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(54) **SWITCH, ELECTRONIC SAFE AND ARM UNIT, FUZE SYSTEM, MUNITION, AND METHOD**

(57) According to the present disclosure there is provided a switch for controlling electrical power supplied by a power source to an electronic safe and arm unit, ESAU, or a munition, the switch comprising: a contact assembly arrangement comprising a contact assembly (112) of a first type arrangeable in a first arrangement defining a first switch state and a second arrangement

defining a second switch state, wherein centrifugal force caused by rotation about a central axis (150) of the switch causes movement of at least a part of the contact assembly of the first type to change the arrangement of the contact assembly of the first type from the first arrangement to the second arrangement.

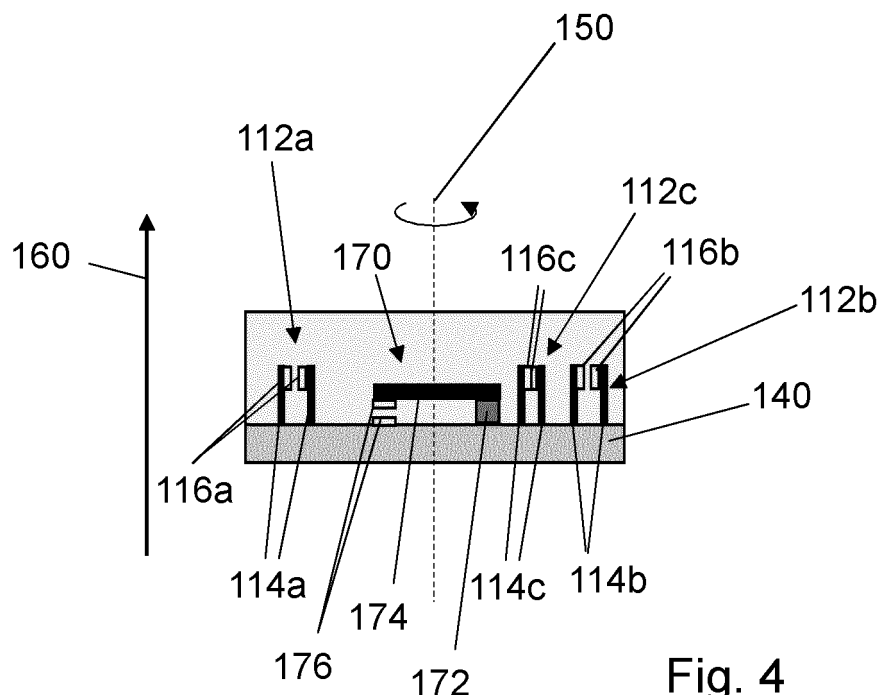


Fig. 4

Description

FIELD

[0001] The present invention relates to a switch, in particular to a switch for controlling electrical power supplied by a power source to an electronic safe and arm unit (ESAU), or to a switch for controlling electrical power supplied by a power source to a munition. The present invention further relates to an ESAU, a fuze system, a munition, and a method.

BACKGROUND

[0002] Munitions are provided in a number of different forms, for a number of different applications. Typically, a particular munition will be used for a particular application or intention. For the purposes of this patent application, munitions are taken to include but are not limited to artillery shells and charges, missiles, rockets, and mortar rounds, as well as small arms munitions such as bullets.

[0003] Electronic safe and arm units (ESAU) are utilised in munitions to prevent inadvertent or accidental detonation of explosive material within the munitions during routine handling or in the launcher, as well as during the initial flight. The ESAU is typically part of a munition fuze system and prevents arming of the fuze until certain conditions are met, such as a determination of launch of the munition.

[0004] The ESAU may incorporate a switch to activate power supply to the ESAU when the condition is met. In this way, the ESAU is not provided with electrical power to allow arming thereof until the condition is met. In this way, the risk of inadvertent or accidental detonation can be mitigated. However, such switches may be complex. Furthermore, the requirement to distinguish between munition launch and transport shocks limits the minimum practical size of the switch. Furthermore, such switches may be expensive to manufacture.

SUMMARY

[0005] According to a first aspect of the present invention, there is provided a switch for controlling electrical power supplied by a power source to an electronic safe and arm unit, ESAU, or to a munition, the switch comprising: a contact assembly arrangement comprising a contact assembly of a first type movable from a first arrangement defining a first switch state to a second arrangement defining a second switch state; and an actuator configured to act on the contact assembly of the first type to cause said movement of the contact assembly, wherein the actuator is configured to act on the contact assembly of the first type under the influence of centrifugal force caused by rotation of the switch.

[0006] By this construction, the switch makes use of centrifugal force to perform switching between the first switch state and the second switch state. This is highly

advantageous in many situations. During storage and transport of the ESAU or munition it is unlikely that spin will be encountered, thus it is unlikely that centrifugal force will be generated to cause switching of the switch.

Furthermore, by such a construction, no latching mechanism is required to maintain a particular switch state, such as an "on" switch state - here, the switched state will be maintained if spin is maintained. Additionally, the switch is simple in construction, small, and cheap to manufacture, at least compared with conventional switches for ESAUs or munitions. Safety benefits are obtained as supply of electrical power from the power source is deactivated when centrifugal force is not generated due to insufficient spinning of the switch. In the present disclosure, the centrifugal force may also be referred to as a "spin force" or "spin-generated force". In one advantageous implementation of the switch, the switch may control electrical power supplied by the power source to the munition. Control of the low voltage power supply is the basis of safety for many types of ESAUs, so as power switch driven by an operational environment (e.g., the spin environment) is an energy break, and thus also forms part of the ESAU function. That is, as the switch may function as both an ON/OFF switch, and as an environment sensor (suitable to detect a spin condition), the switch may be suitable to replace an ESAU rather than be incorporated in an ESAU.

[0007] Furthermore, the contact assemblies and associated actuators can replace specialised sensing devices such as MEMS accelerometers, which can be both costly and come with potential supply chain issues. Additionally, the contact assemblies and associated actuators have the potential to be manufactured by a range of suppliers. This could mitigate against supply chain issues and allow supplier trading to reduce costs. The contact assemblies and associated actuators may be referred to as "electromechanical elements".

[0008] For the avoidance of doubt, rotation of the switch is such that sufficient speed or rate of rotation results in centrifugal forces sufficient to influence or actuate the actuator.

[0009] In one example, the actuator comprises a flexure member, and the flexure member is configured to deflect due to centrifugal force caused by rotation of the switch so as to cause the actuator to act on the contact assembly of the first type.

[0010] Flexure members are simple to manufacture. Furthermore, by providing a flexure member, centrifugal forces generated due to rotation/spinning of the switch can be utilised to drive the flexure members to actuate the contact assembly.

[0011] The flexure member may be formed as part of a body part. The body part may be formed of injection moulded plastic. This reduces costs and facilitates mass-production.

[0012] In one example, centrifugal force caused by rotation of the switch at a rotational frequency greater than a predetermined frequency causes the actuator to act on

the contact assembly of the first type, optionally wherein predetermined frequency is 20Hz or 40Hz.

[0013] In this way, the switch state is unlikely to be changed or maintained during routine handling and transport. Instead, relatively high frequency rotation (e.g., that experienced during typical launch or flight of a munition) is required to generate the centrifugal force to cause the actuator to act on the contact assembly of the first type. Advantageously, safety is improved. Furthermore, by providing a switch having contact assemblies requiring different rotational forces in order to be actuated, said contact assemblies can be used to initiate processes at different times during launch or flight of the munition due to a difference in rotational frequency.

[0014] In one example, the switch comprises a plurality of contact assemblies of the first type and actuators associated therewith configured so as to act on the respective contact assembly of the first type.

[0015] By this construction, safety can be improved as it may be necessary to act on a plurality of contact assemblies of the first type simultaneously in order to enable the provision of electrical power to the ESAU.

[0016] In an advantageous example, two or more of the contact assemblies of the first type are arranged to be actuated on by actuators due to centrifugal, radially outward, forces. In this way, a lateral acceleration, such as that which might be exhibited due to transportation or handling, may only cause one contact assembly of the first type to be actuated. This is because only one of the contact assemblies would be subjected to the outward force, whilst the other would be subjected to an inward force. In this way, the ESAU is prevented from being supplied with electrical power unintentionally, due to dropping, jolting, or the like.

[0017] In one example, the switch comprises a pair of contact assemblies of the first type and actuators associated therewith configured so as to act on the respective contact assembly of the first type, wherein a first one of the pair of contact assemblies connected to a positive electrical power rail and a second one of the pair of contact assemblies connected to a negative electrical power rail.

