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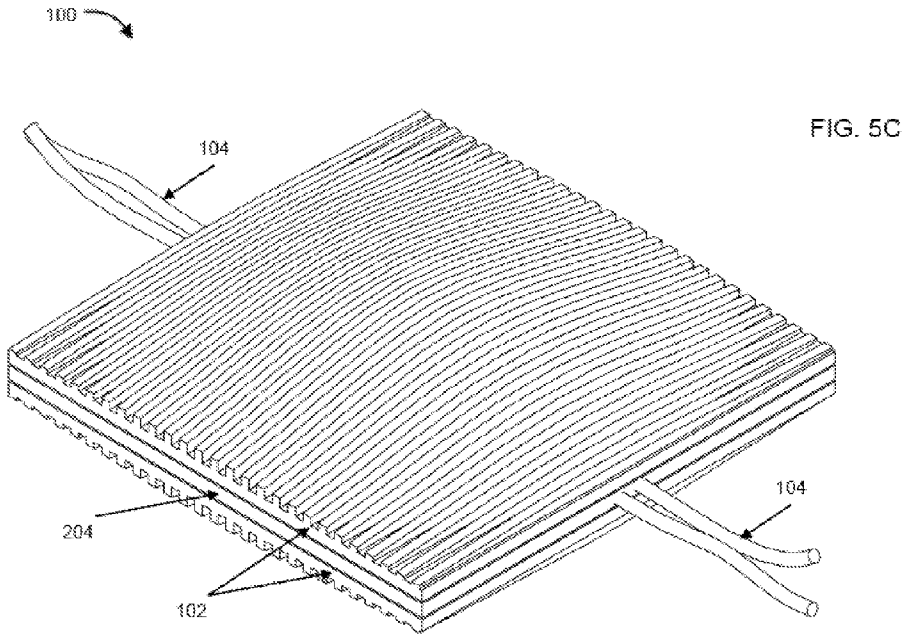

FIG. 5C

(57) Abstract: The present disclosure pertains to a thermoelectric heat transfer apparatus (THTA) that comprises at least two outer flexible conductive layers configured to act as heat sink, wherein the at least two outer flexible conductive layers are formed of any or a combination of polymers and elastomers having high surface area; one or more insulating flexible layers sandwiched between the at least two outer flexible conductive layers; and one or more Peltier modules embedded in or configured with the one or more insulating flexible layers, wherein the one or more Peltier modules being coupled with each other in a series or parallel configuration, and wherein the THTA is operatively coupled with a microcontroller that controls heat transfer operation of the THTA using the one or more Peltier modules. Multiple THTAs are interconnected to form a grid of THTA units so as to achieve one or more desired applications.

[Continued on next page]

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FLEXIBLE AND MODULAR THERMOELECTRIC HEAT TRANSFER APPARATUS

TECHNICAL FIELD

[0001] The present disclosure relates generally to the field of thermoelectric heating and cooling devices. More specifically, the present disclosure pertains to an integrated thermoelectric heat transfer apparatus adaptable to different surface contours to enable efficient heat transfer to and from the surface.

BACKGROUND OF THE INVENTION

[0002] Background description includes information that may be useful in understanding the present invention. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed invention, or that any publication specifically or implicitly referenced is prior art.

[0003] Peltier effect is a phenomenon in which a potential difference applied across a junction of two materials causes a temperature difference between the junction. The method of thermoelectric cooling using peltier effect is useful because it can cool an object without any moving pieces or other complex machinery that isolates the cooler from its ambient surroundings. The devices that are constructed to take advantage of this phenomenon are known as peltier elements, or thermoelectric coolers (TECs). Multiple peltier elements can be connected in series or parallel to construct a peltier module (also known as practical TEC) which has greater cooling capabilities. However, currently available devices that use an array of peltier modules in a combination of series and parallel configuration require bulky and elaborate heat sink or heat transfer apparatus, which gives rise to a rigid and in-flexible structure that incurs limitation of being in-flexible and inefficient for large scale application. Further, these devices almost always require customized assembly of the peltier modules and the heat sinks, and not made available in an integrated ready to use format.

[0004] In a conventional peltier module, temperature of hot side quickly rises, and heat thus generated needs to be dissipated in order to limit the temperature of the hot side in a comfortable range, which may otherwise damage the module. Further, for circulation of the generated heat, and extraction of the heat on cooling side of the peltier module, circulation of a suitable medium is required. This contraption is typically heat sink(s) attached to the heating side, and sometimes to the cooling side as well of the peltier module that allows heat

exchange with a liquid or gaseous medium such as air or water that is circulated in a controlled manner through some tubes or airways. In effect, the entire arrangement turns out to be bulky, rigid, inflexible and unreliable.

[0005] In existing systems, construction of devices that incorporate peltier modules require assembly of such modules to be done differently for each intended application based on configuration required for respective application, making such integration difficult and resulting in a bulky system/device. Specific application is therefore addressed by putting together components in a typically bulky rigid configuration, which are not easily adaptable to other applications. Further, such an approach limits it to be used in very specific and limited applications, limiting the use of such technology in critical areas where it may be very effective.

[0006] There is therefore a need in the art to provide for a lean, self-contained, integrated, readily usable, flexible and modular thermoelectric heat transfer apparatus that is readily usable for diverse applications with limited add-ons and that adapts to various surface contours and enables efficient heat transfer to and from the surface. Further, there exists a need to provide for a flexible and modular thermoelectric heat transfer apparatus that can be configured readily with different wearable accessories such as jackets, vests, caps, helmets and the like. There is also a need for a peltier technology based device that finds applications in wide industrial use as well as personal wearable uses, whereby anyone can readily use this modular, flexible readily usable plug and play device for varied applications. Further, specific THTAs may be produced with complex shapes to be widely used with products such as helmets, whereby any manufacturer can incorporate it easily in any helmet for wide industrial use.

[0007] As used in the description herein and throughout the claims that follow, the meaning of “a,” “an,” and “the” includes plural reference unless the context clearly dictates otherwise. Also, as used in the description herein, the meaning of “in” includes “in” and “on” unless the context clearly dictates otherwise.

[0008] In some embodiments, the numerical parameters set forth in the written description and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by a particular embodiment. In some embodiments, the numerical parameters should be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of some embodiments of the invention are

approximations, the numerical values set forth in the specific examples are reported as precisely as practicable. The numerical values presented in some embodiments of the invention may contain certain errors necessarily resulting from the standard deviation found in their respective testing measurements.

[0009] The recitation of ranges of values herein is merely intended to serve as a shorthand method of referring individually to each separate value falling within the range. Unless otherwise indicated herein, each individual value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g. "such as") provided with respect to certain embodiments herein is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention otherwise claimed. No language in the specification should be construed as indicating any non-claimed element essential to the practice of the invention.

[0010] Groupings of alternative elements or embodiments of the invention disclosed herein are not to be construed as limitations. Each group member can be referred to and claimed individually or in any combination with other members of the group or other elements found herein. One or more members of a group can be included in, or deleted from, a group for reasons of convenience and/or patentability. When any such inclusion or deletion occurs, the specification is herein deemed to contain the group as modified thus fulfilling the written description of all groups used in the appended claims.

OBJECTS OF THE INVENTION

[0011] It is an object of the present disclosure to provide a lean, self-contained, integrated and modular thermoelectric heating and cooling apparatus.

[0012] It is an object of the present disclosure to provide a thermoelectric heating and cooling apparatus that is flexible and adapts to different surface contours.

[0013] It is yet another object of the present disclosure to provide a thermoelectric heating and cooling apparatus that is readily configurable and possibly, readily usable plug and play, to various wearable accessories.

[0014] It is still another object of the present disclosure to provide a thermoelectric heating and cooling apparatus with higher efficiency of heat distribution.

SUMMARY

[0015] The present discourse relates generally to thermoelectric heating and cooling devices. In particular, the present discourse provides a thermoelectric heating and cooling apparatus (also referred to as thermoelectric heat transfer apparatus hereinafter) adaptable to different surface contours to enable efficient heat transfer to and from the surface.

[0016] Aspects of the present disclosure relate to a thermoelectric heat transfer apparatus, hereinafter referred to as "THTA" for sake of brevity, said THTA being a flexible self-contained unit with a minimum functionality of a Peltier module and heat sink(s) and can be laid interconnected in a grid of THTA units so as to achieve one or more desired applications. THTA of the present disclosure can include at least two outer flexible layers, one or more insulating flexible layers arranged between the at least two outer flexible layers, one or more peltier modules, wherein the one or more Peltier modules can be interconnected and arranged together in a grid. THTA of the present disclosure may, in one embodiment, be operatively coupled or include an integrated microcontroller, whereas, in another embodiment, the interconnected grid of THTAs may be connected to a microcontroller. The microcontroller can be configured to control transfer of heat as per requirement of the desired application.

[0017] In an aspect, the thermoelectric heat transfer apparatus of the present disclosure can include of a grid of THTAs, or can include a standalone THTA that may further include a plurality of temperature sensors to detect rise or fall in temperature and transmit respective commands to the microcontroller.

[0018] In an exemplary embodiment, THTA of the present disclosure can include at least two outer flexible layers that are made of highly conductive flexible materials selected from the group consisting of polymers and elastomers having high surface area. In an embodiment, the at least two outer flexible layers can be in direct contact with a medium to effect direct transfer of heat to and from the medium. This medium of transfer may be solid, liquid or gaseous. Thus, the outer layers acting as heat sinks may transfer heat through further air circulation, liquid circulation like water, or even directly to a solid surface in contact, such as through human skin or a metal body or a container like a cup. The efficient surface design of the outer layers shall depend on the type of application and medium contact required. Therefore, the proposed THTA may be made available in certain variations to be readily available for various types of applications.

[0019] In an embodiment, the one or more insulating flexible layers can be made of flexible materials selected from the group consisting of polymers and elastomers.

[0020] In an embodiment, Peltier elements or modules in a THTA may be assembled on flexible circuits selected from the group consisting of single sided flex circuits, double access flex circuits, sculptured flex circuits, rigid-flex circuits and multi-layer flex circuits. Alternatively, a simpler or any advanced way of assembling a circuit may be used to interconnect the Peltier elements within a THTA and provide connectivity of a THTA with other THTAs in a grid and to connect THTAs with external elements such as power source or micro controllers or other devices.

