(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 891 418 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.07.2015 Bulletin 2015/28

(51) Int Cl.:
A41D 13/04 *(2006.01)* ***A41D 19/015*** *(2006.01)*
A41F 1/00 *(2006.01)*

(21) Application number: **14150390.4**

(22) Date of filing: **07.01.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) **Easily donned and doffed metal-mesh butcher's clothing**

(57) A metal-mesh tunic (125) has an apron region and two full-length sleeves (120), the tunic (125) presenting a closed-figure neck aperture through which a user's head (155) and neck (150) project when worn, the neck aperture becoming an open-figure to facilitate easy donning and doffing without requiring a pullover action. In an illustrative embodiment, the tunic (125) may present a contiguous protective surface from the neck region of a user (110) down to a knee region. A closure system (140) secures the tunic (125) to a user (110) by fixing the closed-figure neck aperture around the user's neck (150). The closure system (140) may have a buckle including a male member attached to one side of the neck region and a female member on an other side of the neck region. In an exemplary embodiment, the metal-mesh tunic (125) may advantageously provide full frontal armored protection in an easily donned garment.

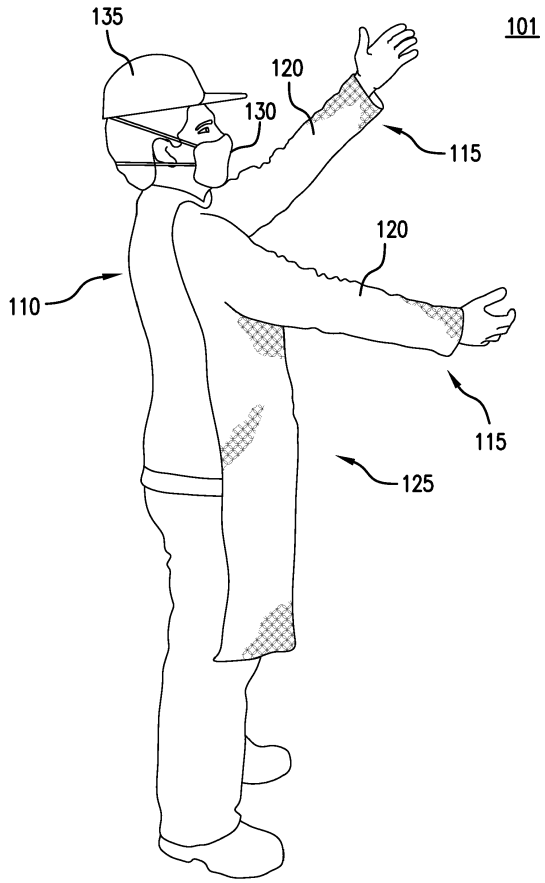


FIG.1A

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Description

TECHNICAL FIELD

[0001] Various embodiments relate generally to metal-mesh protective clothing, and more specifically to such clothing that is easily donned and doffed.

BACKGROUND

[0002] Wire-mesh safety fabrics have a long and storied history. Wire-mesh safety fabrics were called chainmail and used as a kind of armor in the middle ages. As the instruments of war became more and more deadly, chainmail gave way to plate armor. And with today's instruments of war, heavy armor is the norm for today's battle arenas. But these wire-mesh safety fabrics have found use in other places in society, and continue to see use even today. These wire-mesh fabrics are made into gloves and used by butchers and woodworkers to provide cut-resistance. They are made into bodysuits and worn by scuba divers to provide shark-resistance. They are made into bodysuits and worn by sword fighting athletes to provide protection during competitions.

[0003] Fabrics made from metal links provide good protection from contact with sharp instruments, while hanging well on the human form. Small links allow the necessary flexibility that body movements require. But fabrics made from wire mesh can be difficult to don and doff. When donning and doffing any garment, a user must cooperate with the design of the garment. Butchers use metal-mesh garments to protect themselves from accidental cuts and punctures from sharp knives and/or bones. Butchers often wear other safety equipment as well. Many butchers wear helmets, earplugs, safety glasses, breathing filters, and/or mobcaps. Butchers often work in a refrigerated environment, requiring heavy clothing in addition to their butcher specific safety clothing.

SUMMARY

[0004] Apparatus and associated methods relate to a metal-mesh tunic having an apron region and two full-length sleeves, the tunic presenting a closed-figure neck aperture through which a user's head and neck project when worn, the neck aperture becoming an open-figure to facilitate easy donning and doffing without requiring a pullover action. In an illustrative embodiment, the tunic may present a contiguous protective surface from the neck region of a user down to a knee region. In some embodiments, a closure system may secure the tunic to a user by fixing the closed-figure neck aperture around the user's neck. The closure system may have a buckle including a male member attached to one side of the neck region and a female member on an other side of the neck region. In an exemplary embodiment, the metal-mesh tunic may advantageously provide full frontal armored protection in an easily donned garment.