[0018] Advantageously, this provides an additional level of safety as both of the pair of contact assemblies need to close for power to be provided to the ESAU.

[0019] In one example, the switch comprises a contact assembly of a second type movable from a first arrangement defining a first switch state to a second arrangement defining a second switch state; and wherein forces due to linear acceleration of the switch causes said movement of the contact assembly of the second type.

[0020] In this way, setback and setforward forces can be detected and used to initiate arming of the ESAU. The point of inflection in the axial acceleration (i.e., in the direction of travel of the munition) profile can thus be detected, by the point of change from the first switch state to the second switch state. This point of inflection in axial acceleration is distinct to launch of the munition, and thus

provides a robust and secure signal to arm the ESAU.

[0021] In one example, the contact assembly of the first type and/or second type comprises a pair of electrical contacts.

5 **[0022]** In this way, a completed circuit can be formed by contact of the pairs of electrical contacts.

[0023] In one example, in the first arrangement the contact assembly of the first type and/or second type is open and in the second arrangement the contact assembly of the first type and/or second type is closed.

10 **[0024]** In this way, a completed circuit can be formed by movement from the first arrangement to the second arrangement.

[0025] In one example, in the first arrangement the contact assembly of the first type is closed and in the second arrangement the contact assembly of the first type is open.

[0026] In this way, a circuit can be broken by movement from the first arrangement to the second arrangement.

20 **[0027]** In one example, the switch comprises at least one contact assembly wherein, in the first arrangement, the contact assembly is open and in the second arrangement the contact assembly is closed, and at least one contact assembly wherein, in the first arrangement, the contact assembly is closed and in the second arrangement the contact assembly is open.

[0028] In this way, safety is improved against fault conditions. For example, a fault may cause a set of contacts to be permanently short-circuit or open-circuit. This may result from manufacturing issues, moisture ingress, corrosion, damage, or the like. Robustness is thus obtained.

30 **[0029]** In one example, the contact assembly of the first type and/or second type is provided on a second body part. The second body part may comprise a printed circuit board, PCB.

35 **[0030]** In this way, a single integrated unit can be assembled for installation into an ESAU or fuze system. In addition, using a PCB can facilitate the mounting of additional electronic components, such as those for the ESAU.

40 **[0031]** In one example, a first body part comprises the actuator, and the second body part is mounted on the first body part. That is, the PCB may be mounted on the first body part.

45 **[0032]** In this way, a single integrated unit can be assembled for installation into an ESAU or fuze system. The first body part provides a mount for the PCB.

[0033] According to a second aspect of the present invention, there is provided an electronic safe and arm unit, ESAU, comprising a switch according to the first aspect.

50 **[0034]** In this way, power can be supplied to the ESAU only when suitable centrifugal forces are generated on launch or during travel of a munition. Safety of munition arming is thus improved. Other benefits of incorporation a switch according to the first aspect will be evident from the above.

[0035] According to a third aspect of the present inven-

tion, there is provided a fuze system comprising a switch according to the first aspect or an ESAU according to the second aspect.

[0036] In this way, power supply to the fuze system can be controlled with greater safety.

[0037] In one example, the fuze system comprises a power source in the form of a battery.

[0038] Using a battery rather than, for example, a conventional energiser is advantageous for a number of reasons. Energisers are expensive and, with limited sources worldwide, potential for supply chain disruption is high. Furthermore, certain energisers (such as Lithium Thionyl Chloride energisers) pose a number of health, safety and environmental hazards because the ingredients present therein are toxic and corrosive, as well as likely to explode if malfunctioning. Disposal of energisers thus poses a significant challenge. In addition, the battery life of such energisers is limited and thus might not be suitable for use with longer range targets. The present fuze system may a battery as an alternative to an energiser, and the switch herein described is simple in its construction, is small in size, and is low cost to manufacture. The power supply can be effectively switched on and off using the present switch.

[0039] According to a fourth aspect of the present invention, there is provided a munition comprising a switch according to the first aspect, an ESAU according to the second aspect, or a fuze system according to the third aspect

[0040] In this way, the supply of power for arming the munition, or other uses, can be effectively controlled by the present switch. An advantageous munition is thus provided. Other benefits of incorporating a switch, ESAU, or fuze system according to the first, second or third aspects in a munition will be evident from the above.

[0041] According to a fifth aspect of the present invention, there is provided a method of a switch, comprising the steps of: providing a switch according to the first aspect, an ESAU according to the second aspect, or a fuze system according to the third aspect; and controlling electrical power supplied by a power source to an ESAU or munition using the switch.

[0042] According to a sixth aspect of the present invention, there is provided a switch for controlling electrical power supplied by a power source to an electronic safe and arm unit, ESAU, or a munition, the switch comprising: a contact assembly arrangement comprising a contact assembly of a first type arrangeable in a first arrangement defining a first switch state and a second arrangement defining a second switch state, wherein centrifugal force caused by rotation of the switch causes movement of at least a part of the contact assembly of the first type to change the arrangement of the contact assembly of the first type from the first arrangement to the second arrangement.

[0043] In this way, centrifugal force causes movement of a part of the contact assembly. As such, the need for an actuator may be negated. This may simplify construc-

tion of the switch. Furthermore, in a similar manner to the first aspect of the present invention, by this construction, the switch makes use of centrifugal force to perform switching between the first switch state and the second switch state. This is highly advantageous in many situations. During storage and transport of the ESAU or munition it is unlikely that spin will be encountered, thus it is unlikely that centrifugal force will be generated to cause switching of the switch. Furthermore, by such a construction, no latching mechanism is required to maintain a particular switch state, such as an "on" switch state - here, the switched state will be maintained if spin is maintained. Additionally, the switch is simple in construction, small, and cheap to manufacture, at least compared with conventional switches for ESAUs or munitions. Safety benefits are obtained as supply of electrical power from the power source is deactivated when centrifugal force is not generated due to insufficient spinning of the switch. In the present disclosure, the centrifugal force may also be referred to as a "spin force" or "spin-generated force". In one advantageous implementation of the switch, the switch may control electrical power supplied by the power source to the munition. Control of the low voltage power supply is the basis of safety for many types of ESAUs, so as power switch driven by an operational environment (e.g., the spin environment) is an energy break, and thus also forms part of the ESAU function. That is, as the switch may function as both an ON/OFF switch, and as an environment sensor (suitable to detect a spin condition), the switch may be suitable to replace an ESAU rather than be incorporated in an ESAU.

[0044] It will be appreciated that many of the advantages of the sixth aspect of the present invention may be understood from the advantages described above in relation to previous aspects of the invention, by virtue of the many corresponding features.

[0045] In one example, the contact assembly of the first type comprises an arm in the form of a flexure member configured to deflect due to centrifugal force caused by rotation of the switch.

[0046] That is, the flexure member of the contact assembly may itself be configured, or arranged, to deflect due to the rotation, without being acted on by an actuator.

[0047] In one example, the flexure member is configured to deflect due to centrifugal force caused by rotation of the switch at a rotational frequency greater than a predetermined frequency. In one example, the predetermined frequency is 20Hz or 40Hz.

[0048] In one example, the switch comprises a plurality of contact assemblies of the first type.

[0049] In one example, the deflection of the flexure member (due to centrifugal force) is the movement of the at least a part of the contact assembly of the first type to change the arrangement of the contact assembly of the first type from the first arrangement to the second arrangement. That is, the deflection of the flexure member causes, or is, the change in the arrangement of the contact assembly.

[0050] In one example, the flexure member may be deflectable from a first member position corresponding with the first arrangement to a second member position corresponding with the second arrangement.

[0051] In one example, the contact assembly of the first type comprises a moveable element moveable due to centrifugal force caused by rotation of the switch from a first element position corresponding with the first arrangement to a second element position corresponding with the second arrangement.

[0052] In this way, a moveable element may replace an actuator. A moveable element may have more precise control than an actuator.

[0053] In one example, the contact assembly of the first type comprises a pair of arms, and one or both of the arms are arranged so as not to move or deflect due to centrifugal force. That is, one or both of the arms may be fixedly provided. The moveable element may be moveable to form a connection between a pair of contacts provided on the arms. In this way, an electrical connection may be formed without movement or deflection of the arms of the contact assembly, but rather by movement of the moveable element.

[0054] In one example, the moveable element may be moveable into a second position to provide a conductive bridge between the pair of contacts.

