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VAN VLIET et al.(10) **Pub. No.: US 2015/0308805 A1**(43) **Pub. Date: Oct. 29, 2015**(54) **MINIATURE ELECTRO-PYROTECHNIC
IGNITER, AND IGNITION HEAD FOR THE
SAME**(30) **Foreign Application Priority Data**

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NARDINI, 's-Gravenhage (NL)(57) **ABSTRACT**

An electric non-pyrotechnic ignition head (100) suitable for use in an electro-pyrotechnic igniter (1), comprising: a housing (102) defining a front opening (106); —an electrically insulative, thermally conductive bridge filament support body (130) that is at least partly disposed in said front opening, and that defines a frontal heating surface (132b); and a bridge filament (120) including at least one cross-over portion (122) that extends over the frontal heating surface (132b) of the bridge filament support body (130).

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§ 371 (c)(1),

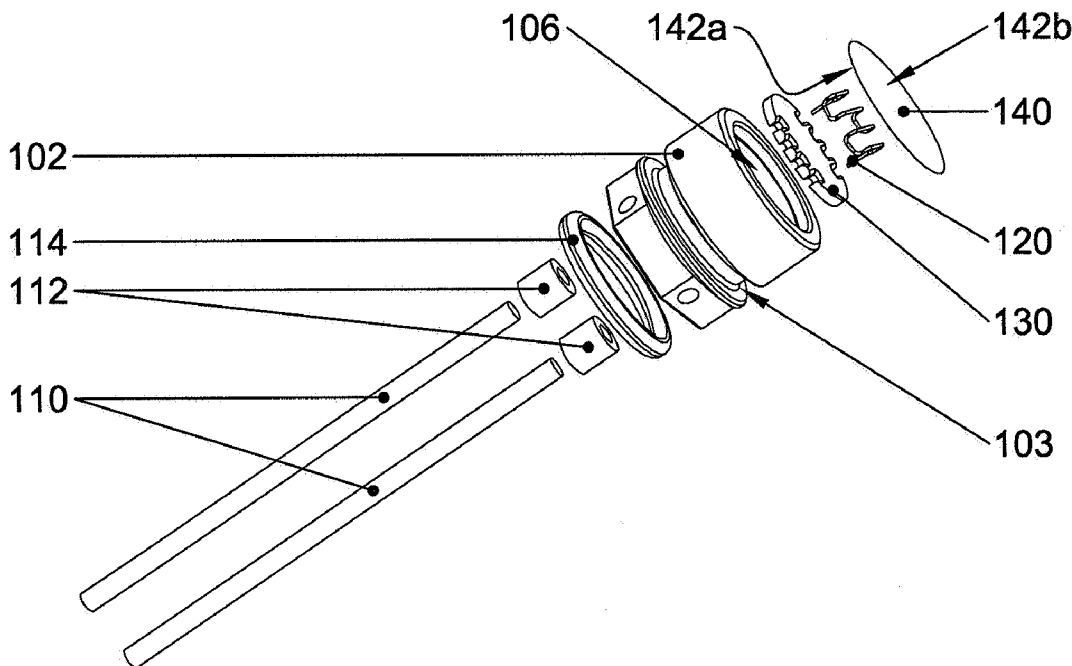
(2) Date: **Jun. 9, 2015**

Fig. 1B

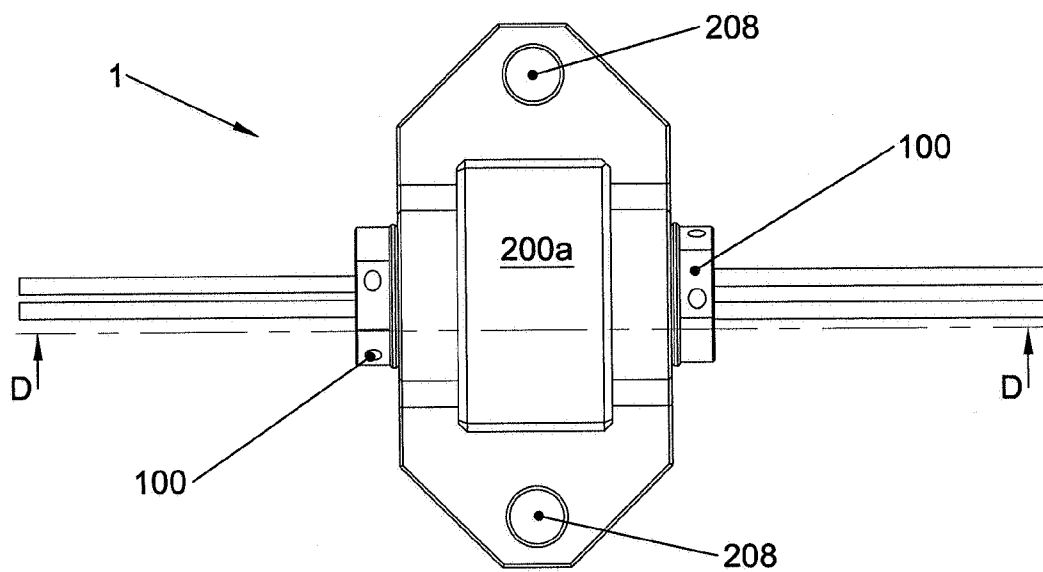


Fig. 1C

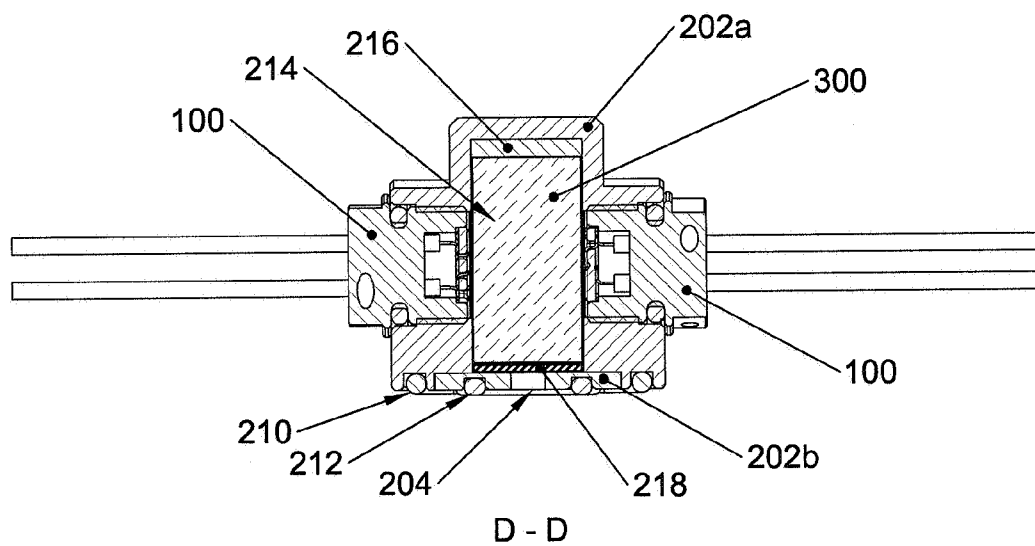


Fig. 1D

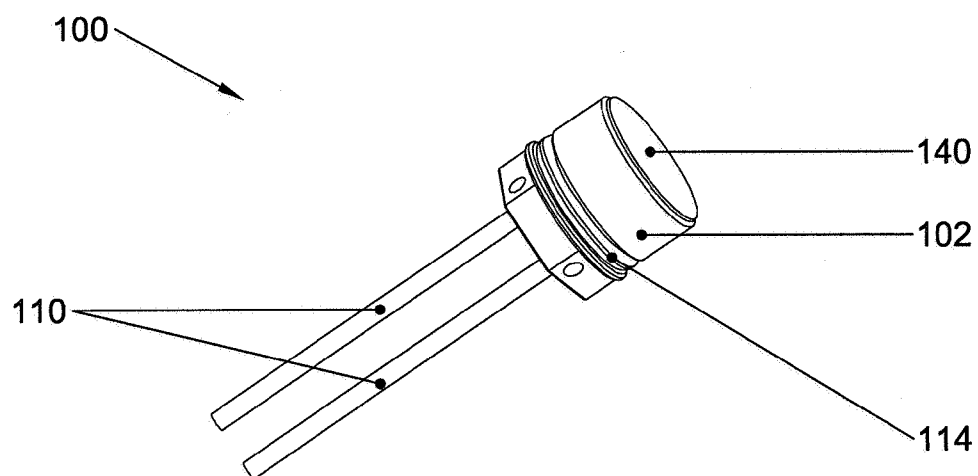


Fig. 2A

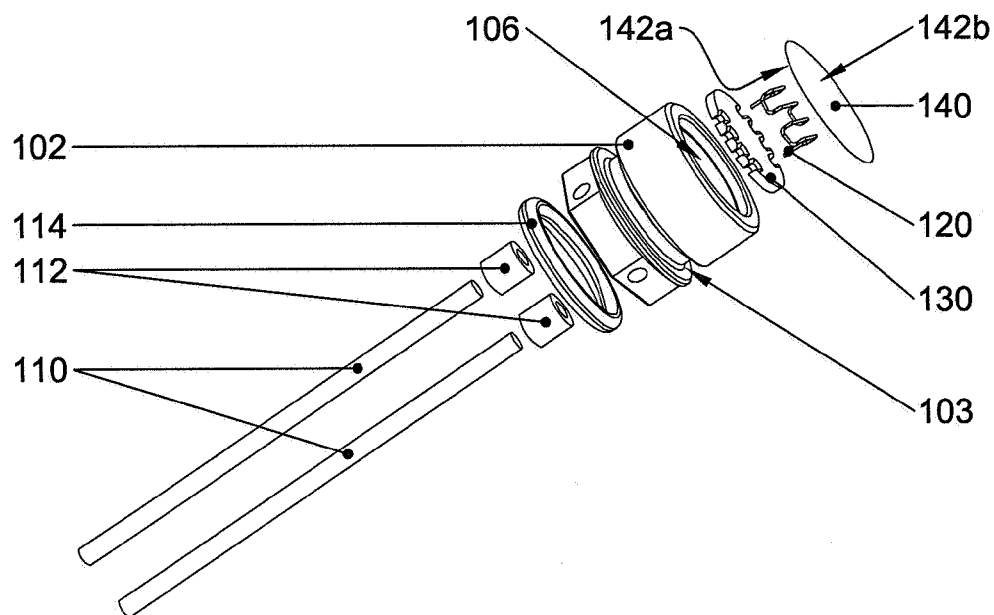


Fig. 2B

Fig. 2D

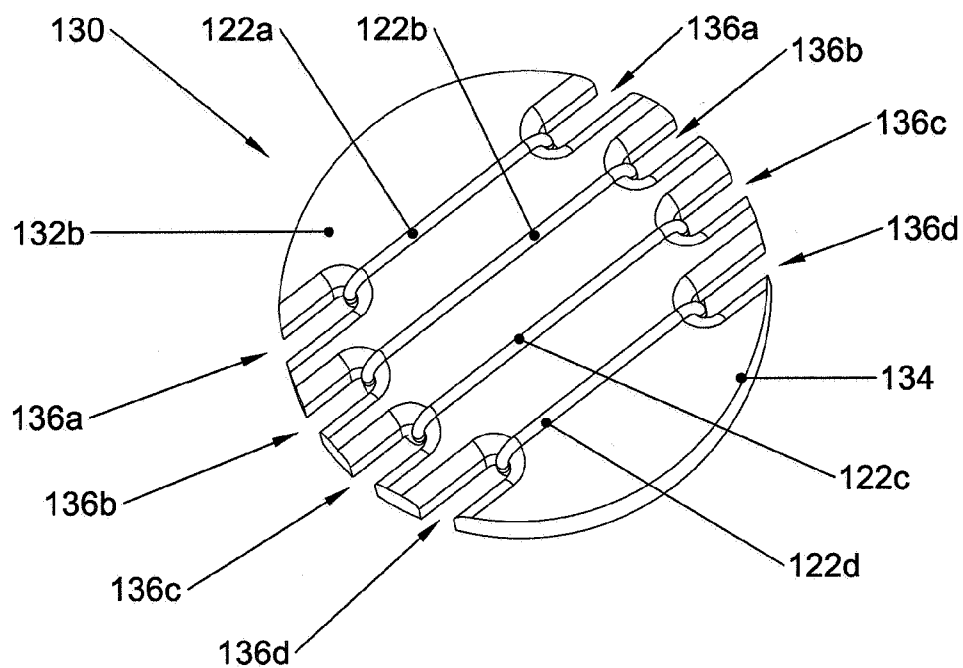


Fig. 2E

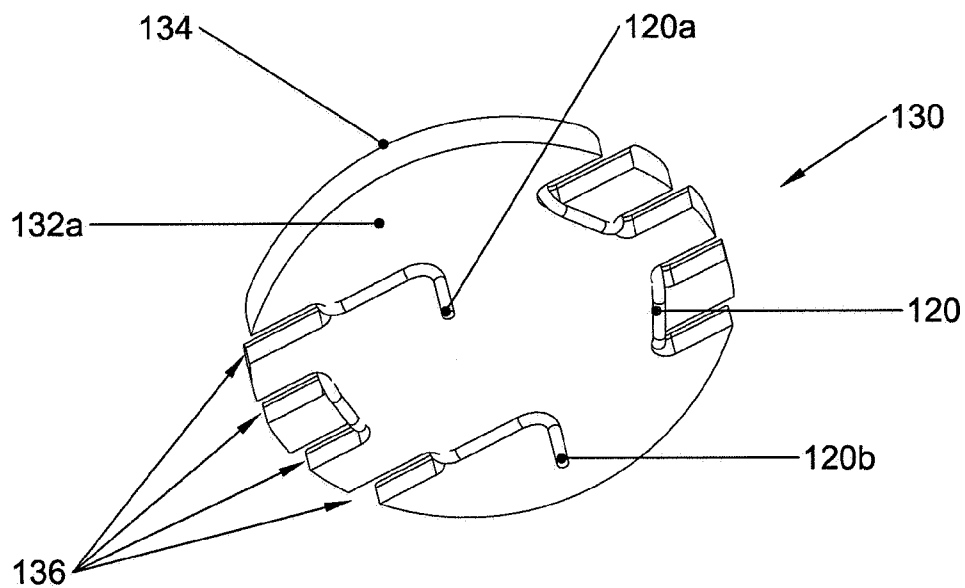


Fig. 2F

MINIATURE ELECTRO-PYROTECHNIC IGNITER, AND IGNITION HEAD FOR THE SAME

