to achieve the most optimal position for the operation.

The use of the device 5 is straight forward and hassle free, and should not cause any additional steps in current procedures and protocols. Once the device 5 is installed or mounted on the
15 PBB, the device 5 will approach the aircraft together with the PBB and contact it when the leading edge of the PBB (which is normally a black or yellow rubber bumper) gets very near to the fuselage. The conductive canvass 85 that is wrapping the wheel 20 will interface with the fuselage of the aircraft and compensates itself according to the curvature it encounters.

Figures 7 and 8 illustrates how the device 5 works when used. As described above, the device
20 5 is mounted on a PBB 110 which will approach an aircraft when the aircraft arrives at the gate of a terminal of an airport. When the PBB 110 approaches the aircraft, the wheel 20 of the device 5 will contact the fuselage of the aircraft. This firm interface will offer a good area of contact which provides low resistance for the current flow into the structural element of
25 the PBB and subsequently, to its earth protection system.

With reference to Figure 8, should lightning strike the aircraft, the lightning current travels along the skin of the aircraft fuselage shown in the arrows and enter the wheel 20 of the device 5. It then continues to travel to the earth straps 30 which are connected to the PBB
30 110. Hence, the electric current enters the PBB 110 through its steel structure. Hence, the system of the PBB will safely discharge the lightning current.

The following describes the travel of current from the wheel 20 to the earth strap in great detail. The lightning current enters the conductive canvass 85 and through to the third wheel earth strap 65. It then enters the first ring 55 via the slot 70, and travels to the free rotating electrically conductive core 40 and axle 45 via the copper bush 80. From the axle 45, the current enters the earth strap 30.

Figure 7 shows the advantages of the invention. The aircraft will move vertically up and down (shown by the arrows marked A) due to the loading and unloading of passengers and/or cargo. As such, the free rotating wheel 20 can turn accordingly (shown by arrows marked B) in response to the change in vertical height. In addition, before of the biasing member 25, the rod 15 can self-compensate linearly in response to any change in the vertical height (shown by arrows marked C). This free rotation will induce a smooth “rolling” effect on the fuselage instead of a dragging force, hence minimising any potential damage on the contact surface of the aircraft.

Thus, in addition, the wheel 20 freely rotates or rolls to allow for the accommodation of different fuselage curvatures – which is a result of different aircraft sizes. The device 5 can self-compensate and adapt to different curvatures of fuselage by adjusting its length or distance from the aircraft via movement of the rod 15 with the aid of the biasing member 25 which acts like a suspension mechanism allowing the rod 15 movement to accommodate and adjust to the distance between the device 5 and the aircraft fuselage. As such, if the device 5 is mounted on the underside of the PBB, the device can adapt to whether the PBB connects to the upper or the lower deck. Or, it can also adapt to different sizes of aircrafts.

The electrically conductive material used in this invention may be stainless steel, although any other types of material may be used. Advantages to using stainless steel here include its strength and resilience to corrosion, which are important given that the device 5 is used outdoors and exposed to weather elements daily. Alternatively, other materials that may be used include aluminium, LG2 gun metal and brass.

Non-limiting example:

Adding to the above description, the device 5 will now be described in greater detail with reference to Figures 2A, 2B and 5. In particular, the housing 10 (which includes a portion of the rod 15 may be termed as the Main Body) and wheel 20 (which may be termed as the Wheel Module) will be described in greater detail below.

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The Main Body includes:

a. Insulated Rod Cap 35

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The Insulated Rod Cap 35 is made from hard engineering plastics which is UV-stable. The Insulated Rod Cap 35 bridges the entire Wheel 20 to the housing 10 by sitting directly on to the exposed end of the Linear Sliding Rod 15. The Insulated Rod Cap 35 is secured to the Stainless Steel Yoke 50 by 2 fasteners and is in turn, secured to the Linear Sliding Rod 15 by 3 radial screws. As the material of the Insulated Rod Cap 35 is non-conductive, the lightning current will travel through the 2 x Connecting Earth Strap instead of straying to the housing 10 of the device 5.

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b. Linear Sliding Rod 15

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The Linear Sliding Rod 15 is made from stainless steel with a highly polished external surface. The Linear Sliding Rod 15 supports the entire Wheel 20 and provides the necessary linear stroke length for the self-compensating effect on different aircraft fuselage. The unexposed part of the Linear Sliding Rod 15 features a hidden slot of 180mm length that will be constrained by the Guide Pin 27 for the required linear travel. The Linear Sliding Rod 15 will slide within the Polymer Guide 28 which is held in place by the housing 10.