[0055] In this way, an electrical circuit may be formed by movement of the moveable element.

[0056] In one example, the moveable element may be formed of metal. In one example, the moveable element may be a ball bearing. Such a construction may be robust and cheap to manufacture.

[0057] In one example, the moveable element cooperates with a biasing member. The biasing member may be a spring. In one example, the moveable element acts against a spring. In this way, the position and deflection of the ball bearing may be accurately controlled, as well as facilitating biasing into a position (e.g., a first element position) in the absence of centrifugal force.

[0058] In one example, the moveable element acts on an arm in the form of a flexure member of the contact assembly to cause movement or deflection of said arm. The moveable element may act on said arm so as to cause movement of the arm from a first member position corresponding with the first arrangement to a second member position corresponding with the second arrangement.

[0059] In one example, the switch comprises a contact assembly of a second type moveable from a first arrangement defining a first switch state to a second arrangement defining a second switch state; and wherein forces due to linear acceleration of the switch causes said movement of the contact assembly of the second type.

[0060] In one example, in the first arrangement the contact assembly of the first type and/or second type is open and in the second arrangement the contact assembly of the first type and/or second type is closed.

[0061] In one example, in the first arrangement the

contact assembly of the first type is closed and in the second arrangement the contact assembly of the first type is open.

[0062] In one example, the contact assembly of the first type and/or second type is provided on a second body part. The second body part may comprise a printed circuit board, PCB.

[0063] In this way, a single integrated unit can be assembled for installation into an ESAU, fuze system or munition. In addition, using a PCB can facilitate the mounting of additional electronic components, such as those for the ESAU.

[0064] According to a seventh aspect of the present invention, there is provided an electronic safe and arm unit, ESAU, comprising a switch according to the sixth aspect.

[0065] In this way, power can be supplied to the ESAU only when suitable centrifugal forces are generated on launch or during travel of a munition. Safety of munition arming is thus improved. Other benefits of incorporation a switch according to the sixth aspect will be evident from the above.

[0066] According to an eighth aspect of the present invention, there is provided a fuze system comprising a switch according to the sixth aspect or an ESAU according to the seventh aspect.

[0067] In this way, power supply to the fuze system can be controlled with greater safety.

[0068] In one example, the fuze system comprises a power source in the form of a battery.

[0069] Using a battery rather than, for example, a conventional energiser is advantageous for a number of reasons. Energisers are expensive and, with limited sources worldwide, potential for supply chain disruption is high. Furthermore, certain energisers (such as Lithium Thionyl Chloride energisers) pose a number of health, safety and environmental hazards because the ingredients present therein are toxic and corrosive, as well as likely to explode if malfunctioning. Disposal of energisers thus poses a significant challenge. In addition, the battery life of such energisers is limited and thus might not be suitable for use with longer range targets. The present fuze system may a battery as an alternative to an energiser, and the switch herein described is simple in its construction, is small in size, and is low cost to manufacture. The power supply can be effectively switched on and off using the present switch.

[0070] According to a ninth aspect of the present invention, there is provided a munition comprising a switch according to the sixth aspect, an ESAU according to the seventh aspect, or a fuze system according to the eighth aspect

[0071] In this way, the supply of power for arming the munition, or other uses, can be effectively controlled by the present switch. An advantageous munition is thus provided. Other benefits of incorporating a switch, ESAU, or fuze system according to the sixth, seventh or eighth aspects in a munition will be evident from the above.

[0072] According to a tenth aspect of the present invention, there is provided a method of a switch, comprising the steps of: providing a switch according to the sixth aspect, an ESAU according to the seventh aspect, a fuze system according to the eighth aspect, or a munition according to the ninth aspect; and controlling electrical power supplied by a power source to an ESAU or munition using the switch.

[0073] It will of course be appreciated that features described in relation to one aspect of the present invention may be incorporated into other aspects of the present invention. For example, the second, third, fourth or fifth aspect of the invention may incorporate any of the features described with reference to the first aspect of the invention and vice versa. Additionally, for example, the seventh, eighth, ninth or tenth aspect of the invention may incorporate any of the features described with reference to the sixth aspect of the invention and vice versa. The seventh to tenth aspects may incorporate any of the features of the first to fifth aspects, and vice versa, as desired or as appropriate.

[0074] Other preferred and advantageous features of the invention will be apparent from the following description.

BRIEF DESCRIPTION OF THE FIGURES

[0075] Embodiments of the invention will now be described by way of example only with reference to the figures, in which:

- Figure 1 shows a plan view of a switch as part of an electronic safe and arm unit;
- Figure 2 shows a first body part;
- Figure 3 shows a second body part;
- Figure 4 shows a side view of the switch of Figure 1;
- Figure 5 shows a schematic electronic safe and arm unit;
- Figure 6 shows a schematic fuze system;
- Figure 7 shows a schematic munition; and
- Figure 8 shows general methodology principles;
- Figure 9 shows a further example of a switch;
- Figure 10 shows a further example of a switch;
- Figure 11 shows a further example of a switch
- Figure 12 shows a schematic electronic safe and arm unit;
- Figure 13 shows a schematic fuze system;
- Figure 14 shows a schematic munition; and
- Figure 15 shows general methodology principles.

DETAILED DESCRIPTION

[0076] In overview, a switch is described for controlling electrical power supplied by a power source to an electronic safe and arm unit (ESAU) or munition. In this way, the supply of electrical power to the ESAU or munition can be controlled to prevent arming of the munition prior to launch of the munition.

[0077] Thus, the risk of inadvertent or accidental detonation can be mitigated. The described switch is simple in construction (at least compared with prior art approaches). Furthermore, the described switch can be formed having a small profile, enabling incorporation in small munitions or those having limited internal space. Furthermore, the described switch makes use of a simple switching mechanism, and does not require electrical power to operate.

[0078] Referring to Figure 1, a switch 100 is shown in plan view as part of an ESAU 200. The switch 100 is for controlling electrical power supplied by a power source 300 to the ESAU 200 or munition. The switch 100 may be for controlling electrical power supplied by the power source 300 to the ESAU 200 in a munition. The power source 300 may be a battery. It will be appreciated that in some implementations the switch 100 may replace an ESAU 200 - that is, an ESAU 200 need not be provided, due to the operation of the switch 100 being suitable to perform the function of a typical ESAU.

[0079] The switch 100 comprises a contact assembly arrangement 110. The contact assembly arrangement 110 comprises a contact assembly of a first type 112 (hereinafter "a first type contact assembly 112"). In the illustrated example, the switch 100 comprises a plurality of first type contact assemblies 112a, 112b, 112c.

[0080] The first type contact assembly 110 is moveable from a first arrangement defining a first switch state to a second arrangement defining a second switch state.

[0081] The switch 100 comprises an actuator 120 configured to act on the first type contact assembly 110 to cause said movement of the first type contact assembly 110. That is, the actuator 120 is configured to act on the first type contact assembly 110 to cause the movement from the first arrangement defining the first switch state to the second arrangement defining the second switch state. In the illustrated example, the switch 100 comprises a plurality of actuators 120a, 120b, 120c. Each actuator 120a - 120c is associated with one of the first type contact assemblies 112a - 112c.

[0082] The actuator 120 is configured to act on the first type contact assembly 110 under the influence of centrifugal force caused by rotation of the switch 100. That is, in the illustrated example, the actuators 120a - 120c are configured to act on the associated first type contact assembly 112a - 112c under the influence of centrifugal force caused by rotation of the switch 100.

[0083] By this construction, the switch 100 makes use of centrifugal force to perform switching between the first switch state and the second switch state. This is highly advantageous in many situations. During launch of the munition, the switch 100 will rotate, or spin, at a considerable rotational frequency due to rotation or spinning of the munition. However, during storage and transport of the munition, it is unlikely that rotation or spin will be encountered, thus it is unlikely that centrifugal force will be generated to cause switching of the switch 100. Furthermore, by such a construction, no latching mechanism is

required to maintain a particular switch state, such as an "on" switch state - here, the switched state will be maintained if spin is maintained. Additionally, the switch 100 is simple in construction, small, and cheap to manufacture, at least compared with conventional ESAU switches. Safety benefits are obtained as supply of electrical power from the power source is deactivated when centrifugal force is not generated due to insufficient spinning of the switch 100. In the present disclosure, the centrifugal force may also be referred to as a "spin force" or "spin-generated force".