[0005] Apparatus and associated methods may relate to a metal-mesh glove having a hand region and a wrist region, the wrist region having a metal-mesh securing band attached to the wrist region at a fixed end and having a magnet attached to a free end, wherein the metal-mesh securing band may secure the glove to a user by circumscribing the wrist of the user, the magnet attaching to an underlying circumscribed portion of the securing band. In some embodiments, the wrist region of the metal-mesh glove may be configured to receive a hand and wrist inserted into the metal-mesh glove. Metal-mesh fabric at the wrist region may then be gathered as the securing band circumscribes the wrist. The metal-mesh of the securing band may include interconnecting metal links of ferromagnetic material. In an exemplary embodiment, the metal-mesh glove may advantageously be easily removed by a metal-mesh gloved hand of a user.

[0006] Various embodiments may achieve one or more advantages. For example, some embodiments may permit a wearer to don a protective metal-mesh garment without having to first remove headgear. In some embodiments, safety masks may remain firmly in place throughout the donning and/or doffing of metal-mesh safety clothing. In an exemplary embodiment, a metal-mesh tunic may have comparatively light weight as optimally sized metal links may be used. In some embodiments, metal-mesh protective clothing may be easily donned and/or doffed by hand operations performed by a gloved wearer.

[0007] In some embodiments, an easily doffed tunic may be quickly removed from an injured or unconscious wearer. For example, if a wearer experiences heart failure, it may be necessary to quickly doff the wearer's tunic so as to provide immediate defibrillation therapy. Or, in the case of a knife injury, it may be necessary to quickly doff the injured persons' tunic so as to apply immediate compression to reduce the blood loss. In some examples the quick removal may be facilitated by open figure of the neck aperture, which may permit removal without an overhead maneuver.

[0008] The details of various embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIGS. 1A-1C depict an exemplary donning sequence of a butcher preparing to suit up for a butchering session.

FIGS. 2A-2B depict a front view and a back view of an exemplary neck-opening metal-mesh tunic.

FIG. 3 depicts a front view of an exemplary easily donned metal-mesh tunic worn by a model.

FIG. 4 depicts a back view of an exemplary neck-

opening metal-mesh tunic.

FIGS. 5A-5K depicts various embodiments of neck-opening metal-mesh tunics.

FIG. 6 depicts an exemplary easily donned metal-mesh glove worn by a model.

FIG. 7 depicts a close-up view of an exemplary magnetic wrist-securing metal-mesh glove worn by a model.

FIG. 8 depicts a figure illustrating an exemplary comparison of respective puncture depths for fabrics made of 7 mm outside diameter rings and 6 mm outside diameter rings.

FIG. 9 depicts a schematic showing exemplary relationships between an illustrative knife blade angle, ring diameter and puncture depth.

FIG. 10 depicts a plot of exemplary performance to illustrate a relationship between the ring diameter and stab test results.

[0010] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0011] To aid understanding, this document is organized as follows. First, an exemplary donning procedure is briefly introduced with reference to FIG. 1 to describe the attributes that facilitate donning and doffing of exemplary metal-mesh clothing. Second, with reference to FIGS. 2-5, various exemplary metal-mesh tunics will be described. Then, with reference to FIGS. 6-7, the discussion turns to exemplary embodiments of metal-mesh gloves that illustrate features that promote easy donning and doffing. Finally, with reference to FIGS. 8-10, further explanatory discussion and experimental data is presented to explain the various advantages of different metal-mesh fabric styles.

[0012] FIGS. 1A-1C depict an exemplary donning sequence of a butcher preparing to suit up for a butchering session. In FIGS. 1A-1C, three exemplary steps for donning a metal-mesh suit are shown. In a first step 101, as depicted in FIG. 1A, a butcher 110 has already inserted both arms 115 into sleeves 120 of a metal-mesh tunic 125. The tunic 125 is depicted draped onto the butcher 110 and supported by the arms 115. The butcher is depicted wearing a face mask 130 and a helmet 135. In a second step 102, as depicted in FIG. 1B, the butcher is releasably securing the metal-mesh tunic 125 to the butcher's body. The butcher 110 is fastening a securing member 140 located near an upper back region 145 of the butcher 110. When the securing member 140 is releasably secured, a closed-figure neck aperture will be defined, through which a neck 150 and head 155 of the butcher 110 will project therethrough. Prior to releasably securing the securing member 140, the neck aperture is an open-figure, permitting the butcher 110 to don the metal-mesh tunic 125 without having to pull the metal-mesh tunic 125 over the butcher's head 155.