[0021] In an aspect, the proposed THTA can be adaptable to different contours of a surface in direct contact with an outer flexible layer of the apparatus to enable transfer of heat to and from the surface.

[0022] In another exemplary aspect, the proposed THTA can have a functionality whereby at least a portion of heat generated by the apparatus is converted into electrical energy by a Peltier thermos-power generator to enable storage of the generated electrical energy in one or more batteries.

[0023] Those skilled in the art will further appreciate the advantages and superior features of the disclosure together with other important aspects thereof on reading the detailed description that follows in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The accompanying drawings are included to provide a further understanding of the present disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the present disclosure and, together with the description, serve to explain the principles of the present disclosure.

[0025] In the figures, similar components and/or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label with a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

[0026] FIG. 1 illustrates an exemplary representation of a thermoelectric heat transfer apparatus (THTA) in accordance with an embodiment of the present disclosure.

[0027] FIG. 2 illustrates an exemplary sectional view of a THTA with a grid of Peltier modules in accordance to an embodiment of the present disclosure.

[0028] FIG. 3 illustrates an exemplary representation of a plurality of thermoelectric heat transfer apparatus (THTAs) configured with a surface in accordance to an embodiment of the present disclosure.

[0029] FIGs. 4A and 4B illustrate exemplary representation of a single THTA with single peltier module and a THTA with multiple peltier modules laid in a grid inside the THTA in a desired layout respectively in accordance to an embodiment of the present disclosure.

[0030] FIG. 4C illustrate an exemplary representation of multiple grids of THTAs connected to a microcontroller in accordance with an embodiment of the present disclosure.

[0031] FIGs. 5A and 5B illustrate sectional views of the proposed THTA in accordance to an embodiment of the present disclosure.

[0032] FIG. 5C illustrates isometric view of the proposed THTA in accordance to an embodiment of the present disclosure.

[0033] FIG. 5D illustrates sectional view of a grid of multiple THTAs in accordance with an embodiment of the present disclosure.

[0034] FIGs. 5E and 5F illustrate isometric views of a THTA with grid of multiple peltier modules in accordance with an embodiment of the present disclosure.

[0035] FIG. 5G illustrates exemplary representation of application of the grid of multiple THTAs with a garment in accordance with an embodiment of the present disclosure.

[0036] FIG. 6 illustrates exemplary representation of application of the proposed THTAs with a helmet in accordance with an embodiment of the present disclosure.

[0037] FIGs. 7A and 7B illustrate exemplary representation of application of the proposed THTAs with a jacket/vest in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0038] If the specification states a component or feature “may”, “can”, “could”, or “might” be included or have a characteristic, that particular component or feature is not required to be included or have the characteristic.

[0039] Exemplary embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments are shown. This

disclosure may however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. These embodiments are provided so that this disclosure will be thorough and complete and will fully convey the scope of the disclosure to those of ordinary skill in the art. Moreover, all statements herein reciting embodiments of the disclosure, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future (i.e., any elements developed that perform the same function, regardless of structure).

[0040] Thus, for example, it will be appreciated by those of ordinary skill in the art that the diagrams, schematics, illustrations, and the like represent conceptual views or processes illustrating systems and methods embodying this disclosure. The functions of the various elements shown in the figures may be provided through the use of dedicated hardware as well as hardware capable of executing associated software. Similarly, any electronic code generator shown in the figures are conceptual only. Their function may be carried out through the operation of program logic, through dedicated logic, through the interaction of program control and dedicated logic, or even manually, the particular technique being selectable by the entity implementing this disclosure. Those of ordinary skill in the art further understand that the exemplary hardware, software, processes, methods, and/or operating systems described herein are for illustrative purposes and, thus, are not intended to be limited to any particular named.

[0041] Various terms as used herein are shown below. To the extent a term used in a claim is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in printed publications and issued patents at the time of filing.

[0042] The present discourse relates generally to thermoelectric heating and cooling devices. In particular, the present discourse provides a thermoelectric heating and cooling apparatus (also referred to as thermoelectric heat transfer apparatus hereinafter) adaptable to different surface contours to enable efficient heat transfer to and from the surface.

[0043] Aspects of the present disclosure relate to a thermoelectric heat transfer apparatus, hereinafter referred to as “THTA” for sake of brevity, said THTA being a flexible self-contained unit with a minimum functionality of a Peltier module and heat sink(s) and can be laid interconnected in a grid of THTA units so as to achieve one or more desired applications. THTA of the present disclosure can include at least two outer flexible layers,

one or more insulating flexible layers arranged between the at least two outer flexible layers, one or more peltier modules, wherein the one or more Peltier modules can be interconnected and arranged together in a grid. THTA of the present disclosure may, in one embodiment, be operatively coupled or include an integrated microcontroller, whereas, in another embodiment, the interconnected grid of THTAs may be connected to a microcontroller. The microcontroller can be configured to control transfer of heat as per requirement of the desired application.

[0044] In an aspect, the thermoelectric heat transfer apparatus of the present disclosure can include of a grid of THTAs, or can include a standalone THTA that may further include a plurality of temperature sensors to detect rise or fall in temperature and transmit respective commands to the microcontroller.

[0045] In an exemplary embodiment, THTA of the present disclosure can include at least two outer flexible layers that are made of highly conductive flexible materials selected from the group consisting of polymers and elastomers In an embodiment, the at least two outer flexible layers can be in direct contact with a medium to effect direct transfer of heat to and from the medium. This medium of transfer may be solid, liquid or gaseous. Thus, the outer layers acting as heat sinks may transfer heat through further air circulation, liquid circulation like water, or even directly to a solid surface in contact, such as through human skin or a metal body or a container like a cup. The efficient surface design of the outer layers shall depend on the type of application and medium contact required. Therefore, the proposed THTA may be made available in certain variations to be readily available for various types of applications.

[0046] In an embodiment, the one or more insulating flexible layers can be made of flexible materials selected from the group consisting of polymers and elastomers.

[0047] In an embodiment, Peltier elements or modules in a THTA may be assembled on flexible circuits selected from the group consisting of single sided flex circuits, double access flex circuits, sculptured flex circuits, rigid-flex circuits and multi-layer flex circuits. Alternatively, a simpler or any advanced way of assembling a circuit may be used to interconnect the Peltier elements within a THTA and provide connectivity of a THTA with other THTAs in a grid and to connect THTAs with external elements such as power source or micro controllers or other devices.

[0048] In an aspect, the proposed THTA can be adaptable to different contours of a surface in direct contact with an outer flexible layer of the apparatus to enable transfer of heat to and from the surface.

[0049] In another exemplary aspect, the proposed THTA can have a functionality whereby at least a portion of heat generated by the apparatus is converted into electrical energy by a Peltier thermos-power generator to enable storage of the generated electrical energy in one or more batteries.

[0050] It would be appreciated that although aspects of the present disclosure have been explained with respect to thermoelectric heating and cooling apparatus, the present disclosure is not limited to the same in any manner whatsoever and any other form of heating or cooling that use peltier modules to effect heating and/or cooling of a medium is completely covered within the scope of the present disclosure.

[0051] FIG. 1 illustrates an exemplary representation of a peltier module in accordance with an embodiment of the present disclosure. In an aspect, thermoelectric heating and cooling apparatus (also referred to as thermoelectric heat transfer apparatus or THTA hereinafter) of the present disclosure can pertain to a flexible, modular, integrated self-contained module 100 comprising one or more Peltier elements or modules 202 (also referred to as micro peltier elements or micro sized peltier elements hereinafter) (as shown clearly in FIG. 2), wherein the peltier elements 202 can be interconnected in a combination of series and parallel configuration so as to enable a controlled generation of heat and to limit the heat generated between an upper threshold value and a lower threshold value.

[0052] In an exemplary aspect, each THTA module 100 can include at least two highly conducting outer flexible layers 102, and an insulating flexible layer 204 (as shown clearly in FIG. 2) that can be arranged/sandwiched between the two outer flexible layers 102 such that at least one Peltier element 202 or a grid of interconnected Peltier elements 202 can be embedded in the insulating flexible layer 204. In such a structure, outer surfaces of the Peltier element 202 can be exposed to the conducting outer layers 102. Peltier elements 202 in a THTA 100 can be interconnected with an electrical wiring circuit that can be embedded in the insulating layer 204, wherein such a circuit can include one or more connecting wires or terminals that are exposed outside the THTA 100 for it to be further connected to external elements or to other THTAs so as to form a grid of THTAs.

[0053] In an exemplary aspect, several THTA modules 100 can be interconnected and arranged in a grid so as to constitute a bigger THTA, for a specific application and connected

to a power supply (as clearly shown in FIG. 4C), and a central microcontroller 404 (as clearly shown in FIG. 4C), if so desired, and to any other paraphernalia to achieve desired application.

[0054] In an exemplary aspect, thermoelectric heat transfer apparatus can further include or be operatively coupled with a microcontroller 404 (not shown) or any other suitable control device that can be configured to control operations of the THTA module(s) 100, or an interconnected grid of THTAs. Therefore, the microcontroller 404 can either be configured to control its respective THTA or one or more THTAs that can, for instance, be configured in a grid format/layout/architecture. Any other structure of how one or more microcontroller 404s can be configured to control a plurality of THTAs that arranged in a defined format is well within the scope of the present invention. In an exemplary aspect, microcontroller 404 can be connected to THTA 100 through exposed terminals of the THTA 100. In an exemplary embodiment, a plurality of temperature sensors can be configured to detect rise or fall in temperature and transmit respective commands to the microcontroller 404. In an exemplary implementation, when a condition of temperature spike of the Peltier module 202 is detected by the plurality of sensors, the microcontroller 404 can trigger a command to stop the operation of the peltier module 100 or to regulate the temperature spike of the Peltier module 202 between a desirable temperature range. In an exemplary aspect, such temperature sensors may be integrated within a THTA 100 or used externally to give feedback to the microcontroller 404 or any other suitable control device for operations control.