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c. Rod End Cap

The stainless steel Rod End Cap is used to seal up the hidden end of the Linear Sliding Rod 15 via 3 radial screws. The function of the Rod End Cap is to provide

a flat surface where one end of the biasing member 25 (e.g. spring mechanism) will push against.

d. Front Housing Cap

5 The stainless steel Front Housing Cap is secured to the housing 10 and it prevents the Polymer Guide Bush from creeping outwards. The central hole of the Front Housing Cap is concentric to the Linear Sliding Rod 15 with a small clearance to prevent the components from rubbing against each other.

10 e. Polymer Guide Bush

 The Polymer Guide Bush is made from engineering plastics that is designed to endure long and repetitive sliding runs. The Polymer Guide Bush is maintenance free with a very low coefficient of friction and it retains its properties well even when exposed to water, outdoor heat and UV rays. The
15 Polymer Guide Bush is a consumable item which is subjected to operational wear and should be replaced periodically or as and when it is necessary.

f. Main Body Housing 10

 The Main Body Housing is made from stainless steel and it encapsulates the
20 internal and hidden linear mechanism of the device 5. The internal walls of the Main Body Housing is bored to a smooth finish to ensure an unimpeded travel for both the Linear Sliding Rod 15 and Customized Spring 25. A thin film of lubricating oil is sprayed on the internal walls of the Main Body Housing for added ease of motion. The Main Body Housing 10 also features a series of
25 tapped holes for fasteners to secure the various other components of the Body Module. A stainless steel mounting fin is welded to the top side of the Main Body Housing with an inclined angle of 20 degrees for an angled approach to the fuselage. For the upper deck version, this fin is turned 180 degrees and fashions a horizontal approach instead of an angled approach. At the top end

of the fin, it is secured to the 2 x Mounting Bracket which will be installed on a steel structural element under the passenger loading bridge. The fin offers good mechanical support to the entire Lightning protection device with sufficient vertical and horizontal clearance away from existing infrastructure underneath the bridge.

g. Customized Spring 25

The compression Customized Spring is made from stainless steel grade 301 with a wire diameter of 3mm and an outer spring diameter of 39.5mm. The main function is to provide a positive force to push the Wheel Module and the Linear Sliding Rod (with Rod End Cap) outwards. This spring force will exert a suitable pressure for a good electrical contact on the fuselage of the aircraft without denting it. The free uncompressed length (300 mm) of the Customized Spring enables a self-compensating effect on the Linear Sliding Rod which can accommodate a wide variety of common aircraft.

h. Rear Housing Cap

The stainless steel Rear Housing Cap seals off the open end of the Main Body Housing with the use of 3 radial screws. It provides a fixed surface for the rear end of the Customized Spring to push against in order to move the Linear Sliding Rod. The Rear Housing Cap comes with a central hole for lubricant spray to be applied to the internal moving mechanism of the Lightning protection device. Another hole can be found at the low end of the Rear Housing Cap to drain out any trapped moisture or water in the Main Body Housing.

i. Body Clamp

The Body Clamp is made out of stainless steel and its primary function is to secure the Guide Pin in its position to limit and constrain the linear motion of the Linear Sliding Rod. The Body Clamp is also designed to clamp/lock the Main

Body Housing to the fin as a secondary measure to guard against any weld failure which might separate the two bodies.

j. Guide Pin

5 The stainless steel Guide Pin acts as guiding and limiting constraint for the Linear Sliding Rod. The Guide Pin will be inserted and screwed on to the Body Clamp from the underside and secure its position in the slot of the Linear Sliding Rod. This will determine the maximum and minimum positions of the Linear Sliding Rod with respect to the position of the Guide Pin. The Guide Pin is a consumable component as it will experience operational wear on the areas where the sliding will take place.