[0013] In a third step 103, as depicted in FIG. 1C, the butcher 110 is depicted securing a metal-mesh glove 160 to a left hand 165 of the butcher 110. The depicted butcher 110 may be right handed, and may only glove the left hand 165 with a metal-mesh glove 160. A right hand 170 may be the hand used for wielding a butcher's knife, and may only be gloved with a latex glove 185, for example. In the third step 103, the butcher's latex-gloved right hand 170 is depicted grasping a graspable magnetic securing member 175 attached to a metal-mesh securing strap 180. The strap has been placed circumferentially around a wrist 180 of the butcher 110. The magnetic securing member 175 may be releasably coupled to a portion of the metal-mesh securing strap directly beneath the magnetic securing member 175. Both the metal-mesh tunic 125 and the metal-mesh glove 160 may be easily donned by the butcher 110, who is depicted wearing latex gloves 185, a helmet 135, and a face mask 130.

[0014] FIGS. 2A-2B depict a front view and a back view of an exemplary neck-opening metal-mesh tunic. In FIG. 2A, an exemplary metal-mesh tunic 200 is depicted from a frontal view. The depicted metal-mesh tunic 200 has an apron portion 205 and two full-length sleeves 210. The metal-mesh tunic has a neck aperture 215 through which a wearer's head and neck may project therethrough. The metal-mesh tunic 200 may provide contiguous coverage from the shoulders of a wearer down to the knee region of the wearer. This exemplary metal-mesh tunic permits unprotected frontal exposure of only the lower legs of a wearer, the hands of a wearer, and the neck and head of a wearer.

[0015] In FIG. 2B, the exemplary metal-mesh tunic 200 is depicted from a back-side view. The depicted metal-mesh tunic has a rear closure system 220. The rear closure system includes one or more closure members 225. The closure system may permit the neck aperture 215 to open. When the closure system secures the metal-mesh tunic 200 to the wearer, the neck aperture is defined by a closed figure of surrounding metal-mesh. By opening the neck aperture 215, the metal-mesh tunic may advantageously be donned without having to perform a pull-over operation as may be necessitated with a permanently closed-figure neck aperture. Such a pull-over operation may be difficult for wearer's who are already wearing other head-gear. For example, if a wearer is wearing a helmet or a face-mask, a fixed closed-figure neck aperture may be undersized to permit a helmeted heat to project therethrough. In another example, by performing a pull-over operation to don a metal-mesh tunic, a wearer's gas-mask may be inadvertently dislodged exposing the wearer to potentially dangerous atmospheric toxins. An openable neck aperture may permit a metal-mesh tunic to be simply draped over the wearer as the wearer inserts both arms into the sleeves. Then the wearer may releasably secure a closure member 225 to close the figure of the neck aperture and releasably secure the garment to the wearer's body. In the depicted embodi-

ment, a wearer must reach behind the head or back and secure one of the closure members 225.

[0016] FIG. 3 depicts a front view of an exemplary easily donned metal-mesh tunic worn by a model. In FIG. 3, an exemplary metal-mesh tunic 300 includes a metal fabric 305 which includes interconnected metal rings. Each metal ring may interconnect with one or more of its nearest neighbors. Various interconnect patterns may be used. In some embodiments, a hexagonal close-pack arrangement may be used. In some embodiments, each ring may interconnect with one or more of its nearest neighbors. For example, each ring may link 3, 4, 6, 8, or more of its surrounding neighbors. The size and diameter of each ring may affect the weight of the fabric as well as its resistance to punctures and cuts.

[0017] FIG. 4 depicts a back view of an exemplary neck-opening metal-mesh tunic. In FIG. 4, the metal-mesh tunic 300 is depicted from the back-side. The depicted metal-mesh tunic has four closure members 405. Each of the closure members has a male member 410 which is separable from a female member 415. The male and female members 410, 415 may be secured to each other by inserting the male member 410 into the female member 415. The male member 410 may have locking tabs that engage the female member 415 when inserted.

[0018] In the depicted embodiment, four closure members are shown. Various means for releasably securing the metal-mesh tunic to a wearer's body may be used. For example, various types of buckles may be used to secure a metal-mesh tunic to a wearer's body. Zippers may be used to secure a metal-mesh tunic to a body. Magnetic fasteners may be used to join two regions of a metal-mesh garment to each other, for example. Buttons and/or snaps may be used to releasably secure a metal-mesh garment to a wearer's body. The releasable securement means may include a graspable feature. The graspable feature may be sized to be easily grasped by a gloved hand.