[0055] In an exemplary embodiment, Peltier elements 202 of a THTA 100 can be assembled on flexible circuits including, but not limited to, single sided flex circuits, double access flex circuits, sculptured flex circuits, rigid-flex circuits and multi layer flex circuits.

[0056] In an exemplary embodiment, outer flexible layers 102 Peltier can be configured to act as heat sinks, and can be made of highly conductive flexible materials selected from any or a combination of polymers and elastomers having high thermal conducting value. In an exemplary embodiment, surface of such outer conducting layers 102 may be designed with grooves and fins so as to increase the surface area in case the medium of transfer of heat is a gas or a liquid. In an exemplary embodiment, the outer flexible layers 102 can be in direct contact with a body or an object to effect direct transfer of heat to and from that entity, in which case the surface design of the THTA shall be smooth to allow maximum direct contact without an air gap.

[0057] In an exemplary embodiment, insulating flexible layer 204 can be made of flexible material, for example such polymers and elastomers that have very low thermal conductance value.

[0058] It is to be appreciated that modular arrangement of the THTA modules 100 and flexibility offered by the outer flexible layers 102 and the insulating flexible layer 204 together effect an integrated apparatus without the need of bulky rigid heat sinks, and enable effective transfer of heat to and from a surface/medium in vicinity or in direct contact with an outer flexible layer 102. Further, thermoelectric heat transfer apparatus can adapt to various contours present on the surface so as to provide a self-contained, modular and flexible thermoelectric heat transfer apparatus.

[0059] In an exemplary aspect, outer flexible layers 102 of consecutive peltier modules 100 of the array can be attached/affixed/conjoined to each other by stitching, in a manner of speaking, or by application of conducting adhesives, or even in a grid of interconnected distinct separate THTAs and the structure so formed can be used with a product such as jackets, shirt, helmets, shoes, trousers and the likes to provide heating and cooling of body of a human being.

[0060] In an aspect, the proposed apparatus can be operable through typical AC or DC power supply, standalone power supply like battery banks, portable generators and the like for its most effective application.

[0061] It is to be appreciated that at least a portion of heat generated by the thermoelectric heat transfer apparatus can be converted into electrical energy by a peltier thermo power generator to enable storage of electrical energy in one or more batteries. Thus, providing an efficient way to recycle lost/unused heat to produce usable electrical energy. In an exemplary embodiment, in some cases, the proposed THTA 100 may incorporate this energy saving and efficiency aspect and recycle the energy.

[0062] FIG. 2 illustrates an exemplary sectional view of a THTA module in accordance to an embodiment of the present disclosure. In an aspect, the THTA module 100 can include a single Peltier module/element 202, or a plurality of Peltier elements 202, or one or more grids of interconnected micro-sized Peltier modules/elements 202, embedded in an insulating flexible polymeric insulating/insulation layer 204 so that the side surfaces of the Peltier module 202 are covered completely and tightly with the material of the insulating layer 204, and the outside front two surfaces of the module 202 are in complete contact with conducting flexible polymeric layer 102, which arrangement effectively thermally isolates the

two outer thermal conducting zones of layer 102. The insulating flexible polymeric layer 204 therefore separates outer flexible conductive layers 102 such that thermal zones of the proposed THTA module 100 are insulated from each other.

[0063] In an exemplary aspect, microcontroller 404 can be connected to the plurality of grids of interconnected peltier elements 202 by electrical wiring 104 through the insulating flexible layers 204.

[0064] In an exemplary aspect, the outer flexible layers 102 of the THTA 100 act as heat sinks such that when one outer flexible layer 102 of the THTA 100 gets heated due to peltier effect, the other outer flexible layer 102 experiences cooling effect. In an aspect, the proposed THTA can allow for heating and/or cooling of a large area by having bigger THTAs with more number of micro peltier elements 202 in a grid as well as by providing a large number of THTA modules 100 arranged in a grid 300 in a manner that heats and/or cools the specified area by adapting to the contour of the area.

[0065] In an aspect, arrangement of a plurality of peltier modules 202 as a part of THTAs can form an array or a grid to cover large surface areas for effectively providing a flexible blanket with local heat generation and distribution.

[0066] In an exemplary aspect, the proposed apparatus can contribute to huge energy savings, whereby, personal cooling and comfort can be possible with much lower amount of energy consumption as compared to convention cooling as well as heating applications, which though being more energy efficient, have to cool the entire ambience, thus consuming much higher energy. Further, the proposed apparatus can have a very direct impact on global environment, sustainability, human productivity, pollution levels, and eventually every life form may be impacted.

[0067] FIG. 3 illustrates an exemplary representation of a grid 300 comprising a plurality of thermoelectric heat transfer apparatuses (THTAs) 100, wherein the grid 300 is configured on a surface 350 in accordance to an embodiment of the present disclosure. In an aspect, configuration of the proposed grid 300 on a surface 350 is shown.

[0068] In an exemplary aspect, grid 300 of the present disclosure can include a plurality of THTAs 100 that can be laid out in a defined/desired/configured pattern/format/layout, wherein each THTA 100 can include one or more micro-peltier modules 202 that can be connected in a series-parallel configuration. The proposed grid 300 of THTAs 100 can be configured on/with a surface 350 of a product including, but not

limited to, jackets, shoes, shirts, helmet, sheets and refrigerators by stitching or application of adhesives.

[0069] In an exemplary embodiment, microcontroller 404 (not shown) can control the operation of the grid 300 or of one or more THTAs 100 so as to allow heating and/or cooling of the surface 350 of the desired product. Further, a plurality of sensors can be configured with the grid 300 (or with one or more THTAs 100) so as to detect rise and fall in temperature of the surface and to provide corresponding commands to the microcontroller 404.

[0070] In an exemplary implementation, the proposed grid 300 or one or more THTAs 100 in any combination can be used by various garment manufactures to manufacture climate control jackets, vests and helmets, or climate control blankets. Heat capacity of each peltier module 202 that forms part of a THTA 100 can be fixed as per the configuration. It is envisaged that such modules 202 with higher heat capacity can even be used to prepare isolated compact shelters or tents or small enclosures to protect incumbents from climatic vagaries or exigencies. The proposed apparatus grid 300 can be usable in various applications such as expeditions, adventurous, excursions, military applications and the like through coupling of the grid 300 with desired products/articles/wearables.

[0071] It is to be appreciated that availability of readily usable self-contained, modular and flexible THTA 100 can open up untapped potential of the proposed grid 300. Such THTAs 100, in any desired combination/format, can be used in caps and helmets, whereby relief can be achieved by lowering or increasing temperature of head gear to a limited extent that can bring relief to innumerable people like traffic policemen, bikers, people working in extreme conditions, etc.

[0072] In an aspect, the proposed THTA 100 is readily usable, versatile for many applications, modular, and can be interconnected with other THTAs 100 so as to achieve a grid of THTAs, wherein each THTA 100 can include micro peltiers (also referred to as micro-peltier modules/elements or simply as peltier modules hereinafter) that are connected in a defined/desired format (such as in series/parallel/grid). The proposed THTA 100 is furthermore flexible, is not based on functionally graded material in which P type and N type conductor material is dispersed, is simple in construction with polymeric flexile thermally conductive layers acts as heat sinks on both sides, and does not have wicks for moisture removal or heat pipe, among other such elements.

[0073] In an aspect, microcontroller 404 that is operatively coupled with one or more THTAs 100 can be used for temperature control, as well as to control operations of TEG – or Thermo electric generator, which can have the capability of reconverting temperature difference attribute on the dispersal side of THTA 100 back to electric energy.. The proposed microcontroller 404, in an aspect, can be configured in the THTA 100, to control TEGs and can further help in heat removal by converting it back to electric current and make the apparatus 100 thermally more efficient by putting less load on the heat sink. On the other hand, such an aspect of using TEGs controlled by the microcontroller 404 makes the apparatus 100 electrically and energy efficient by using stored electricity to be reused in the apparatus.

[0074] As mentioned above, the proposed disclosure pertains to a modular, ready to use THTAs that have integrated conducting layers with heat sink properties, which allow the THTA to be used as stand-alone plug and play module. THTAs 100 of the present invention can further be laid into a grid by interconnecting them to create a larger effective THTA for use in diverse applications flexibility, wherein each THTA 100 is flexible for adapting to the contours of an organic or inorganic object for it to be act as ready to use plug and play module. Efficient temperature control and heat dispersal (which is necessary for it to act as readily usable plug and play device) further enhances the functionality of the proposed THTAs. These modular THTA units have low current, low temperature difference micro Peltiers in a grid for efficient heat dispersal, and can be controlled by microprocessor. Each THTA 100 can have TEG (thermos-electric generator) as an option for still better heat management and making it energy efficient.

[0075] FIGs. 4A and 4B illustrate exemplary representations of a single THTA 100 with a single peltier module 202 and another representation of a single THTA 100 with a grid of 9 peltier modules 202 in a desired layout respectively in accordance to an embodiment of the present disclosure. In an aspect, a THTA 100 can include one or more micro peltier elements 202 sandwiched between two highly conducting thermo polymer layers 102 made of flexible materials such as polymers and elastomers. The highly conducting thermo polymer layers 102 can act as heat sinks. In an aspect, outer layers 102 can be ribbed to provide increased surface area for quick and efficient transfer of heat from the THTA 100. At least one conducting wire 104 can be connected to the a THTA 100 for electrical supply and to provide connection to microcontroller 404 or to other THTAs 100.

[0076] As illustrated in FIG. 4B, a plurality of THTAs 100 can be interconnected so as to form a grid 300 of THTAs 100 that can be applied to a garment, electronic appliance, accessories and other like applications to enable transfer of heat to and from the grid 300. As shown, six THTAs 100 or any number can be interconnected to form a grid 300. Conducting wire 104 can be connected to at least one THTA 100 of the grid 300 for electrical supply and to provide connection to microcontroller 404 or to other THTAs 100. The proposed arrangement/layout of the grid 300 gives rise to a flexible and modular heat transfer apparatus that can be used to heat or cool a surface or a plurality of surfaces in contact with or in vicinity of the THTAs 100.