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k. 2 x Mounting Bracket

15 The 2 x Mounting Bracket will hold the fin and suspend itself at the higher end from the steel structural element under the passenger loading bridge. The 2 x Mounting Bracket comes with 5 sets of 6mm through holes at the lower end of which 3 will be fastened consecutively to the fin by bolts and nuts. The other 2 spare holes to the front and rear of the bracket provides the flexibility of positional adjustment during installation. The 2 x Mounting Bracket is installed to the underside of the passenger loading bridge by bolts & nuts via the 3 sets of 8mm through holes. One set of the holes will be used with a longer bolt to clamp against the lug ends of the 2 x Connecting Earth Strap which will be transferring the current into passenger loading bridge.

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25 l. 2 x Connecting Earth Strap

The 2 x Connecting Earth Strap is 25mm in width and 3mm in thickness and approximately 800mm in length. The straps are made from braided tinned copper material which serve to conduct the lightning current from the Wheel

Module to the steel structure under the passenger loading bridge where the Lightning protection device will be installed.

The wheel module 20 comprises:

5 a. Conductive Canvas Jacket 65

10 The Conductive Canvas Jacket is made from 3 layers of specially treated fabric which is electrically conductive with very low resistance. The 3 layers adhere to each other with the use of conductive glue and thread stitching around the perimeter of the jacket. The combination of the 3 layers of Conductive Canvas gives it excellent strength and will not tear easily under normal traction against the aircraft fuselage. The flaps on the sides of the Jacket are folded 90 degrees inwards and 2 eyelets are punched into each flap for screws to secure the Jacket to the Stainless Steel Wheel 40. Each layer of the Conductive Canvas has also been further treated to make it water resistant, flame retardant and UV-
15 stable which makes it ideal for outdoor use under rain and sunlight.

 b. 2 x Wrap-Around Earth Strap 65

20 The 2 x Wrap-Around Earth Strap is approximately 25mm in width and 3mm in thickness and 630mm in length. The straps are made from braided tinned copper material and they lie in direct contact under the Conductive Canvas Jacket. Both lug ends of the Wrap-Around Earth Strap are inserted through 2 side slots that are cut out in both the Rubber Ring and Stainless Steel Wheel so that they may be clamped down and secured to the annular recess of the Stainless Steel Wheel. The main purpose of the 2 x Wrap-Around Earth Strap
25 is to share the electrical current load-carrying capacity of the Conductive Canvas Jacket when lightning current travels through it. The lug ends of the straps that are connected to the Stainless Steel Wheel with the use of 4 clamping screws serve as the pathway for the current to travel when it enters through the Conductive Canvas Jacket.

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c. Rubber Ring 60

The Rubber Ring is made from outdoor rubber which is heat and UV stable. The Rubber Ring seats directly under the 2 x Wrap-Around Earth strap with 2 slots at each side of the ring to allow the straps to channel through to the Stainless Steel Wheel. The Rubber Ring provides a shock absorbent attribute through the soft and deformable compression of its body when the Wheel Module comes into contact of the fuselage. The slight deformation of the Rubber Ring also increases the surface area of contact between the Conductive Canvas Jacket and the aircraft with some added traction force for the wheel to turn.

d. Stainless Steel Wheel 55

The Stainless Steel Wheel provides the basic structural support for the outer deformable components which are the Conductive Canvas Jacket, Earth Straps and Rubber Ring. Like the Rubber Ring, the Stainless Steel Wheel also features 2 side slots to allow the 2 x Wrap-Around Earth Strap to channel through so that they may be secured. In addition to the actual physical support, the Stainless Steel Wheel also acts as a medium for the electrical current to flow during a lightning strike. The Stainless Steel Wheel is machined down with side annular recesses and pockets to lighten its weight so that an optimized weight to strength ratio is achieved.

e. Copper Bush 80

The Copper Bush is pressed fitted into the Stainless Steel Wheel and it serves to bridge the Stainless Steel Wheel to the Stainless Steel Axle. The softer material property of the Copper Bush acts as a consumable item which allows the Stainless Steel Axle to turn against. At the same time, the Copper Bush has excellent conductivity which will allow the current to flow through it from the Stainless Steel Wheel to the Stainless Steel Axle. The internal surface of the Copper Bush is highly polished with minimal surface roughness in order to

prevent arcing across any small gaps at the boundary zone between the Copper Bush and the Stainless Steel Axle.

f. Stainless Steel Axle 45

5 The Stainless Steel Axle supports and allows the free rotation of the combined assembly of the Conductive Canvas Jacket, Wrap-Around Earth Straps, Stainless Steel Wheel and the pressed-in Copper Bush. The Stainless Steel Axle comes with 2 stepped ends with M10 metric threads. The steps are flushed against the outer surface of the Stainless Steel Yoke and is in direct contact with the 2 x Connecting Earth Strap. This serves to channel the lightning current from the Copper Bush to the 2 x Connecting Earth Strap so that it may flow to the steel structural beams under the Passenger Loading Bridge for safe discharge.