[0019] FIGS. 5A-5K depicts various embodiments of neck-opening metal-mesh tunics. In FIG. 5, a variety of open neck-aperture designs are depicted. Each distinct embodiment depicted demonstrates a means of releasably closing the open-figure neck aperture. For example, an exemplary metal-mesh design 500 shows a closure system with closure members 505 coupling each other at a front of the design 500. Closure straps 510 connect from the back-side of the design 500 at an upper back region 515. Another exemplary metal-mesh design 520 shows a closure system with closure members 505 separately coupled at a right side and left side of the front of the design 520. In the depicted design 520, the closure members 505 may each couple at a non-horizontal angle at the lateral frontal coupling locations. In a third exemplary design 525, the closure members 505 may separately couple at a horizontal angle at lateral frontal locations of the design 525. In a fourth metal-mesh tunic design 530, the coupling member may be a vertical zipper located at the upper back region of the design 530. In a fifth design 535, snap fasteners 540 may open the neck aperture figure at a frontal location 545. A right sleeve 550 may be permanently attached only via a metal-mesh fabric located across an upper back region of the design 540. In a sixth design 555, a zipper 560 may be used to releasably close the neck aperture. In a seventh design 565, a frontal zipper 570 may releasably close the neck aperture. An openable neck-aperture figure may advantageously facilitate easy donning and doffing of the garment, especially when headgear is worn by the wearer.

[0020] FIG. 6 depicts an exemplary easily donned metal-mesh glove worn by a model. In FIG. 6, a metal-mesh glove 600 includes a hand portion 605 and a gauntlet portion 610. The gauntlet portion 610 of the glove may be configured to receive a hand and wrist of a human. At a wrist region 615, a wrist strap 620 is coupled to the metal-mesh glove 600 at a fixed end. The depicted wrist strap has a length greater than a circumference of the depicted wearer's wrist 625. The wrist strap is fashioned from metal-mesh fabric. The metal-mesh fabric may include Ferro-magnetic material. A graspable magnetic fastener 630 is coupled to a free end 635 of the wrist strap 620. The wrist strap 620 is shown partially circumscribing the wearer's wrist 625.

[0021] FIG. 7 depicts a close-up view of an exemplary magnetic wrist-securing metal-mesh glove worn by a model. In the FIG. 7 depiction, an exemplary magnetic wrist-securing metal-mesh glove 700 is being modeled on a human hand 705. A graspable magnetic fastener 710 may be releasably coupled to the wrist strap 620. Note that two different styles of metal-mesh fabric are used in this exemplary embodiment, one for the wrist strap 620 and one for the hand portion 605 and gauntlet portion 610 of the metal-mesh glove 700. Some embodiments may use identical styles of metal-mesh fabric for the wrist strap 620 as both the hand portion 605 and wrist portion 620. Various metal-mesh fabric styles have different properties. For example, some metal-mesh fabric styles may be lighter. Some metal-mesh fabric styles may provide better puncture protection, for example.

[0022] FIG. 8 depicts a figure illustrating an exemplary comparison of respective puncture depths for fabrics made of 7 mm outside diameter rings and 6 mm outside diameter rings. In FIG. 8, two different wire-mesh (WMSF) safety fabrics are depicted. A 7 mm outside-diameter rings safety-fabric 800 is shown on the left, and a 6 mm outside-diameter ring safety-fabric 805 is shown on the right. A first 30° knife blade 810 is shown protruding one of the 7 mm outside-diameter rings 815. The first knife blade 810 protrudes the 7 mm outside-diameter ring 815 to a depth of 9.9 mm. A second 30° knife blade 820 is shown protruding one of the 6 mm outside-diameter rings 825. The second knife blade 820 protrudes the 6 mm outside-diameter ring 825 to a depth of 7.9 mm. This represents approximately a 20% reduction in penetration depth.

[0023] FIG. 9 depicts a schematic showing exemplary relationships between an illustrative knife blade angle,

ring diameter and puncture depth. In FIG. 9, a knife 900 is depicted in schematic form with a blade angle 905 represented by the symbol 'a'. A puncture length 910 is depicted as the depth of the blade that protrudes through and beyond a ring 915. An internal diameter 920 of the ring 915 is represented by the symbol 'd'. The knife's puncture length 910, 'L', can be represented in terms of the internal ring diameter 920, and the knife's blade angle 905, by the following formula: L = d/tan(a). A table 925 shows the penetration depth of a 5.7 mm inside diameter ring to be 9.9 mm for a 30° knife blade. The table 925 also shows the penetration depth of a 4.75 mm inside diameter ring to be 8.2 mm for a 30° knife blade.

[0024] FIG. 10 depicts a plot of exemplary performance to illustrate a relationship between the ring diameter and stab test results. In FIG. 10, a chart 1000 plots test points on an x-y grid. An x-axis 1005 of this chart 300 represents the outside-diameter of the ring. A y-axis 1010 of this chart 1000 represents the wire diameter used to make the ring. The weight of the resulting garment is represented by the size of the circle on the chart. The fill-pattern of each circle on the chart represents the safety result of the stab test. A speckled fill-pattern indicates that the stab test failed, and an unfilled circle indicates a passing stab test. A circle with a diagonal fill-pattern represents the optimal solution with regard to both weight and stab test result. A circle 1015 is located at the outside-diameter of 4 mm and a wire diameter of 0.5 mm. A garment made from this ring/wire combination passed the stab test as indicated by the diagonal fill-pattern. The weight of a garment made of this ring/wire combination is approximately the median of all tested. Thus circle 1015 represents an average weight, but a failed stab test. Another circle 1020 is located at the outside-diameter of 7 mm and a wire diameter of 0.7 mm. This circle 1020 has a speckled fill-pattern indicating that the garment made of this ring/wire combination failed the stab test. The size of circle 1020 is one of the larger circles of all those tested. Thus, the garment made of this ring/wire combination is relatively heavy.