FIELD OF THE INVENTION

[0001] The present invention relates to a miniature electro-pyrotechnic igniter suitable for use in miniature spacecraft, and to an ignition head for the same.

BACKGROUND

[0002] Spacecraft, and in particular miniature spacecraft such as cubesats, place stringent demands on, inter alia, the volume, weight, safety and reliability of their components. Common components include cool gas generators and rocket motors, both of which may include electro-pyrotechnic ignition heads.

[0003] A conventional electro-pyrotechnic ignition head may typically include an electrically resistive bridge wire that is at least partially embedded within a pyrotechnic primer charge. By passing an electric current through the bridge wire, the bridge wire may be heated to set off the primer charge. The primer charge may in turn ignite a further pyrotechnic charge, such as a cool gas generator charge in the case of a cool gas generator, or a propellant grain in the case of a rocket motor.

SUMMARY OF THE INVENTION

[0004] One drawback of such conventional ignition heads, in particular when used in cool gas generators, is that they may not be able to uniformly heat and ignite an end surface of an elongate, for instance cylindrical, cool gas generator charge. Instead, they may unevenly heat the end surface and cause only a certain spot thereof to ignite, as a result of which the charge may undergo a decomposition reaction in a non-uniform, irregular fashion.

[0005] Another drawback of such conventional ignition heads is that the amount of electric energy required to set off the primer charge may be in the order of a tenth or several tenths of a Joule. Although this low ignition threshold renders the ignition head fast and responsive, it also entails the inherent risk that the primer charge is unintentionally fired when the relatively low amount of electric energy is generated via, for instance, magnetically-induced currents or electromagnetic radiation. To overcome this issue, conventional ignition heads are often fitted with a safe and arm (S&A) mechanism that prevents accidental ignition. S&A mechanisms, however, are typically mechanical in nature, and relatively large and heavy. They may, for instance, easily have a mass of 500 grams, which makes them unsuitable for use in miniature satellites whose overall allowed maximum mass may be as low as 1.33 kg.

[0006] It is an object of the present disclosure to provide for a miniature, lightweight, safe, and reliable ignition head that overcomes or at least mitigates one or more of the aforementioned drawbacks, and that is suitable for use in an electro-pyrotechnic igniter.

[0007] It is a further object of the present invention to provide for a miniature, lightweight, safe, and reliable electro-pyrotechnic igniter that is suitable for use in spacecraft, such as cubesats.