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15 g. 2 x Insulating Spacers 59

The 2 x Insulating Spacers are sandwiched between the Stainless Steel Wheel and the Stainless Steel Yoke. They are made from UV resistant hard engineering plastics and serve to prevent any arcing from the Wheel to the Yoke. The sides of the Insulating Spacers which are in contact with the turning wheel also act as a bearing surface for the Wheel to rub against.

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h. Stainless Steel Yoke 50

The Stainless Steel Yoke Supports the ends of the Stainless Steel Axle and provides the anchorage points for the Stainless Steel Axle and the 2 x Connecting Earth Strap. 2 fasteners secure the Stainless Steel Yoke to the Insulated Rod Cap which then sits on to the Linear Rod end.

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i. 2 x M10 Lock Nut

The 2 x M10 Lock Nuts are made from Stainless Steel and they clamp down the lug ends of the the 2 x Connecting Earth Strap to the stepped ends of the Stainless Steel Axle. The 2 x M10 Lock Nut has a nylon ring insert which deforms and grips against the threads of the Stainless Steel Axle to prevent unintentional loosening caused by vibrations or creep.

5

Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention.

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Claims

1. A device for discharging an electrical charge from an aircraft, the device comprising:
- 5 (a) a housing;
- (b) a rod having a first end and a second end, the first end is accommodated within the housing and an aircraft contacting member is disposed at the second end, the rod is adapted to slide along a longitudinal length between a first position and a second position;
- 10 (c) a biasing member accommodated within the housing for biasing the rod in the first position;
- (d) at least one earth strap coupled to the aircraft contacting member for discharging the electrical charge to ground, and
- the aircraft contacting member and the at least one earth strap are formed from an electrically conductive material.
- 15 wherein the aircraft contacting member is a wheel, and the wheel comprises at least 3 rings formed radially on a free rotating electrically conductive core, a first innermost ring disposed adjacent the free rotating electrically conductive core, a second ring disposed intermediate the first innermost ring and a third outermost ring, the second
- 20 ring is made of a non-electrically conductive material
2. The device according to claim 1, wherein the device further comprising an insulating cap disposed intermediate the rod and the aircraft contacting member to electrically isolate the aircraft contacting member from the rod.
- 25
3. The device according to claim 1, wherein the free rotating electrically conductive core and an axle of the wheel is coupled to the rod by a yoke, the at least one earth strap is coupled to the axle.
- 30 4. The device according to claim 1, wherein the second ring is made of a rubber material.

5. The device according to claim 1, wherein the first and third outermost rings are made of an electrically conductive material.

6. The device according to any one of the preceding claims, wherein the first and second rings comprises a slot for allowing the third ring to extend into the slot and form a layer intermediate the first ring and the electrically conductive core of the wheel.

7. The device according to any one of the preceding claims, wherein the third ring is made from a material selected from the group comprising of aluminium, copper, tinned copper, stainless steel, a nickel-plated material and a silver-plated material.

8. The device according to any one of the preceding claims, wherein the wheel further comprises a bearing disposed between the free rotating electrically conductive core and the axle.

9. The device according to claim 8, wherein the bearing is a copper bush.

10. The device according to any one of the preceding claims, wherein the aircraft contacting member comprises an outer surface that contacts the surface of the aircraft, said outer surface is covered with a non-scratching and electrically conductive material.

11. The device according to any one of the preceding claims, wherein a portion of the rod extends outside the housing to form an exposed portion of the rod, the exposed portion of the rod is covered with a collapsible bellow.

12. The device according to any one of claims 3 to 11, wherein device comprises two earth straps, each earth strap disposed on opposite ends of the yoke.

13. The device according to any one of the preceding claims, wherein the biasing member is a spring.

14. The device according to any one of the preceding claims, wherein the device further comprising a mounting means for attaching the device to a passenger boarding bridge.

15. The device according to any one of the preceding claims, wherein the electrically
5 conductive material is stainless steel.