[0025] A number of ring/wire combinations are tested around the 6 mm ring diameter and 0.6 mm wire diameter region of the chart 1000. The goal of this testing is to find the optimal combination of ring diameter and wire diameter that would both provide for good stab protection and light weight. A circle 1025 with a diagonal fill-pattern represents the combination of an outside ring diameter of 6.2 mm and a wire diameter of 0.6 mm. This circle 1025 has a diagonal fill-pattern which represents a passing stab test. The size of the circle 1025 is one of the smaller circles on the chart, which means that a garment made of this ring/wire combination is relatively light, especially when compared to the combinations represented by the circles 1015 and 1020. Other acceptable combinations are presented on this figure 1000, such as the ring/wire combination represented by circle 1030. Circle 1030 represents a ring/wire combination of 0.6 mm outside ring diameter and 0.575 wire diameter. This combination 1030 also passes the stab test and has a garment weight that is approximately that of the combination represented by circle 1025. Thus both solutions are good solutions for producing stab protection while simultaneously permitting the manufacture of light-weight garments.

[0026] Although various embodiments have been described with reference to the Figures, other embodiments are possible. For example, some embodiments may relate to an earlier and related PCT/EP2011/061886 (filed 12 July 2011) application that describes examples of tensile strength of mesh metal.

[0027] Another improvement proposed concerned the steel used for making the rings. Actually, the possibility of using very hard and very strong steel was thought to be limited by the web making techniques, especially the necessary operations of metal particle cutting, drawing, forming, bending and/or welding. If used, very hard and very strong metals would enable obtaining webs having higher strength and hardness properties than conventional webs, or having similar properties, but with a lighter weight because a smaller thickness would be used.

[0028] FR-2898250 discloses a method for obtaining hard steel as a base material for making the steel rings, of structurally hardened metal, namely metal presenting in a certain state relatively low strength and hardness characteristics and, in any case, compatible with the steel ring cutting and shaping operations (and possibly the metal web forming operation) and supposedly presenting, after a heat treatment, higher strength characteristics, especially higher than those compatible with the aforementioned cutting/shaping (and possibly forming) operations.

[0029] The heat treated web is possibly not totally in the form that is used for making the final garment. In this case, the corresponding web is finalized by any technique appropriate to the strength and hardness of the metal rings. For example, the steel attaching rings can be made of a conventional stainless steel the properties of which satisfy to the standards in force and which can be bent without being dominantly harmful to the strength of the web assembly. Optionally, before the steel particles or the web are shaped, the steel is subjected to a mechanical deformation/elongation, such as kneading, which enables obtaining a work hardening of the steel to approach the shaping capability limits of the steel elements (according to the available equipment and techniques). This particularity enables optimizing the later heat treatment to obtain the highest possible strength and hardness characteristics.

[0030] However, it has been found that the above known techniques are not always satisfactory. Changing the conventional dimensions of the rings and the diameter of the steel wire also change the way the fabric behaves and this may be not satisfactory in some instances. As for the heating and mechanical treatment proposed, it has the disadvantage of making the process longer and also, in case the treatment is not correctly performed, the disadvantage of rendering the wire brittle or easily break-

able.

[0031] An exemplary embodiment includes chain mail fabric for protective piece of garment made of a mesh of interlocking rings which rings have an external diameter of between 3.98 and 4.02 mm and are made with a wire whose diameter is between 0.47 and 0.52 mm exhibiting a tensile strength between about 1300 and 1500 N/mm^2.

[0032] This is much above the usual tensile strength of conventional wires of 0.5 mm in diameter, whose tensile strength is often comprised between 680 and 750 N/mm^2. It is even more that the conventional wires of 0.55 mm in diameter, whose tensile strength is generally comprised between 900 and 1050 N/mm^2.

[0033] In accordance with an exemplary embodiment, such characteristics are exhibited by rings formed from an embodiment of steel having an austeno-ferritic structure. One exemplary composition includes Fe with:

- a C content not higher than 0.03 % by weight
- a Mn content not higher than 2.00% by weight
- a Si content not higher than 0.75% by weight
- a S content not higher than 0.01% by weight
- a P content not higher than 0.030% by weight
- a Ni content of between 4.50% by weight and 6.50% by weight
- a Cr content of between 21 % by weight and 23 % by weight
- a Mo content of between 2.50% by weight and 3.50% by weight
- a N content of between 0.15% by weight and 0.20% by weight

the balance being substantially Fe and incidental impurities.