[0084] The switch 100 comprises a first body part 130 and a second body part 140. The first body part 130 is shown in isolation in Figure 2. The second body part 140 with the contact assembly arrangement 110 mounted thereon is shown in Figure 3.

[0085] The second body part 140 is configured to be mounted beneath the first body part 130. In this way, the first body part 130 is provided over, or on top of, the second body part 140. In this example, the first body part 130 and second body part 140 each have a circular profile in plan view, and are identically sized, such that the first body part 130 and second body part 140 together have a continuous outer surface when assembled (as shown in Figure 1).

[0086] In this example, the first body part 130 is a moulded plastic component. The first body part 130 comprises the plurality of actuators 120a - 120c. The actuators 120a - 120c comprise flexure members 122a, 122b, 122c. The flexure members 122a - 122c each comprise a shaft 124a, 124b, 124c and a head 126a, 126b, 126c. As will be described in greater detail below, the flexure members 122a - 122c are configured to deflect due to centrifugal force caused by rotation of the switch 100 so as to cause the actuator 120a - 120c to act on the associated first type contact assembly 112a - 112c.

[0087] The second body part 140 provides a mount for the contact assembly arrangement 110. The second body part 140 may also provide a mount for additional electronic components of the ESAU 200. In this example, the second body part 140 is a printed circuit board (PCB). The contact assembly arrangement 110 may be provided on, or mounted on, the second body part 140. Additional electronic components of the ESAU 200 may be provided on, or mounted on, the second body part 140.

[0088] Referring to Figure 4, the switch 100 is shown in a side view, with the first body part 130 absent. The switch 100 is arranged to rotate about a central axis 150 of the assembled first body part 130 and second body part 140. In an implementation, the switch is arranged to be incorporated in the ESAU 200, or in a munition, such that the central axis is parallel to the direction of travel 160 of the ESAU 200 or the munition. In an example, the central axis 150 is coaxial with the direction of travel 160. The direction of travel 160 may be a firing direction of the munition. The ESAU 200, or munition, spins about the central axis 150 during travel, thus generating the centrifugal force to cause the actuator 120 to act on the first

type contact assembly 110.

[0089] For the avoidance of doubt, it will be understood by the skilled person that rotation or spinning about the central axis 150 may also mean rotating or spinning about a, or the, longitudinal axis of the switch 100, or about a, or the, longitudinal axis of the munition as a whole. That is, the central axis 150 may be the same as a central axis or longitudinal axis of the munition, or coaxial with the central axis or longitudinal axis of the munition.

[0090] The first type contact assemblies 112a - 112c each comprise a pair of arms 114a, 114b, 114c mounted on the second body part 140 to extend vertically upward and parallel to one another. At the free end (i.e., distal to the end mounted to the second body part 140), a contact is provided on each arm facing toward one another. That is, a pair of contacts 116a, 116b, 116c are provided in a facing arrangement. The contacts 116 - 116c are electrically conducting contacts.

[0091] A pair of the first type contact assemblies 112a - 112c are "normally open" first type contact assemblies 112a, 112b. The normally open first type contact assemblies 112a, 112b are arranged such that their contacts 116a, 116b are out of contact in absence of actuation by the corresponding actuators 120a, 120b. Centrifugal forces cause the associated actuator 120a, 120b to act on the normally open first type contact assembly 112a, 112b to drive the contacts 116a, 116b into contact with one another. Specifically, the flexure members 122a, 122b deflect outwardly due to the centrifugal force, and the actuator head 126a, 126b contacts an arm of the normally open first type contact assembly 112a, 112b to push, press, or drive one arm toward the other, thereby to bring the contacts 116a, 116b into contact. In a first arrangement the normally open first type contact assemblies 112a, 112b are open, and in a second arrangement the normally open first type contact assemblies 112a, 112b are closed.

[0092] One of the normally open first type contact assemblies is connected to a positive electrical power rail. The other of the normally open first type contact assemblies is connected to a negative electrical power rail. In this way, power can be provided from the power source 300 to the ESAU via the switch 100 when both of the normally open contact assemblies 112a, 112b are closed.

[0093] One of the first type contact assemblies 112a - 112c is a "normally closed" first type contact assembly 112c. The normally closed first type contact assembly 112c is arranged such that the contacts 116c are in contact in absence of actuation by the associated actuator 120c. Centrifugal forces cause the associated actuator to act on the normally closed first type contact assembly to drive the contacts out of contact with one another. Specifically, the flexure member 122c deflects outwardly due to the centrifugal force, and the actuator head 126c contacts an arm of the normally closed first type contact assembly 112c to push, press, or drive one arm away from the other, thereby to separate, or move, the contacts 116c

out of contact. In a first arrangement the normally closed first type contact assembly 112c is closed, and in a second arrangement the normally closed first type contact assembly 112c is open.

[0094] The actuators 120a - 120c are arranged such that deflection of the actuator due to centrifugal force causes the actuator to act on the respective first type contact assembly 112a - 112c. In this way, the contacts 116a - 116c can be actuated into contact with one another (in the case of the normally open first type contact assemblies 112a, 112b), or actuated out of contact with one another (in the case of the normally closed first type contact assembly 112c).

[0095] Rotation of the switch 100 about the central axis 150 generates a centrifugal force. The centrifugal force causes the actuators 120a - 120c to deflect into contact with the first type contact assemblies 112a - 112c. In an example, the arms 114a - 114c of the first type connect assemblies 112a - 112c are sufficiently stiff so as not to move due to the centrifugal forces generated. The actuation force provided by the actuators 120a - 120c acting on the first type contact assemblies 112a - 112c is sufficient to actuate the first type contact assemblies from the first arrangement to the second arrangement.

[0096] The centrifugal force caused by rotation of the switch 100 at a rotational frequency greater than a predetermined frequency causes the actuators 120a - 120c to act on the first type contact assemblies 112a - 112c. That is, when the switch 100 is rotating or spinning at a rotational frequency greater than a predetermined frequency, the centrifugal force causes the actuators 120a - 120c to act on the first type contact assemblies 112a - 112c.

[0097] The predetermined rotational frequency may be 20Hz or 40Hz. That is, the actuators 120a - 120c may be configured to deflect due to centrifugal forces generated at the predetermined rotational frequency. In a preferred example, the predetermined rotational frequency may be 20Hz for the actuator 120c to act on the normally closed first type contact assembly 112c to actuate said contact assembly 112c from the first arrangement to the second arrangement. That is, the normally closed first type contact assembly 112c is actuated into an open state due to centrifugal forces generated at a rotational frequency of 20Hz or greater causing sufficient deflection of the flexure member 122c. Additionally, in a preferred example, the predetermined rotational frequency may be 40Hz for the associated actuators 120a, 120b to act on the normally open first type contact assemblies 112a, 112b to actuate said contact assemblies from the first arrangement to the second arrangement. That is, the normally open first type contact assemblies 112a, 112b are actuated into a closed state due to centrifugal forces generated at a rotational frequency of 40Hz or greater.

[0098] The normally open first type contact assemblies 112a, 112b may be provided equidistant from the axis of rotation 150 (i.e., the central axis of the switch 100). In this way, the normally open first type contact assemblies

112a, 112b may be actuated to close simultaneously when the predetermined rotational frequency is reached. It will be appreciated that other arrangements may be possible to facilitate simultaneous closing of the normally open first type contact assemblies 112a, 112b, such as forming the associated actuators 120a, 120b from materials having appropriate stiffnesses.

[0099] The contact assembly arrangement 110 further comprises a contact assembly of a second type 170 (hereinafter "a second type contact assembly 170"). The second type contact assembly 170 is moveable from a first arrangement defining a first switch state to a second arrangement defining a second switch state. Linear acceleration of the switch 100 causes said movement of the second type contact assembly 170. That is, forces due to linear acceleration of the switch 100 causes the second type contact assembly 170 to move from the first arrangement to the second arrangement.

[0100] The second type contact assembly 170 comprises a mount 172, an arm 174, and a pair of contacts 176. The arm 174 is mounted at one end to the mount 172, and the other end of the arm is free such that it may deflect. The pair of contacts 176 are provided in a facing arrangement. One of the pair of contacts 176 is provided on the second body part 140 (e.g., on a surface of the second body part 140) and the other of the pair of contacts 176 is provided on the free end of the arm 174. The arm 174 has the form of a flexible plate. The second type contact assembly 170 is provided substantially centrally in the switch 100 (e.g., above the central axis 150 of the switch). This is possible as the second type contact assembly 170 does not make use of centrifugal forces, but rather forces due to linear acceleration of the switch 100. That is, the second type contact assembly 170 is arranged to deflect in a direction substantially parallel to the direction of travel 160.