[0077] FIG. 4C illustrate an exemplary representation of multiple grids of THTAs connected to a microcontroller 404 in accordance with an embodiment of the present disclosure. In an aspect, multiple grids 300 of THTAs 100 can be interconnected with one another in any or a combination of a series or a parallel configuration. Connecting wires 104 can be connected to at least one THTA 100 for electrical supply and to provide connection to microcontroller 404 or to other THTAs 100. The microcontroller 404 can control transfer of heat to and from the THTAs 100 as per requirement of the desired application. Further, the microcontroller 404 can be powered by a power supply 402 such as AC or DC power supply, standalone power supply like battery banks, portable generators and the like for its most effective application.

[0078] FIGs. 5A and 5B illustrate sectional views of the proposed THTA in accordance to an embodiment of the present disclosure. FIG. 5C illustrates isometric view of the proposed THTA in accordance to an embodiment of the present disclosure. In an aspect, a THTA 100 can include one or more micro peltier elements 202 sandwiched between two highly conducting thermo polymer layers 102 made of flexible materials such as polymers and elastomers. The highly conducting thermo polymer layers 102 can act as heat sinks. In an aspect, outer layers 102 can be ribbed to provide increased surface area for quick and efficient transfer of heat from the THTA 100. At least one conducting wire 104 can be connected to the micro peltier element 202 for electrical supply and to provide connection to microcontroller 404 or to other THTAs 100. In addition, the proposed THTA 100 can include a highly insulating thermo polymer middle layer 204 that can separate the outer layers 102 and can further prevent conduction of heat between the outer layers 102 so as to only enable convective transfer of heat between the outer layers 102.

[0079] FIG. 5D illustrates sectional view of a THTA with multiple peltier modules 202 in accordance with an embodiment of the present disclosure. FIGs. 5E and 5F illustrate isometric views of THTA in accordance with an embodiment of the present disclosure. FIG. 5G illustrates exemplary representation of application of the grid 300 of multiple THTAs with a garment in accordance with an embodiment of the present disclosure. In an aspect, a grid 300 can include multiple THTAs 100 arranged in a desired layout (such as in a desired series or parallel layout) to provide desired heating or cooling effect. A plurality of THTAs 100 can be interconnected so as to form a grid 300 of THTAs 100 that can be applied to a garment, electronic appliance, accessories and other like applications to enable transfer of heat to and from the grid 300. For instance, nine or any number of THTAs 100 can be interconnected to form a grid 300. Conducting wire 104 can be connected to at least one micro peltier element 202 of the grid 300 for electrical supply and to provide connection to microcontroller 404 or to other THTAs 100. The proposed arrangement/layout of the grid 300 gives rise to a flexible and modular heat transfer apparatus that can be used to heat or cool a surface or a plurality of surfaces in contact with or in vicinity of respective THTAs 100. As illustrated in FIG. 5F, the each THTA 100 is flexible to take on contour shape of the human body or any object and modular such that it can be implemented in innumerable applications including, but not limited to, garments, electronic appliances, accessories and other like applications that involve transfer of heat between multiple mediums.

[0080] Referring now to FIG. 5G, the proposed grid 300 of THTAs 100 can be applied to a garment to enable transfer of heat to and from the garment. The grid 300 can be applied to the garment by suitable means such as stitching, application of adhesives and the likes. When the garment is being used by a user, the user can initiate operation of the THTAs 100 of the grid 300 to enable desired heating and/or cooling.

[0081] FIG. 6 illustrates exemplary representation of application of the proposed THTAs with a helmet in accordance with an embodiment of the present disclosure. In an aspect, the proposed THTA 100 can be use to enable heat transfer to and from a helmet 600 being worn by a user. One or more grids 300 comprising a plurality of THTAs 100 can be arranged between outer hard layer 602 of the helmet and inner lining 604 of the helmet 600. The helmet 600 can include a crush layer 606 to protect the user from head injuries during accidents. At least one or more air ways 610 can be provided in the crush layer to ventilate heat generated by the THTAs 100. A mechanical ventilation 608 such as a fan can be provided to assist heat removal through the at least one air ways.

[0082] FIGs. 7A and 7B illustrate exemplary representation of application of the proposed THTAs with a jacket/vest in accordance with an embodiment of the present disclosure. FIG. 7A illustrates configuration of one or more grids 300 comprising multiple THTAs 100 in a desired layout at a front section 700 of the jacket. FIG. 7B illustrates configuration of one or more grids 300 comprising multiple THTAs 100 in a desired layout at a rear section 750 of the jacket. In an aspect, grid 300 comprising multiple THTAs 100 can be laid in front section of the jacket so as to provide conductive transfer of heat between the grid 300 and front/rear part of body of a user wearing the jacket. Conductive heat transfer is enabled as body parts of the user are in direct contact with the THTAs 100. Heated side of the jacket can be ventilated by providing a patch on the jacket or by providing a metal stud (fashion/style accessory display) or through another layer of heat conducting polymer connected to the garment. Grids 300 can be configured at various locations of the jacket so as to enable heating and/or cooling of various desired body parts of the user. One or more storage packet 702 can be available in the jacket to provide a storage space for a battery bank powering the THTAs 100.

[0083] It is to be appreciated that although aspects of the present disclosure are explained with respect to a helmet and a jacket, the present disclosure is not limited to the same in any manner whatsoever and any other form of application of the proposed THTA is completely covered within the scope of the present disclosure.

[0084] It should be apparent to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms “comprises” and “comprising” should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced. Where the specification claims refers to at least one of something selected from the group consisting of A, B, C ….and N, the text should be interpreted as requiring only one element from the group, not A plus N, or B plus N, etc. The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing

from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the appended claims.

[0085] While embodiments of the present disclosure have been illustrated and described, it will be clear that the disclosure is not limited to these embodiments only. Numerous modifications, changes, variations, substitutions, and equivalents will be apparent to those skilled in the art, without departing from the spirit and scope of the disclosure, as described in the claims.

ADVANTAGES OF THE INVENTION

[0086] The present disclosure provides a flexible and modular thermoelectric heating and cooling apparatus.

[0087] The present disclosure provides a thermoelectric heating and cooling apparatus that adapts to different surface contours.

[0088] The present disclosure provides a thermoelectric heating and cooling apparatus that is configurable to various wearable accessories.

[0089] The present disclosure provides a thermoelectric heating and cooling apparatus with high efficiency of heat distribution.

I Claim:

1. A modular thermoelectric heat transfer apparatus (THTA) comprising:

   at least two outer flexible conductive layers configured to act as heat sink, said at least two outer flexible conductive layers being formed of any or a combination of polymers and elastomers having high surface area and high thermal conductivity;

   one or more insulating flexible layers sandwiched between the at least two outer flexible conductive layers; and

   one or more Peltier modules embedded in or configured with the one or more insulating flexible layers, said one or more Peltier modules being coupled with each other in a series or parallel configuration, wherein said THTA is operatively coupled with a microcontroller that controls heat transfer operation of the THTA using the one or more Peltier modules.
2. The apparatus of claim 1, wherein said apparatus is laid interconnected with one or more other THTAs in a grid layout.
3. The apparatus of claim 1, wherein said apparatus comprises or is operatively coupled with a temperature sensor to detect rise or fall in temperature and transmit respective commands to the microcontroller.
4. The apparatus of claim 1, wherein the at least two outer flexible conductive layers are in direct contact with a medium to effect direct transfer of heat to and from the medium.
5. The apparatus of claim 1, wherein said one or more insulating flexible layers are made of flexible materials selected from the group consisting of polymers and elastomers.
6. The apparatus of claim 1, wherein the one or more Peltier modules are assembled on flexible circuits selected from the group consisting of single sided flex circuits, double access flex circuits, sculptured flex circuits, rigid-flex circuits and multi-layer flex circuits.
7. The apparatus of claim 1, wherein at least a portion of heat generated by the apparatus is converted into electrical energy by a Peltier thermo-power generator to enable storage of the generated electrical energy in one or more batteries.
8. An article comprising a grid layout of one or more thermoelectric heat transfer apparatuses (THTAs), each of said one or more THTAs comprising:

   at least two outer flexible conductive layers configured to act as heat sink, said at least two outer flexible conductive layers being formed of any or a combination of polymers and elastomers having high surface area and high conductivity;

one or more insulating flexible layers sandwiched between the at least two outer flexible conductive layers; and

one or more Peltier modules embedded in or configured with the one or more insulating flexible layers, said one or more Peltier modules being coupled with each other in a series or parallel configuration, wherein said THTA is operatively coupled with a microcontroller that controls heat transfer operation of the THTA using the one or more Peltier modules.