[0034] An embodiment of steel comprising the above specified composition yields a wire of high tensile strength without the need for thermal treatment. The wires were processed according to a conventional method in web machines to form mail fabric which was found to be comfortable, with good protection properties against perforation, and not too heavy.

[0035] The pieces of garment can be, for example, gloves, sleeves, aprons, chasubles, jackets, etc. If necessary, some parts of the protective garments can be made in other material, according to the level of protection required for the different parts of the garment. For example, a jacket can be made with a body and sleeves made from titanium in order to have a lighter jacket.

[0036] In the case of gloves, by comparison with steel mesh gloves made with a 0.5 mm wire having a tensile strength between 680 and 750 N/mm^2, it has been found that the use of a wire with higher tensile strength between 1300 and 1500 N/mm^2 substantially doubles the lifetime of the glove.

[0037] In various embodiments, devices may involve the WMSF being made in the form of a glove. In another exemplary embodiment, the WMSF is made in the form of a sleeve. In an exemplary embodiment the WMSF is made in the form of an apron. In accordance with another embodiment, the WMSF is made in the form of a tunic. In still another exemplary embodiment, the WMSF is made in the form of a pull-over (with a body and sleeves). In another exemplary embodiment the WMSF is made in the form of body armor.

[0038] In an exemplary embodiment, a portion of a garment will be made using steel rings and another portion of the garment may be made using titanium rings. Such a garment may have increased strength in certain critical locations, while permitting light weight in certain locations. In accordance with another embodiment, the steel may have an austeno-ferritic structure, which may permit the metal to have both excellent corrosion resistance and still be malleable at room temperatures.

[0039] In various embodiments, the ring arrangement may be such that each ring links multiple adjacent rings. In some embodiments, the rings will have a hexagonal close-packed structure, where each ring will link the two closest rings in the row above and the two closest rings in the row below the one in which it resides. In other embodiments, each ring may link a fewer or a greater number of adjacent rings.

[0040] In an illustrative embodiment, a metal-mesh tunic for easy donning and doffing without the need for the removal of headgear may include a metal-mesh fabric having a plurality of interconnecting metal rings. In some embodiments, the metal-mesh fabric may have an apron portion extending from a neck region to a knee region. In some embodiments, the metal-mesh fabric may have two sleeves, each of the two sleeves connecting to the apron portion. In an exemplary embodiment, the metal-mesh tunic may include a closure system having an open mode and a closed mode, wherein when in the closed mode, a neck region is securely closed to present a closed-figure aperture through which the user's neck and head project, when worn. In some embodiments, when in the open mode, the neck region may be opened to present an open-figure aperture such that the apron portion can be freely draped onto the front of a user, when the user inserts each of a user's arms into each corresponding one of the tunic's two sleeves.

[0041] In another illustrative embodiment, a metal-mesh glove for easy donning and doffing, the metal-mesh glove may include a metal-mesh fabric comprising a plurality of interconnecting metal rings, the metal-mesh fabric having an hand portion configured to receive a user's hand such that each of a user's fingers are received into a corresponding finger receptacle. In some embodiments, the metal-mesh fabric may have a wrist portion configured provide continuous circumferential protection to a user's wrist, when worn. In an exemplary embodiment, the metal-mesh glove may include a closure system having an open mode and a closed mode, wherein when in the closed mode, a metal-mesh wrist strap, having a fixed end attached to the wrist portion of the metal-mesh fabric, circumscribes the wrist and a magnet attached to a free end of the metal-mesh wrist strap is af-

fixed to the metal-mesh wrist strap at the same circumferential location and directly beneath the magnet. In some embodiments, the closure system may include a grasp handle coupled to the magnet for providing a graspable feature by a metal-mesh gloved hand of a user.

[0042] A number of implementations have been described. Nevertheless, it will be understood that various modification may be made. For example, advantageous results may be achieved if the steps of the disclosed techniques were performed in a different sequence, or if components of the disclosed systems were combined in a different manner, or if the components were supplemented with other components. Accordingly, other implementations are within the scope of the following claims.

Claims

1. A metal-mesh tunic for easy donning and doffing without the need for the removal of headgear, the metal-mesh tunic comprising:

a metal-mesh fabric comprising a plurality of interconnecting metal rings, the metal-mesh fabric having an apron portion extending from a neck region to a knee region, the metal-mesh fabric having two sleeves, each of the two sleeves connecting to the apron portion; and
a closure system having an open mode and a closed mode, wherein when in the closed mode, a neck region is securely closed to present a closed-figure aperture through which the user's neck and head project, when worn, and when in the open mode, the neck region is opened to present an open-figure aperture such that the apron portion can be freely draped onto the front of a user, when the user inserts each of a user's arms into each corresponding one of the tunic's two sleeves.