[0008] To this end, a first aspect of the present disclosure is directed to an electric non-pyrotechnic ignition head suitable for use in an electro-pyrotechnic igniter. The ignition head

may include a housing defining a front opening; an electrically insulative, thermally conductive bridge filament support body that is at least partly disposed in said front opening, and that defines a frontal heating surface; and a bridge filament including at least one cross-over portion that extends over the frontal heating surface of the bridge filament support body.

[0009] To prevent spot heating of a pyrotechnic charge to be ignited, the presently disclosed ignition head features a bridge filament having at least one, and preferably multiple, cross-over portions that extend over a frontal heating surface of an electrically insulative, thermally conductive bridge filament support body. The electrically insulative nature of the bridge filament support body allows for multiple spread apart cross-over portions to extend over the same frontal heating surface without short-circuiting. The thermally conductive nature of the bridge filament support body additionally facilitates the distribution of heat therein. Accordingly, heat generated by the cross-over portions of the bridge filament may quickly spread across the entire frontal heating surface to enable the uniform heating of an end face of a pyrotechnic charge that is in contact therewith.

[0010] In one embodiment, the ignition head may further comprise a non-pyrotechnic, electrically insulative, thermally conductive shield film, for instance made of Kapton®, that is applied over the at least one cross-over portion of the bridge filament. In embodiments wherein the shield film does not form part of the ignition head, it may alternatively form part of a pyrotechnic charge to be ignited, e.g. as a coating of the pyrotechnic composition of the pyrotechnic charge. At any rate, in an operational setting, the shield film may be interposed between at least the bridge filament's cross-overs and the pyrotechnic composition of the pyrotechnic charge, and preferably between the entire frontal heating surface of the bridge wire support body and the pyrotechnic composition of the pyrotechnic charge.

[0011] The shield film may act as an ignition retardation control, and as such as a lightweight safety mechanism that prevents accidental ignitions much like a conventional safe and arm device. It enables the transfer of heat from the cross-over portions of the bridge filament, and preferably from the entire frontal heating surface of the bridge filament support body, to the pyrotechnic composition of the pyrotechnic charge. By properly selecting the thermal conductivity of the material of the shield film and/or the thickness of the shield film, the shield film may be provided with a heat transfer coefficient that—in a given, overall configuration—ensures that a minimum amount of electric ignition energy is required to effect ignition of the pyrotechnic charge. Since the thickness of the shield film is an easily variable parameter, the presently disclosed ignition head is conveniently tunable for different ignition times.

[0012] A second aspect of the present disclosure is directed to an electro-pyrotechnic igniter. The electro-pyrotechnic igniter may include a casing. The casing may define an interior reaction chamber, and at least one exhaust orifice via which the reaction chamber is fluidly connected to an external environment of the electro-pyrotechnic igniter. The electro-pyrotechnic igniter may further include at least one ignition head according to the first aspect of the present disclosure, whose housing is integrated with the casing, such that its bridge filament is at least partially disposed within the reaction chamber. The electro-pyrotechnic igniter may also include a pyrotechnic charge that is disposed within the reaction chamber, such that a pyrotechnic composition of the

pyrotechnic charge is in thermally conductive contact with (any cross-overs portions of) the bridge filament of the at least one ignition head via an interposed non-pyrotechnic, electrically insulative, thermally conductive shield film.

[0013] A third aspect of the present disclosure is directed to a spacecraft, for instance a satellite such as a cubesat, including at least one of an ignition head according to the first aspect of the present disclosure and/or an electro-pyrotechnic igniter according to the second aspect of the present disclosure.

[0014] These and other features and advantages of the invention will be more fully understood from the following detailed description of certain embodiments of the invention, taken together with the accompanying drawings, which are meant to illustrate and not to limit the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 schematically illustrates an exemplary embodiment of an electro-pyrotechnic igniter according to the present disclosure in, respectively, a bottom perspective view (FIG. 1A), a top perspective view (FIG. 1B), an orthogonal top view (FIG. 1C), and a cross-sectional side view taken along line D-D indicated in FIG. 1C (FIG. 1D); and

[0016] FIG. 2 schematically illustrates an ignition head comprised by the electro-pyrotechnic igniter shown in FIG. 1 in, respectively, a perspective view (FIG. 2A), an exploded perspective view (FIG. 2B), a side view (FIG. 2C), a cross-sectional side view taken along line D-D indicated in FIG. 2C (FIG. 2D), a top perspective view of the bridge filament support body and the bridge filament (FIG. 2E), and a bottom perspective view of the bridge filament support body and the bridge filament (FIG. 2F).

DETAILED DESCRIPTION

[0017] FIG. 1 schematically illustrates an exemplary embodiment of an electro-pyrotechnic igniter 1 according to the present disclosure. Such an electro-pyrotechnic igniter 1 may include at least one ignition head 100. The embodiment of the electro-pyrotechnic igniter depicted in FIG. 1 includes two identical ignition heads 100, whose construction is schematically illustrated in more detail in FIG. 2. Below, the construction and operation of the ignition head 100 and the electro-pyrotechnic igniter 1 according to the present disclosure are described in general terms, where appropriate with reference to FIGS. 1-2.

[0018] The ignition head 100 according to the present disclosure may be characterized as a non-pyrotechnic, electric ignition head 100. That is, the electrically powered ignition head 100 may itself be void of any pyrotechnic composition, and merely be configured to effect the ignition of a separate or external pyrotechnic charge 300 when it is brought in contact therewith, for instance when it is applied to ignite a cool gas generator charge in a cool gas generator or a booster-pellet in an electro-pyrotechnic igniter 1. In this respect some conventional ignition heads that are suitable for igniting pyrotechnic charges may differ from the presently disclosed ignition head 100. Such conventional ignition heads may in particular comprise a pyrotechnic primer charge or primer composition in which a bare/uncoated bridge wire of the ignition head is embedded. It is understood that the non-pyrotechnic ignition head 100 according to the present disclosure may include no such pyrotechnic primer charge, and that its bridge filament 120 may not be embedded in a pyrotechnic composition. As will be clarified below, any pyrotechnic composition to be

ignited with the presently disclosed ignition head 100 may be separated from the bridge filament 120 by an electrically insulative, thermally conductive shield film 140, which may either form part of the ignition head 100 or part of the pyrotechnic charge 300.