[0101] The second type contact assembly 170 is moveable from a first arrangement defining a first switch state to a second arrangement defining a second switch state.

[0102] The second type contact assembly 170 is a "normally open" contact assembly. The normally open second type contact assembly 170 is arranged such that the contacts 176 are out of contact in absence of forces due to linear acceleration. In a first arrangement the normally open second type contact assembly 170 is open, and in a second arrangement the normally open second type contact assembly 170 is closed.

[0103] The second type contact assembly 170 is arranged to close due to setback force and reopen due to setforward force. Setback and setforward forces are well understood by those skilled in the art. Setback force is the rearward force of inertia which is created by the forward acceleration of a projectile or missile during its launching phase. Setforward force is the frontward force of inertia which is created by the rearward acceleration of a projectile or missile at muzzle exit. The second type contact assembly 170 is arranged to close on launch (i.e., due to setback force) and reopen at muzzle exit (i.e., due

to setforward force). In an example, the second type contact assembly 170 is arranged to close at a setback force corresponding to an acceleration greater than a threshold acceleration (e.g., 500 times the acceleration due to gravity), and the second type contact assembly 170 is arranged to open subsequent to launch when the acceleration is reduced below a threshold acceleration (e.g., 500 times the acceleration due to gravity). This is highly indicative of a typical munition launch procedure, and thus provides a robust signal for arming of the ESAU 200.

[0104] The second type contact assembly is arranged to provide an electrical signal to trigger a latch (for example, a D-type latch) in the ESAU 200. The action triggered by the change of state on transition from setback to setforward protects against latch up/down conditions.

[0105] In an exemplary operation of the switch 100, the switch 100 is comprised in an ESAU 200 of a fuze system of a munition. At launch, the munition will spin, thus causing a change in switch state of each first type contact assembly 112 of the contact assembly arrangement 110. Power is thereby supplied to the ESAU 200 by the formation of a complete circuit by the normally open first type contact assemblies 112a, 112b connecting the positive and negative power rails. The normally open first type contact assemblies 112a, 112b thus each provide a static energy break. Setback/setforward force can then be used to trigger the latch, as power is supplied to the latch. A reset can be used, which is long enough in time to ensure power is connected and stable before enabling latch, but short enough not to miss the transition pulse from the second type contact assembly 170. The reset time may be of the order of 1 - 2ms. The second type contact assembly 170 experiences a transition from setback to setforward force at muzzle exit. The second type contact assembly 170 thus provides a dynamic energy break. Power can then be supplied to an electronic delay and high frequency oscillator (HFO). Arming of the munition can then take place. The energy breaks mentioned above prevent the electronic delay and HFO from operating in absence of spin, or setback/setforward transition, in addition to providing power to a transformer for providing voltage to a fireset. If the spin/rotation state is lost then power ceases to be supplied to the ESAU or fuze system. In this way, safety is improved, and a simple switch 100 can control power provided by a power source to the ESAU as no complex latching mechanism is required as a complete circuit is formed as long as spin is maintained.

[0106] Referring to Figure 5, an ESAU 200 is schematically shown. The ESAU 200 comprises the switch 100. The ESAU 200 and switch 100 are as described above, and may comprise any or all of the features of the above described ESAU 200 and switch 100.

[0107] Referring to Figure 6, a fuze system 500 is schematically shown. The fuze system 500 comprises the switch 100 or the ESAU 200. The ESAU 200 and switch 100 are as described above, and may comprise any or all of the features of the above described ESAU 200 and

switch 100.

[0108] The fuze system 500 further comprises a power source 510. In this example, the power source 510 is a battery. This is highly advantageous, as the battery (such as a Li-Ion battery) can replace conventional energisers.

[0109] Referring to Figure 7, a munition 600 is schematically shown. In an example, the munition 600 comprises the switch 100. Additionally, or alternatively, in an example, the munition 600 comprises the ESAU 200. Additionally, or alternatively, in an example, the munition 600 comprises the fuze system 500. The ESAU 200 and switch 100, or fuze system 500, are as described above, and may comprise any or all of the features of the above described ESAU 200, switch 100 and/or fuze system 500.

[0110] Referring to Figure 8, a method of a switch is schematically shown. Step 810 comprises providing the switch 100, the ESAU 200, and/or the fuze system 500. Step 820 comprises controlling electrical power supplied by a power source (which may be a battery) to an ESAU 200 using the switch 100.

[0111] Referring to Figures 9 to 11, embodiments of switches 1000, 1100, 1200 are shown. The switches 1000, 1100, 1200 operate in largely the same manner as the switch 100 described above. However, in each switch 1000, 1100, 1200, an actuator is not incorporated. Instead, rather than centrifugal force causing movement of an actuator which acts on the contact assembly to cause movement thereof, centrifugal force causes movement of at least a part of the contact assembly. In these embodiments, the contact assembly may comprise an arm in the form of a flexure member, or a moveable element moveable due to centrifugal force generated by rotation of the switch 1000, 1100, 1200. The key difference with respect to the switch 100 described above is that centrifugal force causes movement of a part of the contact assembly itself, without said movement being caused by the influence of an actuator. Aside from this distinction, operation of the switches 1000, 1100, 1200 will be understood from the description of operation of switch 100 described above. Thus, many of the features of switch 100 will be understood by the skilled person to be compatible with switches 1000, 1100, 1200 herein described. For this reason, repetition of a number of features of the switches 1000, 1100, 1200 has been avoided for brevity, as the skilled person will understand that operation corresponds largely with that described above in relation to switch 100.

[0112] Each of the switches 1000, 1100, 1200 are for controlling electrical power supplied by a power source to an ESAU or a munition. Each switch 1000, 1100, 1200 comprises a contact assembly arrangement 1010, 1110, 1210. The contact assembly arrangement 1010, 1110, 1210 comprises a contact assembly of a first type 1012, 1112, 1212 (hereinafter "a first type contact assembly 1012, 1112, 1212"). In the illustrated examples, each switch 1000, 1100, 1200 comprises a plurality of first type contact assemblies. The first type contact assemblies 1012, 1112, 1212 are arrangeable in a first arrangement

defining a first switch state and a second arrangement defining a second switch state.

[0113] Centrifugal force caused by rotation of the switch 1000, 1100, 1200 causes movement of at least a part of the first type contact assembly 1012, 1112, 1212 to change the arrangement of the first type contact assembly 1012, 1112, 1212 from the first arrangement to the second arrangement.

[0114] Referring to Figure 9, the switch 1000 is shown. In said switch 1000, rather than an actuator (as in switch 100), at least one of the arms 1014a, 1014b, 1014c is in the form of a flexure member. The flexure member is configured to deflect due to centrifugal force caused by rotation of the switch. The flexure member may be formed from a material able to bend due to centrifugal force, such as a flexible material, e.g. a copper plate or rubber body. This is the only difference with respect to the switch 100 described above. It will be appreciated that such first type contact assemblies may be provided in normally open or normally closed configurations.

[0115] Rotation of the switch 1000 about the central axis 150 generates a centrifugal force. The centrifugal force causes the flexure members to deflect so as to cause the contacts to be brought into, or out of, contact, dependent on whether the contact assembly is a normally open or normally closed contact assembly. That is, the arms 1014a, 1014b, 1014c have a stiffness so as to move due to centrifugal forces generated.

[0116] In this example, the deflection of the flexure member is the movement of the at least a part of the contact assembly of the first type 1012 to change the arrangement of the contact assembly of the first type from the first arrangement to the second arrangement.

[0117] Furthermore, in this example, the flexure member is deflectable from a first member position (which may be a non-deflected position) to a second member position (which may be a deflected position) corresponding with the second arrangement.

[0118] Referring to Figures 10 and 11, switches 1100, 1200 are shown. In said switches, rather than an actuator (as in switch 100), the first type contact assemblies 1112, 1212 comprise a moveable element 1116, 1216 moveable due to centrifugal force caused by rotation of the switches 1100, 1200. The moveable elements are moveable from a first element position corresponding with the first arrangement to a second element position corresponding with the second arrangement. That is, rather than an actuator being moveable (as in switch 100), a moveable element 1116, 1216 is moveable due to centrifugal force caused by rotation. In switch 1100, this is the only difference with respect to switch 100 described above - that is, the actuator is replaced with the moveable element.