9. The article of claim 1, wherein said article is a wearable article.

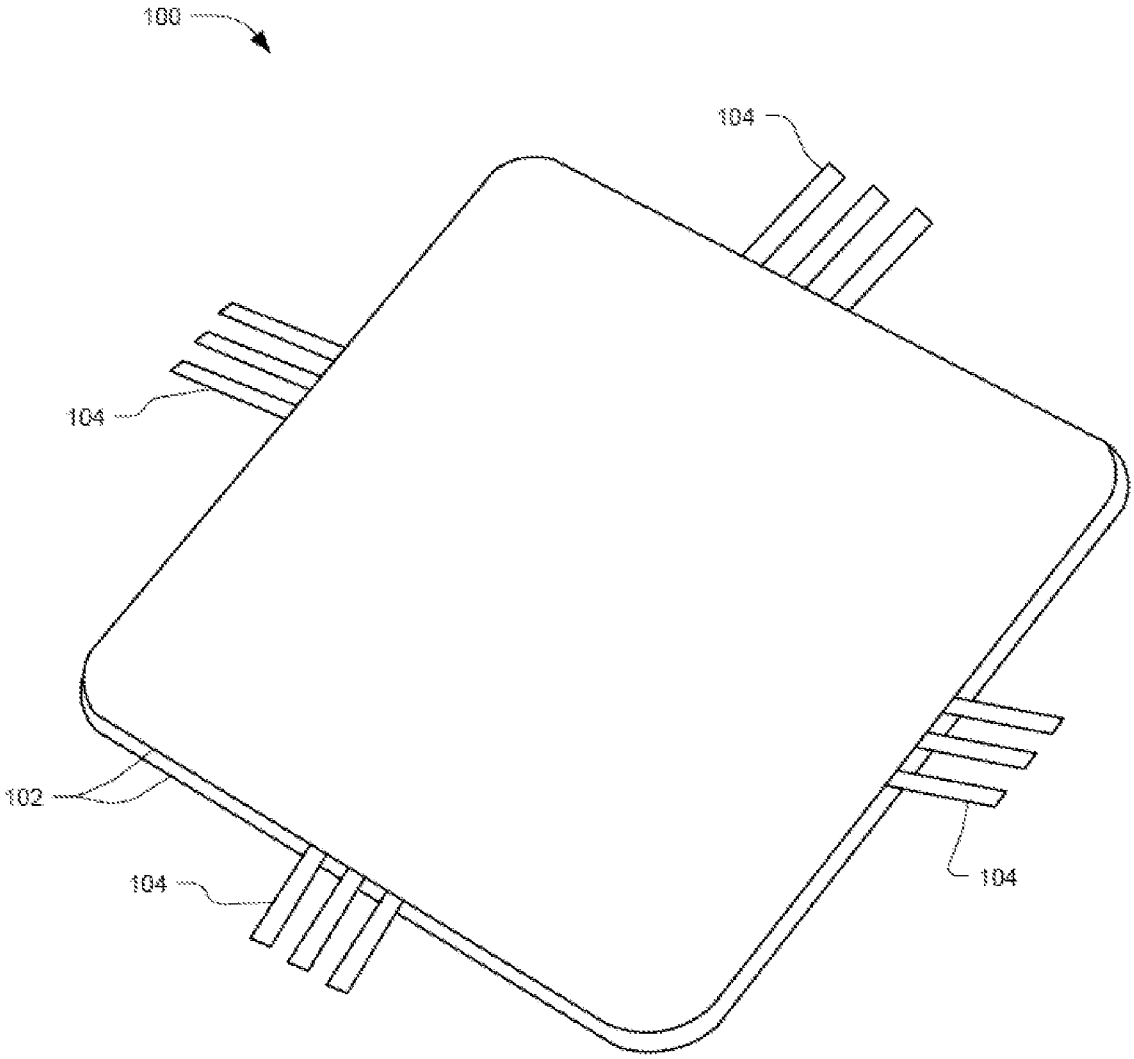


FIG. 1

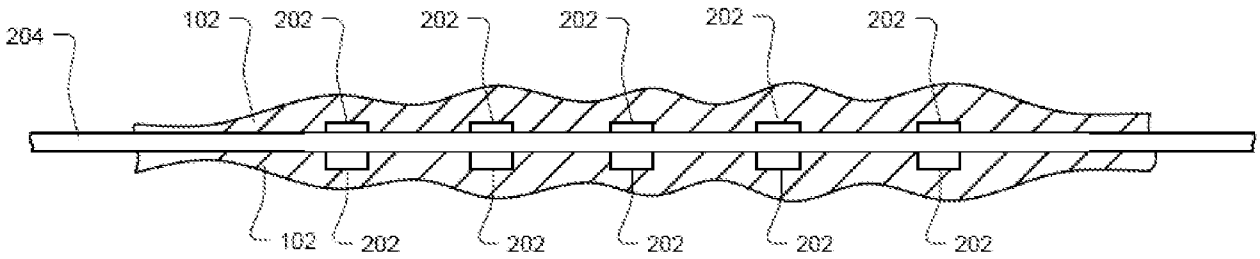


FIG. 2

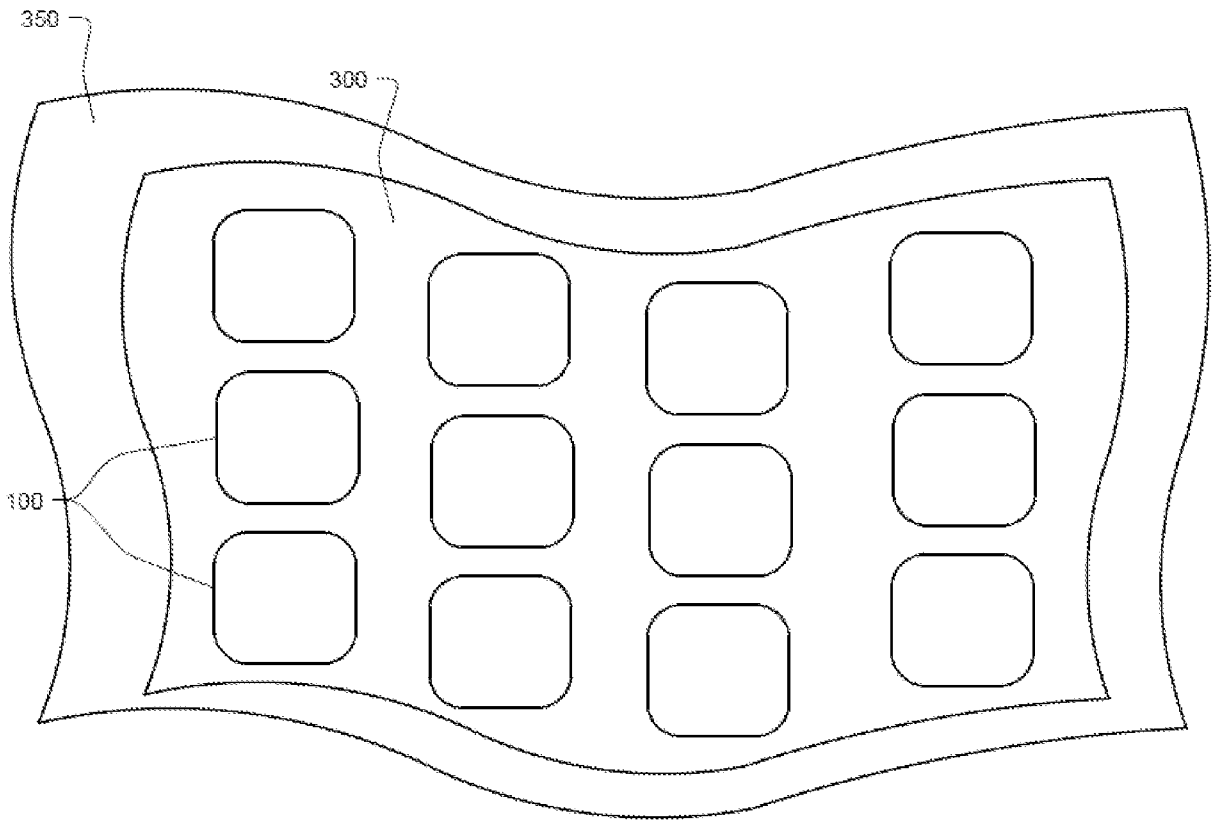


FIG. 3

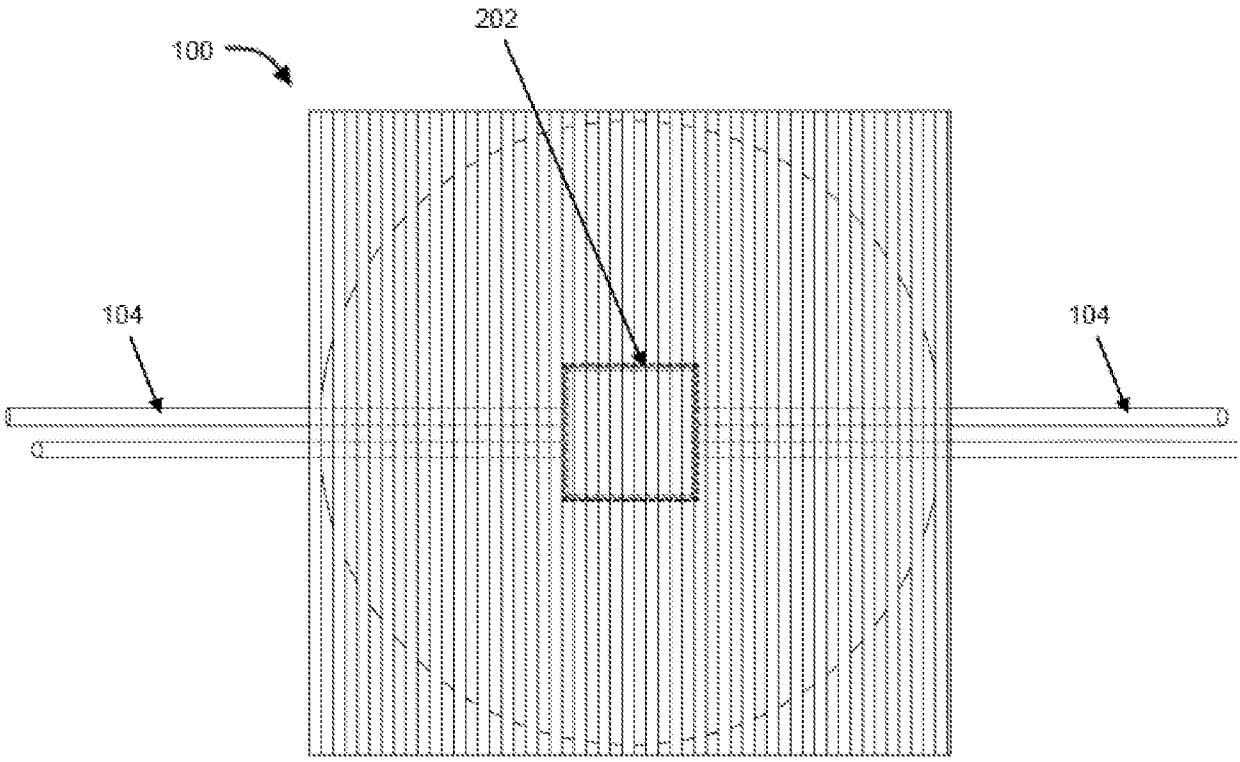


FIG. 4A