[0019] The ignition head 100 may include a housing 102. The housing 102 may in principle have any suitable shape, and be made from any suitable material. In one embodiment, such as the depicted embodiment, the housing 102 may be generally cylinder-jacket shaped. For reasons of robustness and easy machinability, the housing 102 may preferably be made of metal or a metal alloy; preferred materials may include copper, brass, titanium, aluminum, and stainless steel. To facilitate a fluidtight connection to/integration with a casing of a device in which the ignition head 100 may be incorporated, for instance the casing 200 of an electro-pyrotechnic igniter 1, an outer surface of the housing 102 may define one or more circumferential grooves 103 in which an O-ring 114 may be provided. The housing 102 may further define an interior space 104, and a front opening 106 giving access to the interior space 104. Optionally except for the front opening 106, the interior space 104 of the housing 102 may be fluidtightly sealed.

[0020] The ignition head 100 may also include a bridge filament support body 130. Although the bridge filament support body 130 may in principle have any suitable shape, it may preferably take the form of a relatively thin plate, for example with an average thickness in the range of 0.2-2 mm (measured in a direction that is normal with respect to frontal heating surface 132b). The bridge filament support body 130 may be circumferentially dimensioned such that it is approximately fittingly receivable in the front opening 106 of the housing 102, and be at least partially disposed therein such that an inner surface 132a of the bridge filament support body 130 faces the interior space 104 of the housing 102, and an outer frontal heating surface 132b of the bridge filament support body 130 faces outward from the interior space 104. As will become clear below, the bridge filament support body 130 may serve to mechanically support a thin bridge filament 120, to electrically insulate the cross-overs 122 of the bridge filament 120 from each other and the housing 102, and to distribute heat produced by the bridge filament 120 over its frontal heating surface 132b. Accordingly, the bridge filament support body may preferably be (one or more of) substantially rigid, electrically insulative, heat resistant and thermally conductive. In addition, at least the frontal heating surface 132b of the bridge filament support body 130 may preferably be heat reflective, such that it reflects radiative heat given off the bridge filament's cross-overs 122. To this end, the frontal heating surface 132b may be provided with a heat reflective coating. In one embodiment, the bridge filament support body 130 is at least partially made of a ceramic material, such as, for instance, silicon nitride (Si_3N_4), silicon carbide (SiC), or aluminum oxide (Al_2O_3).

[0021] In a preferred embodiment, the frontal heating surface 132b may define a plurality of pairs of cross-over terminals 136, i.e. locations where the bridge filament 120 may pass, e.g. extend through or around, the bridge filament support body 130, from its back side 132a to its front side 132b and/or vice versa. In one embodiment, the cross-over terminals 122 may take the form of through-holes or circumferentially bounded passages. In another embodiment, such as the depicted embodiment (see FIGS. 2E-F), the cross-over terminals 122 may take the form of indentations or recesses

defined by an outer circumferential edge **134** of the frontal heating surface **134**. The cross-over terminals **136** may be arranged such that straight lines interconnecting the terminals of respective pairs do not intersect each other. A bridge filament **120** may thus be provided on, e.g. wrapped around, the bridge filament support body **130** to define a plurality of cross-overs **122**, each of which cross-overs **122** may be uniquely associated with a pair of cross-over terminals **136**, and each of which may extend only between its associated pair of cross-over terminals **136** across the frontal heating surface **123b** and without intersecting other cross-overs.

[0022] The bridge filament **120** may be a relatively thin, relatively high-electrical-resistance element in the form of a continuous wire, ribbon (flat wire) or the like. In some embodiments, the bridge filament **120** may be at least partially printed, e.g. screen-printed, onto the bridge filament support body **130**, and/or be at least partially embedded therein. The bridge filament **120** may extend between a first end **120a** and a second end **120b**. The first and second ends **120a**, **120b** may typically be mutually electrically insulatively arranged within the interior space **104** of the housing **102** and thus on the inner side of the bridge filament support body **130**. In between its first and second ends **120a**, **120b**, the bridge filament **120** may include at least one portion that extends over the frontal heating surface **132b** of the bridge filament support body **130**. It is understood that each such portion **122** of the bridge filament **120** that extends over the frontal heating surface, typically between two cross-over terminals **136**, may be referred to as a 'cross-over' or 'cross-over portion'. The bridge filament **120** may be made of any suitable material, such as, for instance, a Nickel-Chromium (NiCr) alloy (e.g. Evanohm®), Alloy 815, Alloy 837, or Alloy 875. Preferably, the cross-over sections **122** of the bridge filament **120** extends continuously over the frontal heating surface (being continuously supported thereby), uninterrupted contacting that surface, to provide a relatively high heat transfer contact area there-between.

[0023] The first and second ends of the bridge filament **120** may be electrically conductively connected to respective relatively thick, relatively low-electrical-resistance lead wires **110**. As follows from the drawing, the connections may e.g. be located within the interior space **104**. In the example, the bridge filament support body **130** is spaced-apart from the nearby ends of the lead wires **110**. Also, in the example, the bridge filament support body **130** is spaced-apart from sealing means **112** of the back of the housing **102**. It follows that in this case, the bridge filament support body **130** is a separate element with respect to those sealing means **112**, so that it has a relatively small thermal mass.