2. The device of claim **1,** wherein each ring has an external diameter of between 5.95 mm and 6.05 mm.

3. The device of claim **1,** wherein each ring has a wire diameter of between 0.61 mm and 0.63 mm.

4. The device of claim **1,** wherein the rings are made of stainless steel.

5. The device of claim **1,** wherein at least some of the rings further comprise titanium.

6. The device of claim **1,** wherein the rings are made of steel having an austeno-ferritic structure comprising Fe with:

a C content not higher than 0.03% by weight;
a Mn content not higher than 2.00% by weight;
a Si content not higher than 0.75% by weight;
a S content not higher than 0.01 % by weight;
a P content not higher than 0.03% by weight;
a Ni content not higher than 0.03% by weight;
a Cr content not higher than 0.03% by weight;
a Mo content not higher than 0.03% by weight;
a N content not higher than 0.03% by weight; and
a balance being substantially Fe and incidental impurities.

7. The device of claim **1,** wherein the closure system comprises a buckle having a male member and a female member, the male member attaching to a first side of the neck region, and the female member attached to a second side of the neck region.

8. A metal-mesh tunic for easy donning and doffing without the need for the removal of headgear, the metal-mesh tunic comprising:

a metal-mesh fabric comprising a plurality of interconnecting metal rings, the metal-mesh fabric having an apron portion extending from a neck region to at least a waist region, the metal-mesh fabric having two sleeves, each of the two sleeves connecting to the apron portion; and
a closure system having an open mode and a closed mode, wherein when in the closed mode, a neck region is securely closed to present a closed-figure aperture through which the user's neck and head project, when worn, and when in the open mode, the neck region is opened to present an open-figure aperture such that the apron portion can be freely draped onto the front of a user, when the user inserts each of a user's arms into each corresponding one of the tunic's two sleeves.

9. A metal-mesh glove for easy donning and doffing, the metal-mesh glove comprising:

a metal-mesh fabric comprising a plurality of interconnecting metal rings, the metal-mesh fabric having an hand portion configured to receive a user's hand such that each of a user's fingers are received into a corresponding finger receptacle, the metal-mesh fabric having a wrist portion configured provide continuous circumferential protection to a user's wrist, when worn; and
a closure system having an open mode and a closed mode, wherein when in the closed mode, a metal-mesh wrist strap, having a fixed end attached to the wrist portion of the metal-mesh fabric, circumscribes the wrist and a magnet attached to a free end of the metal-mesh wrist strap is affixed to the metal-mesh wrist strap at the same circumferential location and directly beneath the magnet, wherein a grasp handle is

coupled to the magnet for providing a graspable feature by a metal-mesh gloved hand of a user.

10. The device of claim **9,** wherein at least some of the rings have an external diameter of between 5.95 mm and 6.05 mm.

11. The device of claim **9,** wherein at least some of the rings have a wire diameter of between 0.61 mm and 0.63 mm.

12. The device of claim **9,** wherein at least some of the rings comprise stainless steel.

13. The device of claim **9,** wherein at least some of the rings comprise titanium.

14. The device of claim **9,** wherein at least some of the rings comprise steel having an austeno-ferritic structure comprising Fe with:

a C content not higher than 0.03% by weight;
a Mn content not higher than 2.00% by weight;
a Si content not higher than 0.75% by weight;
a S content not higher than 0.01 % by weight;
a P content not higher than 0.03% by weight;
a Ni content not higher than 0.03% by weight;
a Cr content not higher than 0.03% by weight;
a Mo content not higher than 0.03% by weight;
a N content not higher than 0.03% by weight; and
a balance being substantially Fe and incidental impurities.

15. The device of claim **9,** wherein the metal-mesh of the wrist strap comprises Ferro-magnetic material.

16. The device of claim **9,** wherein the wrist strap has a length of at least four inches.

17. A metal-mesh protective outfit comprising:

a tunic for easy donning and doffing without the need for the removal of headgear, the metal-mesh tunic comprising:

a metal-mesh fabric comprising a plurality of interconnecting metal rings, the metal-mesh fabric having an apron portion extending from a neck region to a knee region, the metal-mesh fabric having two sleeves, each of the two sleeves connecting to the apron portion; and
a closure system having an open mode and a closed mode, wherein when in the closed mode, a neck region is securely closed to present a closed-figure aperture through which the user's neck and head project, when worn, and when in the open mode, the neck region is opened to present an open-figure aperture such that the apron portion can be freely draped onto the front of a user, when the user inserts each of a user's arms into each corresponding one of the tunic's two sleeves; and

a metal-mesh glove for easy donning and doffing, the metal-mesh glove comprising:

a metal-mesh fabric comprising a plurality of interconnecting metal rings, the metal-mesh fabric having an hand portion configured to receive a user's hand such that each of a user's fingers are received into a corresponding finger receptacle, the metal-mesh fabric having a wrist portion configured provide continuous circumferential protection to a user's wrist, when worn; and
a closure system having an open mode and a closed mode, wherein when in the closed mode, a metal-mesh wrist strap, having a fixed end attached to the wrist portion of the metal-mesh fabric, circumscribes the wrist and a magnet attached to a free end of the metal-mesh wrist strap is affixed to the metal-mesh wrist strap at the same circumferential location and directly beneath the magnet, wherein a grasp handle is coupled to the magnet for providing a graspable feature by a metal-mesh gloved hand of a user.