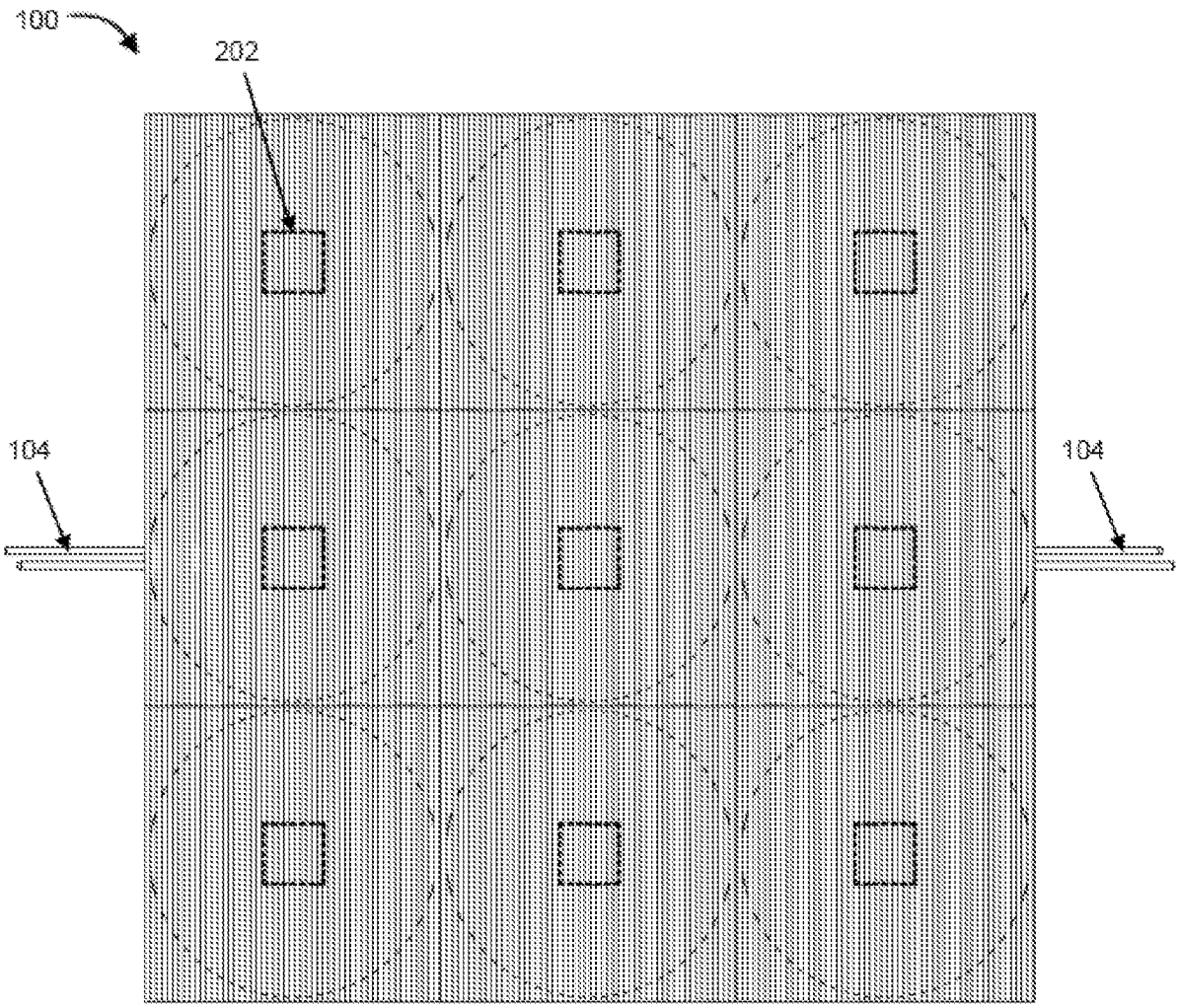


FIG. 4B

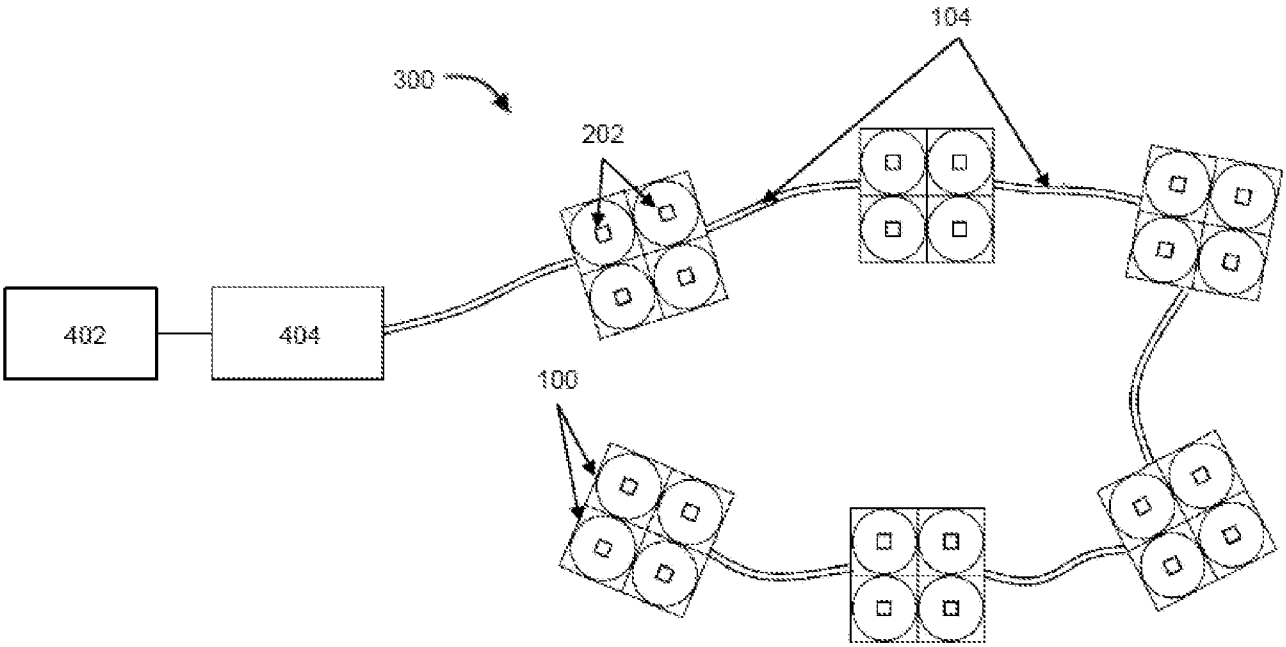


FIG. 4C

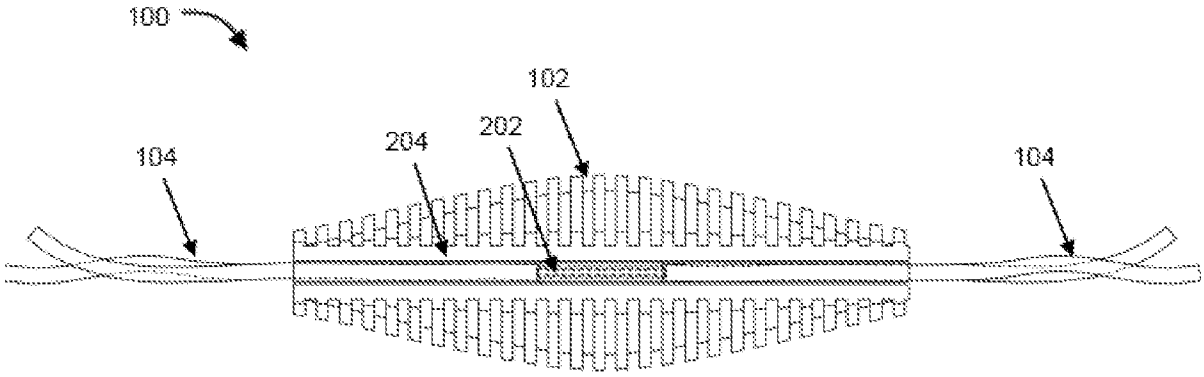


FIG. 5A

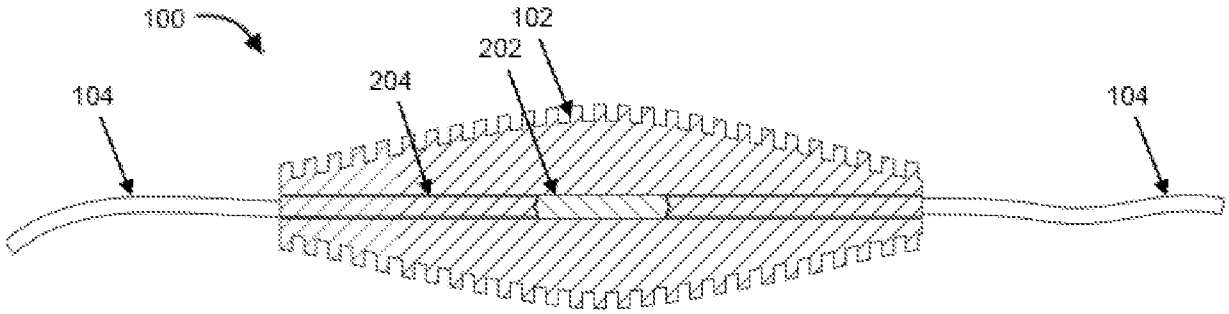


FIG. 5B

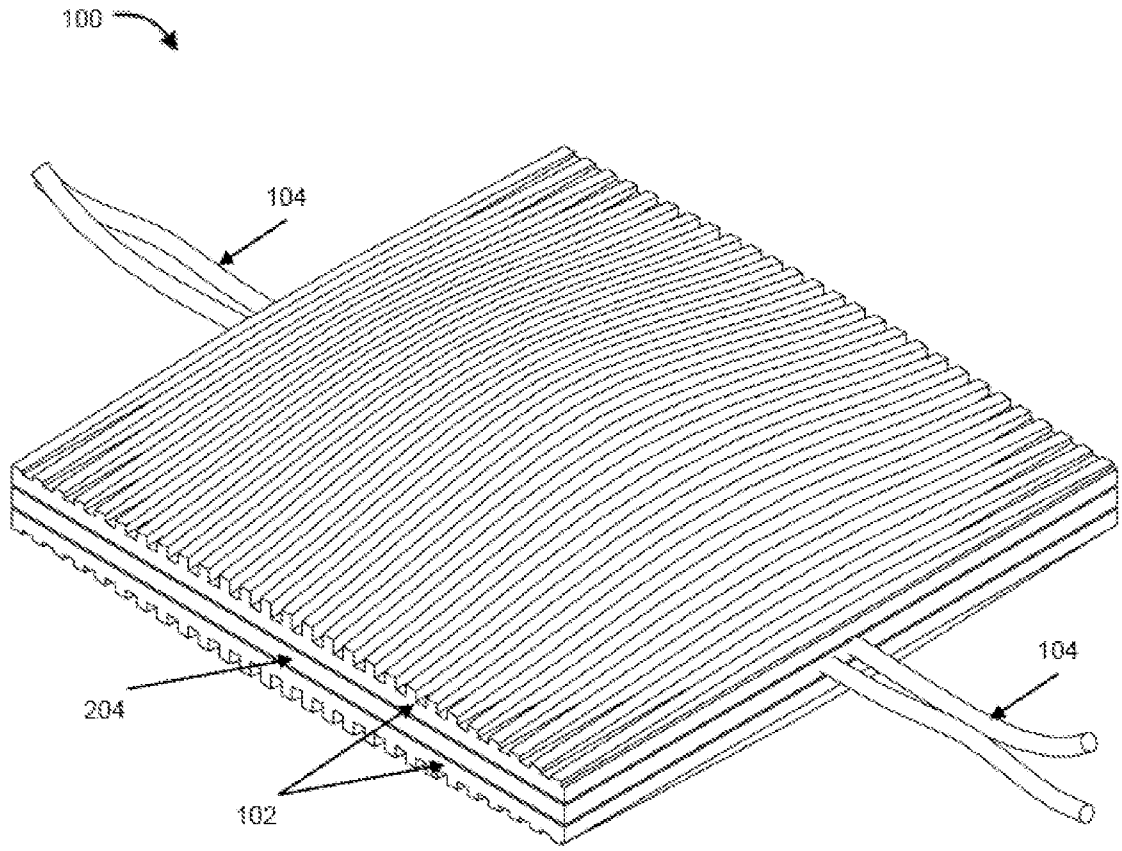
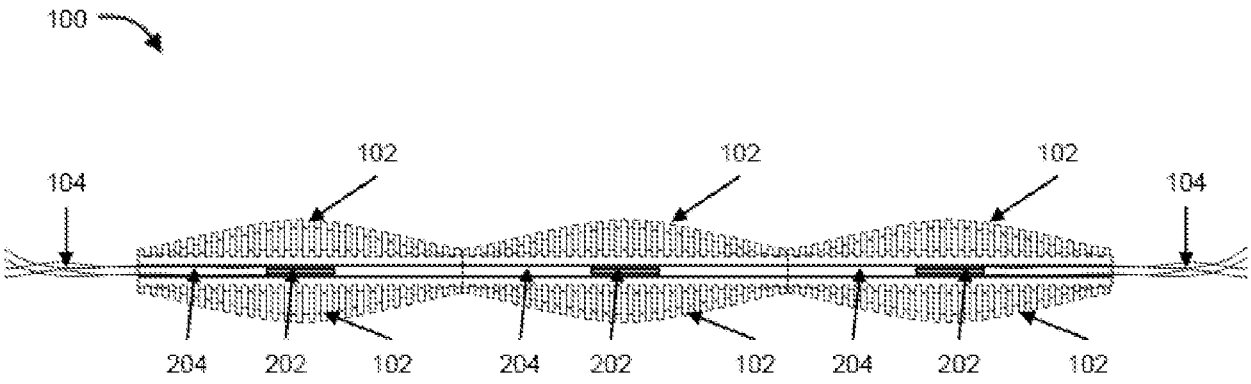