[0024] The lead wires **110** may be made from any suitable material, such as metals or alloys like copper, titanium or stainless steel, and be bare or uncoated. The lead wires **110** may exit the housing **102** via respective lead wire outlets **108**, e.g. including an opening in the (back of the) housing **102**, which lead wire outlets **108** may provide for a respective fluidtight seals **112** (i.e. distal ignition head sealing means) between the housing **102** and the respective lead wire **110**. The fluidtight seal may, for instance, take the form of a glass mass, which, in case the housing **102** and the lead wires **110** are made of metal, may provide for an hermetic glass-to-metal seal. In a preferred embodiment the lead wires **110** may be made of a material with approximately the same (e.g. $\pm 10\%$) thermal expansion coefficient as the material from which the housing **102** of the ignition head **100** is manufac-

tured; this may ensure that no residual tension remains in the seal **112** when the ignition head is subject to temperature variations during operation/use.

[0025] The bridge filament **120**, and in particular its cross-overs **122** (**122a**, **122b**, **122c**, **122d**), may preferably not electrically conductively contact a pyrotechnic charge **300** to be ignited. Such direct electric contact may be prevented by interposing a shield film **140** in between the bridge filament **120** and the pyrotechnic charge **300**.

[0026] In one embodiment, the shield film **140** may be applied to the bridge element **120**, in particular to its cross-overs **122**. The shield film **140** may, for instance, be 'wrapped around' at least a portion of the bridge element **120** as such and thus take the form of an electrically insulative jacket. Alternatively or in addition, the shield film **140** may take the form of a layer that overlays or covers at least part of the frontal heating surface **132b** of the bridge filament support body **130**, including the cross-overs **122** of the bridge filament **120** running over it. In this latter case, which is illustrated in the depicted embodiment (see FIGS. 2A-B), the shield film **140** may have an inner surface **142a** that faces the frontal heating surface **132b** of the bridge filament support body **130**, and an outer surface **142b** that faces outward for direct physical contact with a pyrotechnic charge **300** to be ignited.

[0027] In another embodiment, the pyrotechnic charge **300**—typically instead of the bridge filament **140** and/or the frontal heating surface **132b**—may be coated with a shield film **140**. For instance, in case the pyrotechnic charge is a pellet, a shield film **140** may be applied to at least a portion of an outer surface of the pellet that is configured for contact with the (frontal heating surface **132b** of the) ignition head **100**. It is understood, however, that this embodiment is functionally equivalent to that in which a shield film **140** is applied to the frontal heating surface **132b** of the bridge filament support body **130**: in both cases, a shield film is interposed between the bridge filament's cross-overs **122** and the pyrotechnic composition of the pyrotechnic charge **300**.

[0028] The shield film **140** may be electrically insulative so as to prevent short-circuiting any cross-overs **122** of the bridge filament **120**, and thermally conductive so as to enable the transfer of heat generated by the bridge filament **120** to the pyrotechnic charge **300**. The shield film **140** may preferably have a heat transfer coefficient in the range of 240-24,000 W/m²K, and more preferably in the range of 1,250-4800 W/m²K. Depending on the envisaged application of the ignition head **100**, the shield film **140** may additionally be (i) chemically inert with respect to the chemical composition of a pyrotechnic charge **300** to be ignited (and its decomposition products) so as to enable the generation of clean gases, and/or (ii) low outgassing to enable the generation of clean gases and to render the ignition head **100** suitable for use under vacuum conditions, e.g. in space environments, and/or (iii) non-porous, and crack-resistant when subject to operational temperature variations, to prevent electrically conductive decomposition products of an ignited pyrotechnic charge from short-circuiting any cross-overs **122**.

[0029] Preferred materials for the shield film **140** may include Kapton®, in particular Kapton® MT and Kapton® MTB. Kapton is a registered trademark of DuPont, headquartered in Wilmington, Del., U.S.A. Other materials may include glass, glass-mica, glass-fiber, phenolic/bakelite, silicon, plastic, ceramics, and laminates of these materials. A thickness of the shield film **140** may typically be in the range of 5-500 μm ,

and, in case the shield film is at least partially made of Kapton®, preferably in the range of 25-125 μm .

[0030] It is understood that the shield film **140** may act as a thermal buffer in between the bridge filament **120** and the pyrotechnic composition of the pyrotechnic charge **300**. As such, it may protect the bridge filament **120** from burning out early due to the development of heat upon ignition of the pyrotechnic charge **300**. Moreover, the shield film **140** may act as an ignition retardation control, and as such as a light-weight safety mechanism that prevents accidental ignitions much like a conventional safe and arm device. It enables the transfer of heat from the cross-over portions **122** of the bridge filament **120**, and preferably from the entire frontal heating surface **132b** of the bridge filament support body **130**, to the pyrotechnic composition of the pyrotechnic charge **300**. By properly selecting the thermal conductivity of the material of the shield film **140** and/or the thickness of the shield film, the shield film may be provided with a heat transfer coefficient that—in a given, overall configuration—ensures that a minimum amount of electric ignition energy (or more accurately: a minimum average electric ignition energy supply rate (Watt) for a certain period of time) is required to effect ignition of the pyrotechnic charge **300**. Since the thickness of the shield film **140** is an easily variable parameter, the presently disclosed ignition head is conveniently tunable for different ignition times. It will be clear however, that in the overall configuration of an ignition system **1**, the ignition energy required to effect ignition of a pyrotechnic charge **300** may also depend on other factors, such as the amperage and voltage at which electric energy is provided to the ignition head **100**, the thickness and type of the bridge filament **120**, and the pyrotechnic composition of the pyrotechnic charge **300**; in practice, these factors may preferably be considered in conjunction, and tailored to each other so as to achieve the desired ignition time.

[0031] The electro-pyrotechnic igniter **1** according to the present disclosure may include a casing **200**, at least one ignition head **100** of the above-described type, and at least one pyrotechnic charge **300**.