[0119] Referring to Figure 10, the first type contact assemblies 1112 comprise pairs of arms 1114. One of the arms 1114 may be arranged so as not to move or deflect due to centrifugal force. That is, the arms 1114 may have a stiffness such that one or both of the arms do not move

or deflect due to centrifugal force. This may mean that the arms have a stiffness such that they do not deflect by a sufficient distance or amount to cause a change from the first arrangement to the second arrangement due to centrifugal force alone. Instead, the moveable element may be arranged so as to act on the arm to caused movement or deflection of said arm. One or both of the arms may nevertheless be provided in the form of flexure members.

[0120] The moveable element 1116, 1216 may comprise a ball bearing moveable along a track or guide assembly. When the switch 1100 exhibits rotation, the ball bearing is moved along the track and into contact with an arm, to cause deflection thereof. This results in the change of the arrangement from the first arrangement to the second arrangement. This movement is indicated by arrows 1118 in Figure 10.

[0121] The moveable element 1116 may cooperate with a biasing member 1117. The biasing member may be a spring. The biasing member may cause the moveable element 1116 to be brought out of contact with the arm in the absence of rotation of the switch 1100.

[0122] Referring to Figure 11, the first type contact assemblies 1212 comprise pairs of arms 1214. The arms 1214 are provided in a configuration which is rotated by 90 degrees with respect to those of the switch 100 of the first example. The arms 1214 may not deflect due to centrifugal force, due to their configuration. The moveable element 1216 again comprises a ball bearing moveable along a track or guide assembly (as in switch 1100). When the switch 1200 exhibits rotation, the ball bearing is moved along the track (from a first element position) and into a second element position to provide a conductive bridge between the pair of contacts provided on the arms. That is, the ball bearing is deflected outwardly due to the centrifugal force, and when deflected provides a conductive bridge. In this way, an electrical circuit may be formed, or broken, depending on rotation of the switch 1200. The rotated configuration of the arms 1214 and the provision of a moveable element 1216 are the only differences with respect to the switch 100 of the first example, and all other features will be understood therefrom and not repeated here for brevity.

[0123] The moveable element 1216 may also cooperate with a biasing member in the switch 1200. The biasing member may again be a spring.

[0124] In each of switches 1000, 1100, 1200, the switch 1000, 1100, 1200 may comprise a contact assembly of a second type 1030, 1130, 1230 (hereinafter "a second type contact assembly 1030, 1130, 1230") moveable from a first arrangement defining a first switch state to a second arrangement defining a second switch state; and wherein forces due to linear acceleration of the switch causes said movement of the contact assembly of the second type (similar to that described above in relation to switch 100). The second type contact assembly may comprise an actuator (as in the switch 100 of the first example), or may comprise an arm in the form of a

flexure member, or a moveable element to act on an arm or moveable to provide a conductive bridge between the pair of contacts. The skilled person will understand how the flexure member or moveable element need be oriented to provide switching due to linear acceleration of the switch 100, 1100, 1200.

[0125] Referring to Figure 12, an ESAU 1300 is schematically shown. The ESAU 1300 comprises the switch 1100, 1200. The ESAU 1300 and switch 1100, 1200 are as described above, and may comprise any or all of the features of the above described ESAU 1300 and switch 1100, 1200.

[0126] Referring to Figure 13, a fuze system 1400 is schematically shown. The fuze system 1400 comprises the switch 1100, 1200 or the ESAU 1300. The ESAU 1300 and switch 1100, 1200 are as described above, and may comprise any or all of the features of the above described ESAU 1300 and switch 1100, 1200.

[0127] The fuze system 1400 further comprises a power source 1410. In this example, the power source 1410 is a battery. This is highly advantageous, as the battery (such as a Li-Ion battery) can replace conventional energisers.

[0128] Referring to Figure 14, a munition 1500 is schematically shown. In an example, the munition 1500 comprises the switch 1100, 1200. Additionally, or alternatively, in an example, the munition 1500 comprises the ESAU 1300. Additionally, or alternatively, in an example, the munition 1500 comprises the fuze system 1400. The ESAU 1300 and switch 1100, 1200, or fuze system 1400, are as described above, and may comprise any or all of the features of the above described ESAU 1300, switch 1100, 1200 and/or fuze system 1400.

[0129] Referring to Figure 15, a method of a switch is schematically shown. Step 1610 comprises providing the switch 1100, 1200, the ESAU 1300, and/or the fuze system 1400. Step 1620 comprises controlling electrical power supplied by a power source (which may be a battery) to an ESAU 1300 or munition 1500 using the switch 1100, 1200.

Claims

1. A switch for controlling electrical power supplied by a power source to an electronic safe and arm unit, ESAU, or a munition, the switch comprising:

a contact assembly arrangement comprising a contact assembly of a first type arrangeable in a first arrangement defining a first switch state and a second arrangement defining a second switch state, wherein centrifugal force caused by rotation of the switch causes movement of at least a part of the contact assembly of the first type to change the arrangement of the contact assembly of the first type from the first arrangement to

the second arrangement.

2. The switch according to claim 1, wherein the contact assembly of the first type comprises an arm in the form of a flexure member configured to deflect due to centrifugal force caused by rotation of the switch.
3. The switch according to claim 2, wherein the flexure member is configured to deflect due to centrifugal force caused by rotation of the switch at a rotational frequency greater than a predetermined frequency, optionally wherein the predetermined frequency is 20Hz or 40Hz.
4. The switch according to claim 2 or claim 3, wherein the deflection of the flexure member is the movement of the at least a part of the contact assembly of the first type to change the arrangement of the contact assembly of the first type from the first arrangement to the second arrangement.
5. The switch according to any one of claims 2 to 4, wherein the flexure member is deflectable from a first member position corresponding with the first arrangement to a second member position corresponding with the second arrangement.
6. The switch according to any one of the preceding claims, wherein the contact assembly of the first type comprises a moveable element moveable due to centrifugal force caused by rotation of the switch from a first element position corresponding with the first arrangement to a second element position corresponding with the second arrangement.
7. The switch according to claim 6, wherein the contact assembly of the first type comprises a pair of arms, and one or both of the arms are arranged so as not to move or deflect due to centrifugal force.
8. The switch according to claim 6 or claim 7, wherein the moveable element is moveable into a second element position to provide a conductive bridge between a pair of contacts.
9. The switch according to any one of claims 6 to 8, wherein the moveable element cooperates with a biasing member.
10. The switch according to any one of claims 6 to 9, wherein the moveable element acts on an arm in the form of a flexure member of the contact assembly to cause movement or deflection of said arm.
11. The switch according to any one of the preceding claims, wherein the switch comprises a contact assembly of a second type moveable from a first arrangement defining a first switch state to a second

arrangement defining a second switch state; and wherein forces due to linear acceleration of the switch causes said movement of the contact assembly of the second type.

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12. An electronic safe and arm unit (1300), ESAU, comprising the switch according to any one of the preceding claims.

13. A fuze system comprising the switch according to any one of claims 1 to 11 or the ESAU according to claim 12, optionally wherein the fuze system comprises a power source in the form of a battery.

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14. A munition comprising the switch according to any one of claims 1 to 11, the ESAU according to claim 12, or the fuze system according to claim 13.

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15. A method of a switch, comprising the steps of:

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providing the switch according to any one of claims 1 to 11, the ESAU according to claim 12, the fuze system according to claims 13, or the munition according to claim 14; and controlling electrical power supplied by a power source to an ESAU or munition using the switch.