100
104
204
102
104

FIG. 5C


100
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102

FIG. 5D

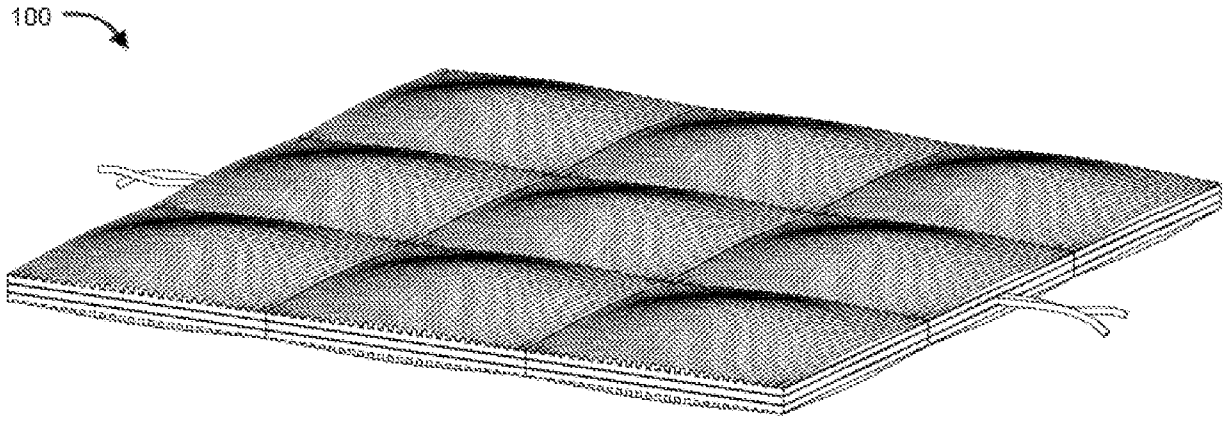

FIG. 5E

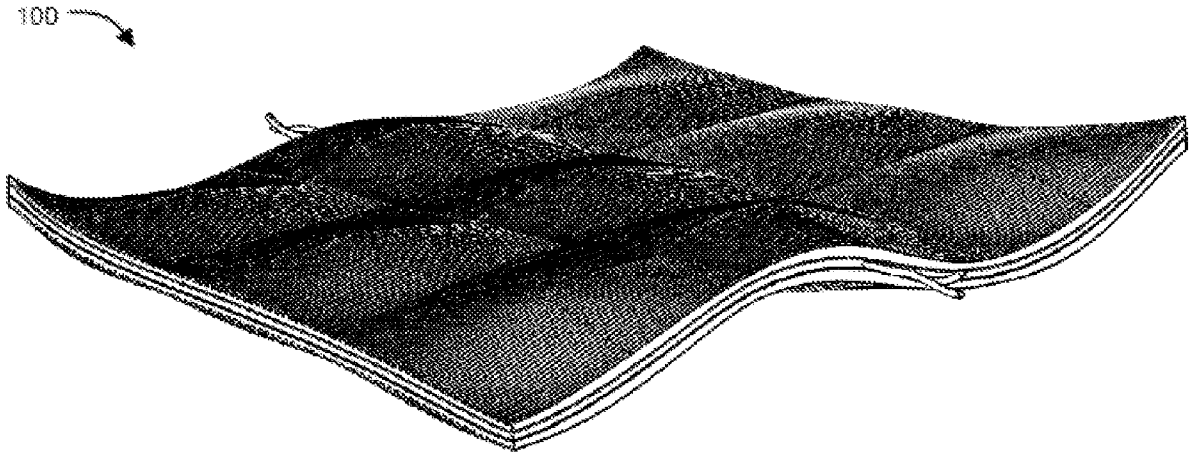

FIG. 5F

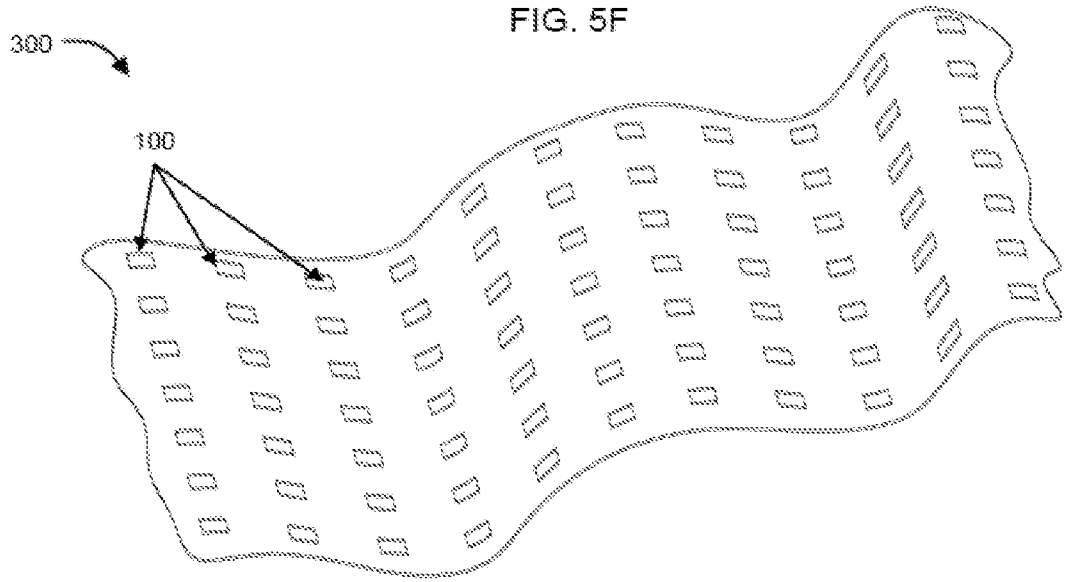

FIG. 5G

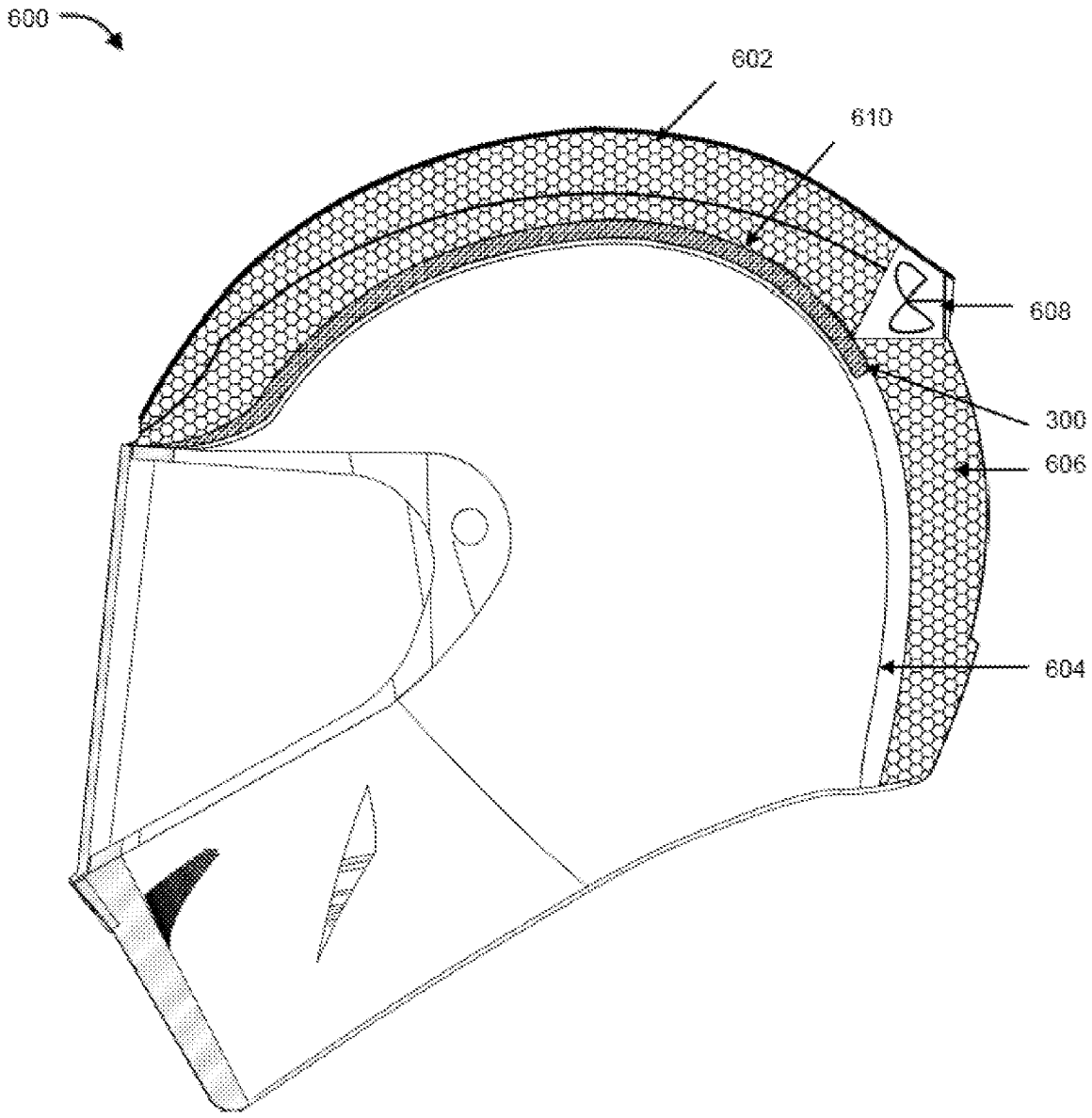

FIG. 6

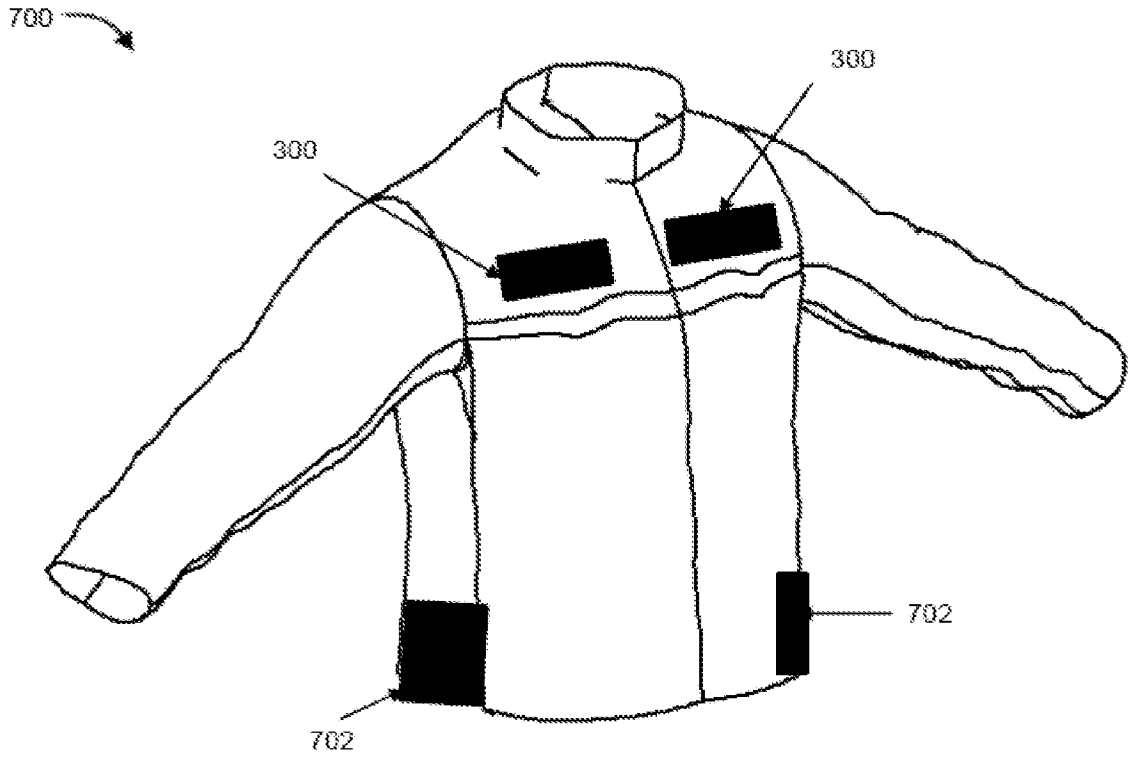

FIG. 7A

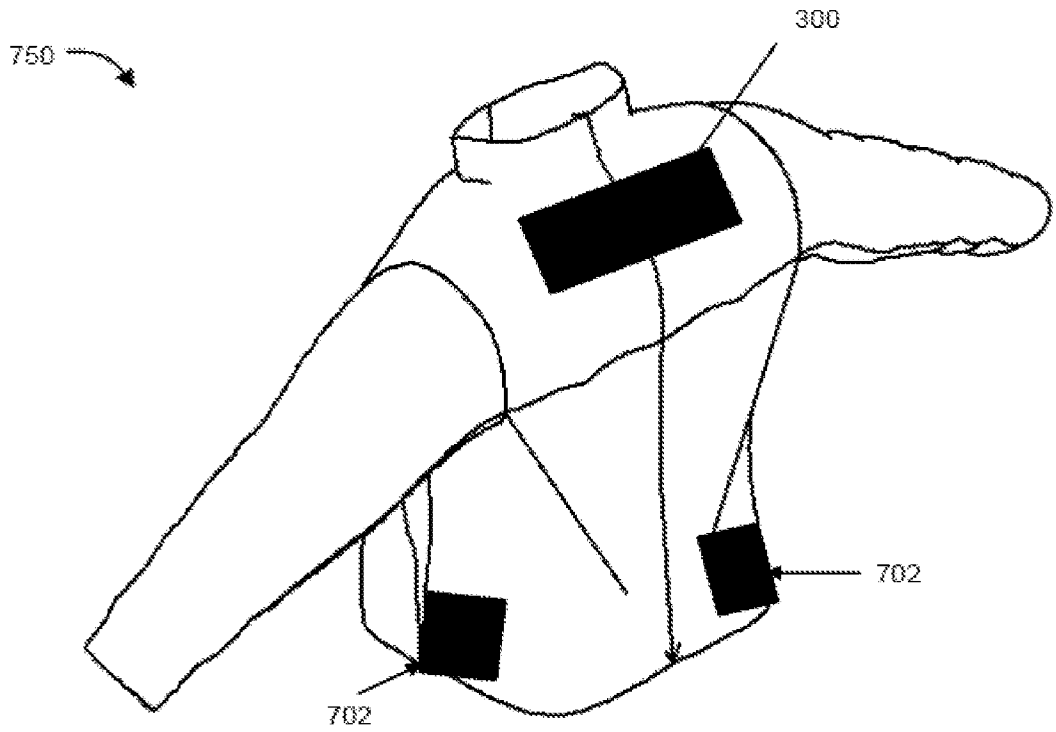

FIG. 7B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2018/057872

A. CLASSIFICATION OF SUBJECT MATTER
F25B21/02 Version=2019.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

TotalPatent One, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP2375190A1 (LAMOS INC) 12 October 2011 (12.10.2011) Page 4 Line [0014-0015], Page 5 Line [0025-0055], Page 14-15 Line [0075-0076]	1-9
Y	WO2003071198A1 (VARMARAF EHF.) 28 August 2003 (28.08.2003) Page 3 Line [0010-0020], Page 4 Line [0010-0025] & NO FAMILY	4
Y	WO2010088433A1 (MICRO Q LIC) 05 August 2010 (05.08.2010) Page 37,Line (0025-0030], Page 2,Line [0025-0025], Page 7,Line [0010-0020] & NO FAMILY	1-9
A	US5040381A (PRIME COMPUTER INC) 20 August 1991 (20.08.1991) Column 1 Line [0025-0040] & NO FAMILY	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07-02-2019	07-02-2019
Name and mailing address of the ISA/ Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075 Facsimile No.	Authorized officer Ashutosh Dhaketa Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2018/057872

Citation	Pub.Date	Family	Pub.Date
EP 2375190 A1	12-10-2011	WO 2010067368 A2	17-06-2010
		US 20120067064 A1	22-03-2012