[0032] The casing **200** may in principle have any suitable shape, and be manufactured from any suitable material. For reasons of robustness and easy machinability, the casing **200** may preferably be made of a metal or a metal alloy; preferred materials may include copper, titanium and stainless steel. The casing **200** may define an interior reaction chamber **214**, which may be dimensioned to typically snugly receive the pyrotechnic charge **300**. Where desired, a flexible sheet **218**, for instance made of rubber, may be provided to fix or clamp the pyrotechnic charge **300** within the reaction chamber **214**, i.e. between the walls of the housing **200**. The flexibility of the sheet **218** may accommodate a possible difference in thermal expansion of the housing **200** and the pyrotechnic charge **300**, such that such a difference does not lead to mechanical failure of the latter.

[0033] The casing **200** may further define at least one exhaust orifice **204** via which the reaction chamber **214** is fluidly connected to an external environment of the electro-pyrotechnic igniter **1**, e.g. the reaction chamber of a second-stage igniter. The exhaust orifice **204** may typically have a diameter in the order of millimeters. In one embodiment, such as the depicted embodiment, the casing **200** may define a plurality of exhaust orifices **204**, e.g. three identical orifices angularly spaced 120° apart in a same plane. A plurality of exhaust orifices may improve the reliability of the igniter **1**,

since having multiple orifices **204** may reduce the chance of ignition failure (of a main charge) in case the pyrotechnic charge **300** of the igniter breaks or decomposes into different pieces which can clog or block an exhaust orifice **204**. The number, size and arrangement of the exhaust orifices may be tailored to the application at hand.

[0034] As in the depicted embodiment of FIG. 1, the casing **200** may comprise two parts: a main body **202a**, and a nozzle plate **202b**; the latter may include the at least one exhaust orifice **204**. With the nozzle plate **202b** removed from the main body **202a**, the reaction chamber **214** is easily accessible, which allows for installation, removal and/or replacement of the pyrotechnic charge **300** during assembly or subsequent use. The nozzle plate **202b** and the main body **202a** may be preferably be connectable to each other by releaseable fastening means, such as screws **206**.

[0035] To facilitate the mounting of the igniter **1** to another body, its casing may be provided with one or more mounting holes **208**. Furthermore, a mounting surface of the igniter **1**, which may typically comprise the normally planar outer surface of the casing **200** including the at least one exhaust orifice **204**, may include at least one endless groove in which a respective O-ring **210**, **212** may be provided. The at least one groove and O-ring **210**, **212** may preferably encircle the at least one exhaust orifice **204** in order to enable the fluidtight fluid communication with another chamber provided in the body onto which the igniter **1** may be mounted, such as the aforementioned reaction chamber of a second-stage igniter. For improved reliability, multiple grooves and respective O-rings may be provided. As in the depicted embodiment, for instance, one groove and O-ring **210** may be provided in the mounting surface of the main body **202a** of the casing **200** to encircle a seam between the main body **202a** and the nozzle plate **202b**, while another groove and O-ring **212** may be provided in the nozzle plate **202b** to encircle the at least one exhaust orifice **204**.

[0036] To enable the build-up of a certain amount of pressure in the reaction chamber **214** upon ignition and initial decomposition of the pyrotechnic charge **300** before any gases are exhausted via the at least one exhaust orifice **204**, the igniter **1** may include a non-reclosing pressure relief device **218**, such as a burst disc. The non-reclosing pressure relief device, which in itself may be of a conventional design, may be arranged to close off the at least one exhaust orifice **204** in the nozzle plate **202b**, and be configured to open it once a predetermined pressure has developed within the reaction chamber **214**. The pressure at which the non-reclosing pressure relief device is configured to open the at least one exhaust orifice **204** may preferably be chosen such that further autonomous decomposition of the pyrotechnic charge **300** is facilitated and effectively guaranteed.

[0037] In one embodiment, such as the embodiment of FIG. 1, the electro-pyrotechnic igniter **1** may be provided with a plurality of ignition heads **100** to provide for redundancy and reliability, which is a practical requirement for space applications given the lack of opportunities to repair or replace malfunctioning parts. In embodiments of the igniter **1** including a plurality of ignition heads **100**, the frontal heating surfaces **132b** of the ignition heads may preferably (pairwise) face each other and clasp the pyrotechnic charge **300** in between them, so as to enable ignition of the charge from opposite sides.

[0038] The pyrotechnic charge **300** may typically be provided in the form of a pellet that is at least partially made of a

certain pyrotechnic composition, such as, for instance, boron potassium nitrate (BKNO₃). As mentioned, some embodiments of the pyrotechnic charge **300** may be at least partially coated with a non-pyrotechnic, electrically insulative and thermally conductive shield film. The pyrotechnic charge **300** may then be installed in the reaction chamber **214** such that the shield film is interposed between the cross-overs **122** of the bridge filament **120** of the at least one ignition head **100** and the pyrotechnic composition of the charge.

[0039] The electro-pyrotechnic igniter **1** may be integrated into an ignition system that may further include a power supply to which the at least one ignition head **100** of the electro-pyrotechnic igniter may be operably connected. The power supply may typically be configured to provide electrical energy at a certain amperage and voltage, and the ignition system as a whole may preferably be configured such that an ignition energy to be supplied by the power supply at said amperage and voltage in order to ignite the pyrotechnic charge is at least 10 Joules, for instance in the safe range of 10-200 Joules, and preferably in the range of 25-100 Joules.

[0040] Although illustrative embodiments of the present invention have been described above, in part with reference to the accompanying drawings, it is to be understood that the invention is not limited to these embodiments. Variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, it is noted that particular features, structures, or characteristics of one or more embodiments may be combined in any suitable manner to form new, not explicitly described embodiments.