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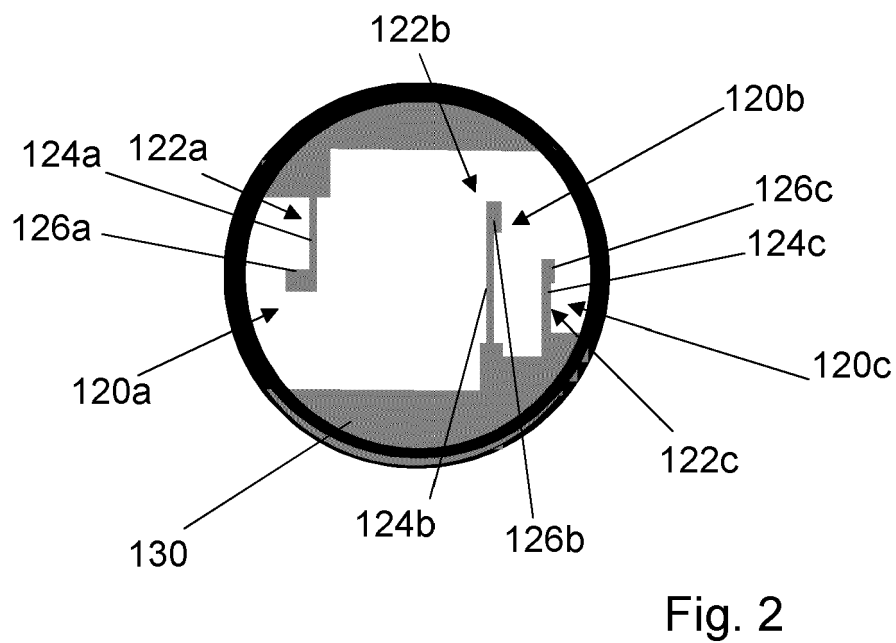
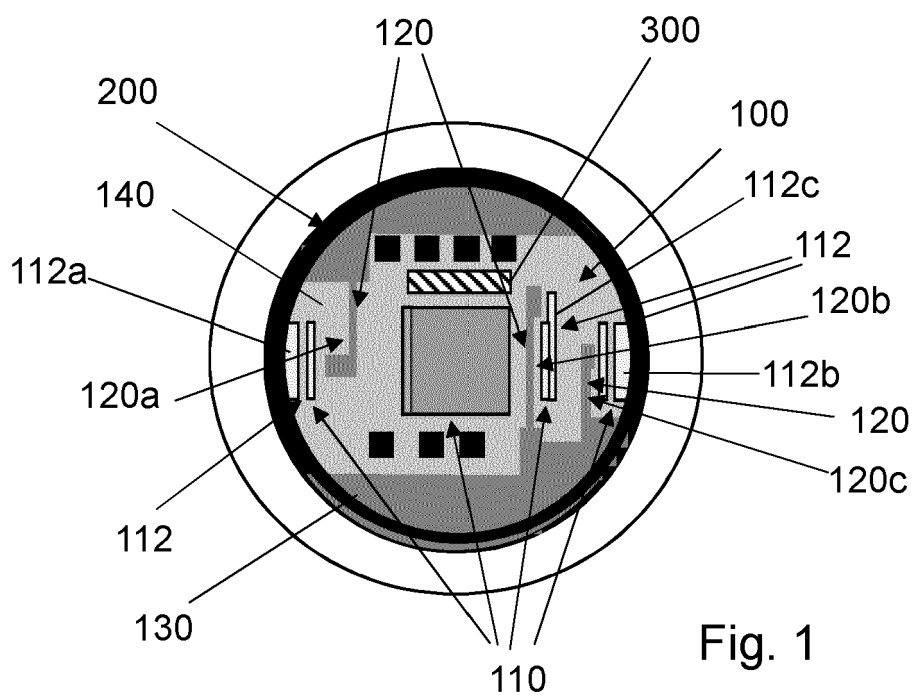
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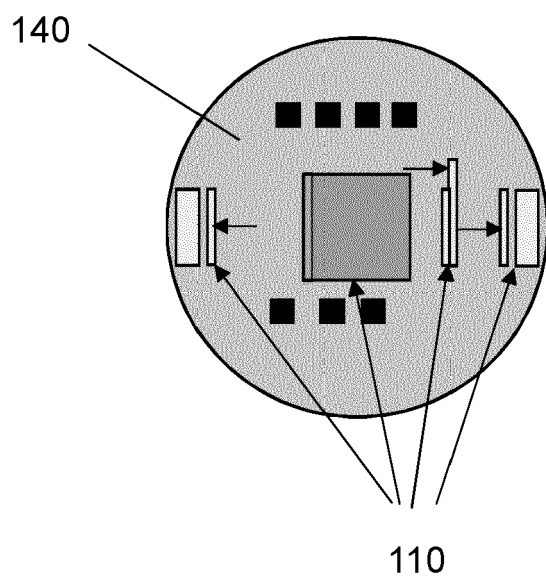