LIST OF ELEMENTS

[0041]	1 electro-pyrotechnic igniter
[0042]	100 non-pyrotechnic, electric ignition head
[0043]	102 housing
[0044]	103 circumferential groove
[0045]	104 interior space
[0046]	106 front opening
[0047]	108 lead wire outlet
[0048]	110 low-electrical-resistance lead wire
[0049]	112 fluidtight seal
[0050]	114 O-ring
[0051]	120 bridge filament
[0052]	120a, b first (a) and second (b) end of bridge filament
[0053]	122 cross-over (portion), i.e. portion of bridge filament that extends over the frontal heating surface of the bridge filament support body
[0054]	130 bridge filament support body
[0055]	132a, b inner surface (a) and outer, frontal heating surface (b) of bridge filament support body
[0056]	134 circumferential edge of frontal heating surface
[0057]	136a, b, c, . . . pairs (a, b, c) of cross-over terminals
[0058]	140 shield film
[0059]	142a, b inner (a) and outer (b) surface of shield film
[0060]	200 casing

[0061]	202a main body
[0062]	202b nozzle plate
[0063]	204 exhaust orifice/nozzle in nozzle plate
[0064]	206 screw
[0065]	208 mounting hole in main body of casing
[0066]	210 O-ring
[0067]	212 O-ring
[0068]	214 reaction chamber
[0069]	216 rubber mat
[0070]	218 non-reclosing pressure relief device (burst disc)
[0071]	300 pyrotechnic charge

1. An electric non-pyrotechnic ignition head suitable for use in an electro-pyrotechnic igniter, comprising:

a housing defining a front opening;

an electrically insulative, thermally conductive bridge filament support body that is at least partly disposed in said front opening, and that defines a frontal heating surface; and

a bridge filament including at least one cross-over portion that extends over the frontal heating surface of the bridge filament support body.

2. The ignition head according to claim **1**, further comprising a non-pyrotechnic, electrically insulative, thermally conductive shield film that is applied over the at least one cross-over portion.

3. The ignition head according to claim **2**, wherein the shield film has a heat transfer coefficient in the range of 240-24,000 W/m²K, and more preferably in the range of 1,250-4,800 W/m²K.

4. The ignition head according to claim **2**, wherein the shield film is at least partially made of Kapton®.

5. The ignition head according to claim **1**, wherein the frontal heating surface defines a plurality of pairs of cross-over terminals, and

wherein the at least one cross-over portion includes a plurality of cross-over portions, each of said cross-over portions being uniquely associated with a pair of cross-over terminals, such that a respective cross-over portion extends over the frontal heating surface only in between the cross-over terminals of the pair of cross-over terminals with which it is associated.

6. The ignition head according to claim **5**, wherein the cross-over terminals include at least one of: indentations defined by a circumferential edge bounding the frontal heating surface of the bridge filament support body, and through-holes in the bridge filament support body.

7. The ignition head according to claim **1**, wherein the bridge filament support body is a plate-like body.

8. The ignition head according to claim **7**, wherein the bridge filament support body is at least partially made of a ceramic material.

9. The ignition head according to claim **1**, wherein the bridge filament support body has an average thickness in the range of 0.2-2 mm, measured in a direction that is normal with respect to the frontal heating surface.

10. The ignition head according to claim **1**, wherein the bridge filament support body is circumferentially dimensioned such that it is fittingly receivable in the front opening of the housing.

11. The ignition head according to claim **1**, wherein the housing defines an interior space, wherein the support body extends along or in the front opening and covers the interior space.

12. The ignition head according to claim **11**, wherein an inner surface of the filament support body faces the interior space, the inner surface extending opposite ignition head sealing means.

13. The ignition head according to claim **11**, wherein lead wires extend through sealing means towards the interior space, wherein the lead wires are connected to proximal ends of the bridge filament, for example at connections located within the interior space.

14. The ignition head according to claim **1**, wherein the frontal heating surface has an area in the range of 4-1,000 mm², preferably in the range of 4-160 mm², and more preferably in the range of 9-36 mm².

15. The ignition head according to claim **1**, wherein the housing, optionally except for the front opening thereof, is fluidtightly sealed, and

wherein the bridge filament extends between a first end and a second end, which ends are disposed inside the housing and electrically conductively connected to respective low-electrical-resistance lead wires that extend from the housing via at least one fluidtightly sealed lead wire outlet.

16. An electro-pyrotechnic igniter, comprising:

a casing defining an interior reaction chamber and at least one exhaust orifice via which the reaction chamber is fluidly connected to an external environment of the electro-pyrotechnic igniter;

at least one electric non-pyrotechnic ignition head according to claim **1**, whose housing is integrated with the casing, such that the bridge filament is at least partially disposed within the reaction chamber; and

a pyrotechnic charge that is disposed within the reaction chamber, such that a pyrotechnic composition of the pyrotechnic charge is in contact with the bridge filament of the at least one ignition head via an interposed non-pyrotechnic, electrically insulative, thermally conductive shield film.

17. The electro-pyrotechnic igniter according to claim **16**, further comprising:

a non-reclosing pressure relief device, for instance a burst disc, that closes off the at least one exhaust orifice, and that is configured to open said at least one exhaust orifice once a predetermined pressure has developed within the reaction chamber.

18. The electro-pyrotechnic igniter according to claim **16**, wherein said at least one exhaust orifice comprises a plurality of exhaust orifices.

19. The electro-pyrotechnic igniter according to claim **16**, wherein said at least one ignition head comprises a plurality of ignition heads.

20. An ignition system, including:

a power supply; and

an electro-pyrotechnic igniter according to claim **16**, whose at least one ignition head is operably connected to the power supply,

said system being configured such that an ignition energy to be supplied by the power supply in order to ignite the pyrotechnic charge is in the range of 10-200 Joules, and preferably in the range of 25-100 Joules.

21. A spacecraft, for instance a satellite, including at least one of an ignition head according to claim **1**.

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