Fig. 3

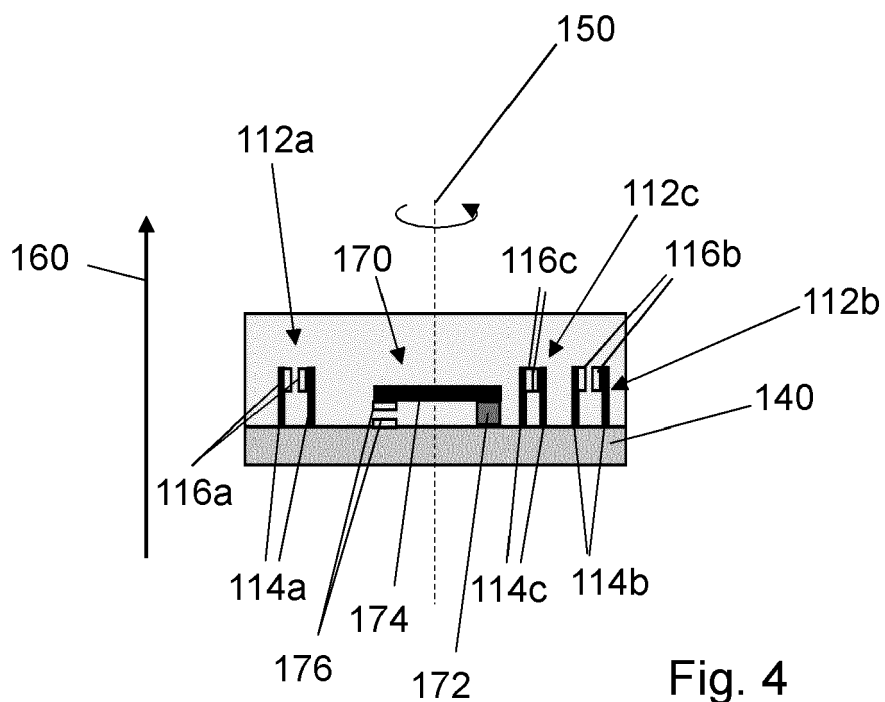


Fig. 4

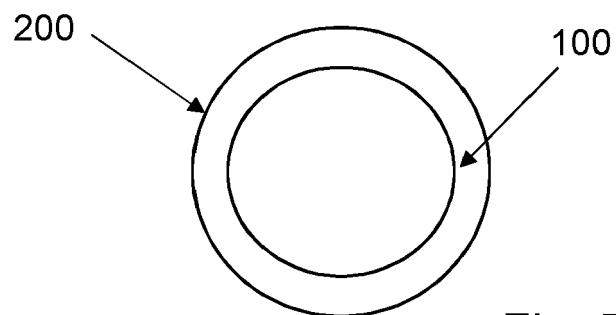


Fig. 5

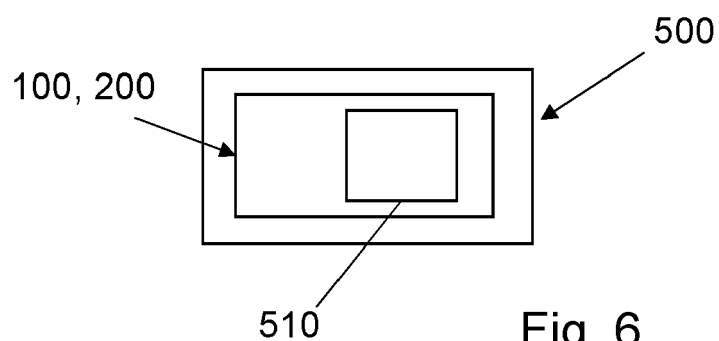


Fig. 6

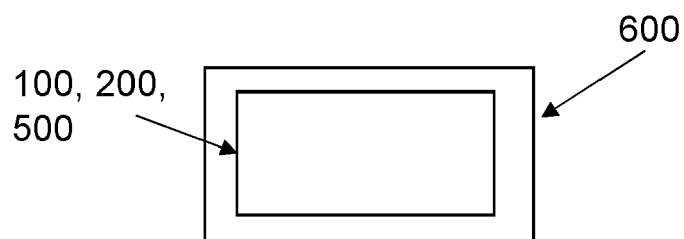


Fig. 7

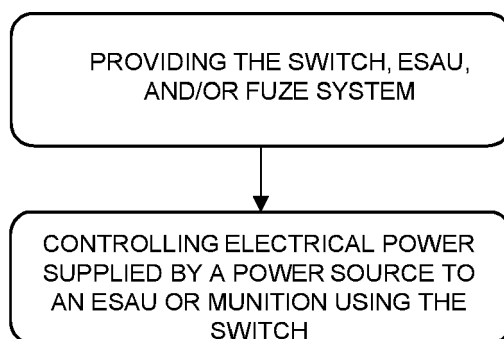


Fig. 8

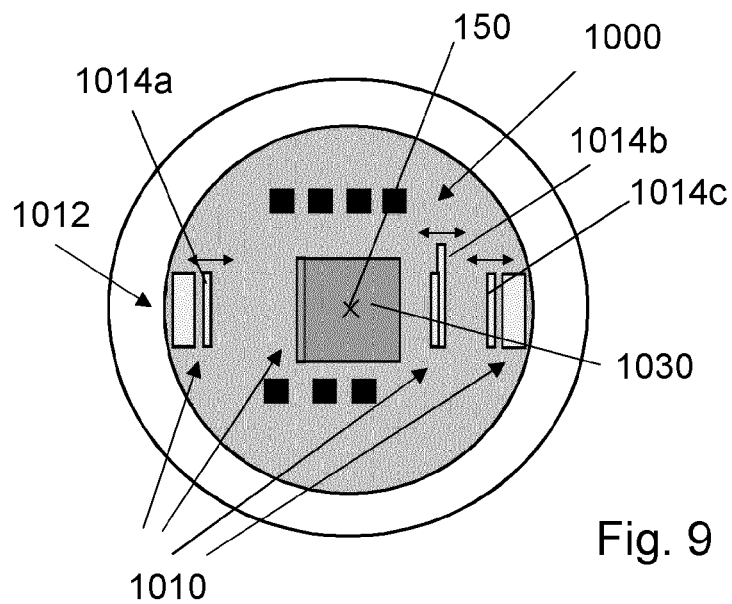


Fig. 9

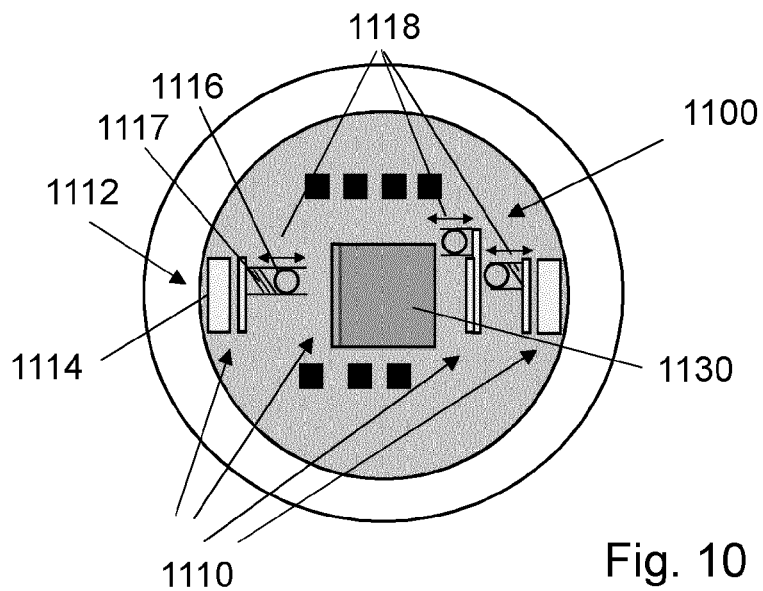


Fig. 10

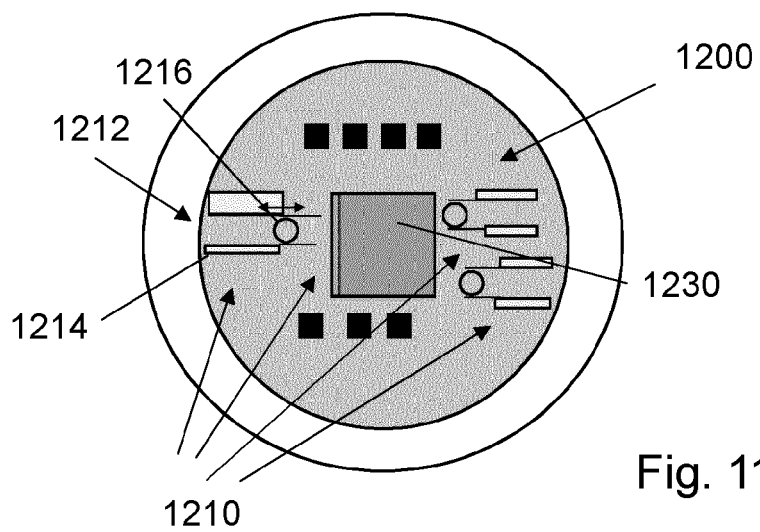


Fig. 11

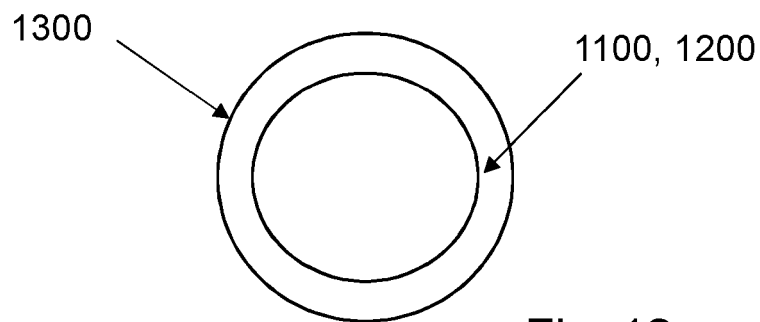


Fig. 12

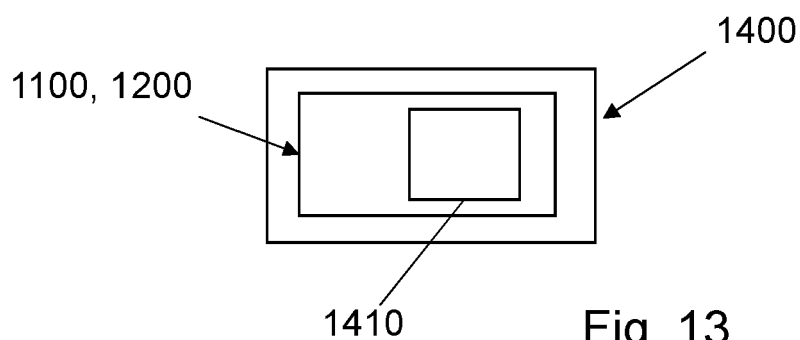


Fig. 13

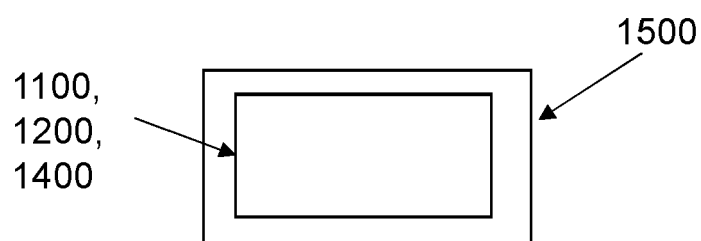


Fig. 14

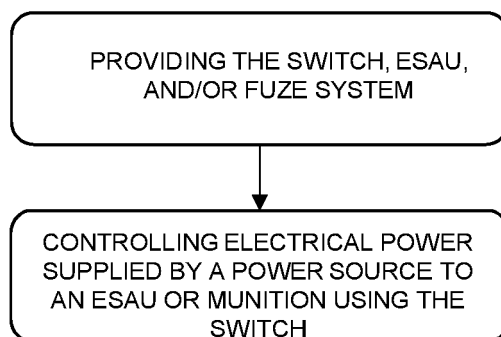


Fig. 15



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Application Number

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X	WO 00/12953 A1 (ROYAL ORDNANCE PLC [GB]; HICKEY DENNIS JAMES [GB] ET AL.) 9 March 2000 (2000-03-09) * abstract; figures 3a-4b * * page 7, last paragraph - page 10, paragraph 1 *	1-6, 9, 11-15	
X	EP 1 909 057 A1 (JUNGHANS MICROTEC GMBH [DE]) 9 April 2008 (2008-04-09) * abstract; figure 1 * * paragraphs [0011] - [0016] *	1, 6, 8, 9, 12-14	TECHNICAL FIELDS SEARCHED (IPC) F42C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 4 May 2023	Examiner Schwingel, Dirk
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