18. The protective outfit of claim **17,** wherein the metal-mesh of the wrist strap comprises Ferro-magnetic material.

19. The device of claim **17,** wherein the wrist strap has a length of at least four inches.

20. The device of claim **17,** wherein the metal-mesh of the wrist strap comprises Ferro-magnetic material.

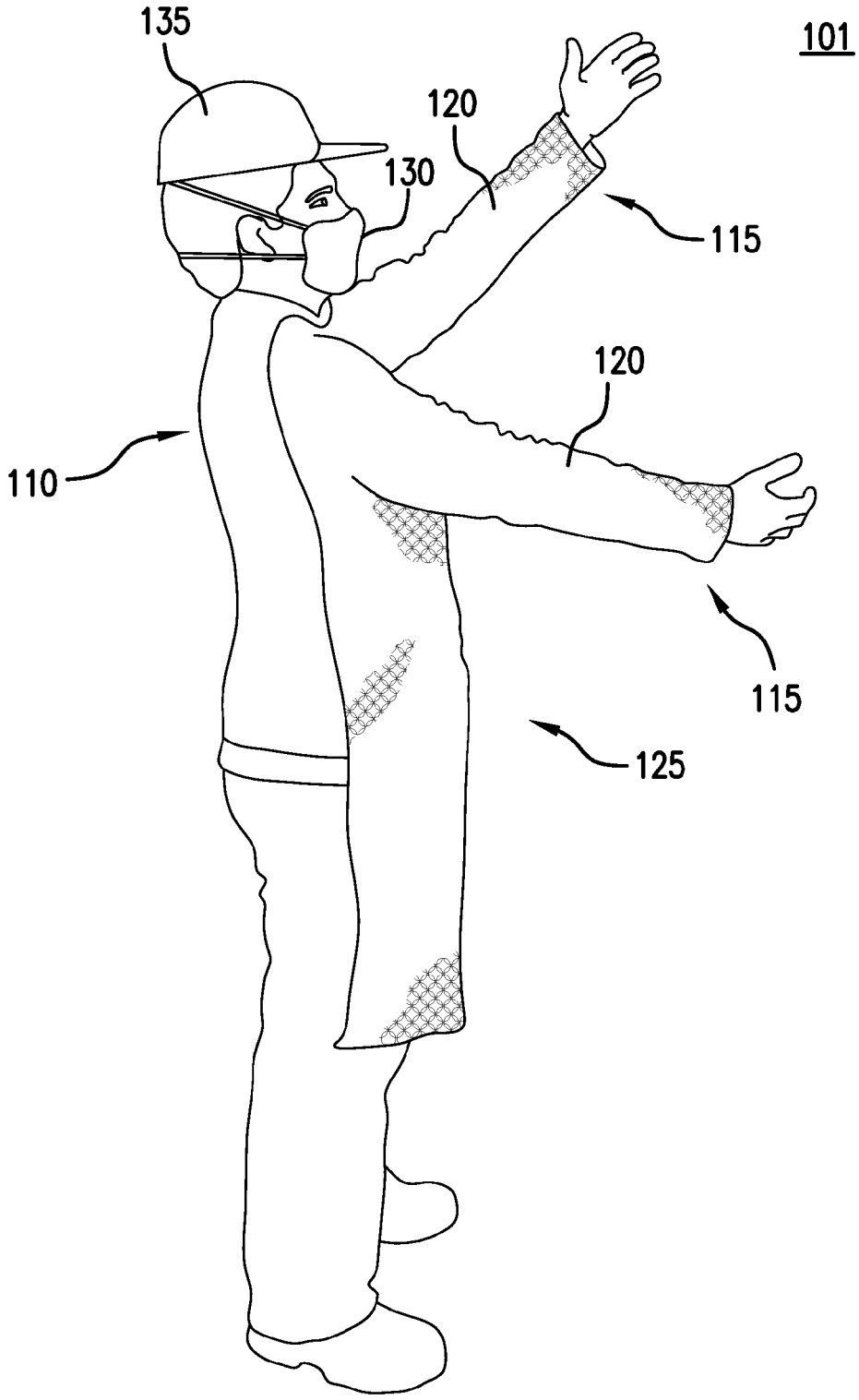


FIG. 1A

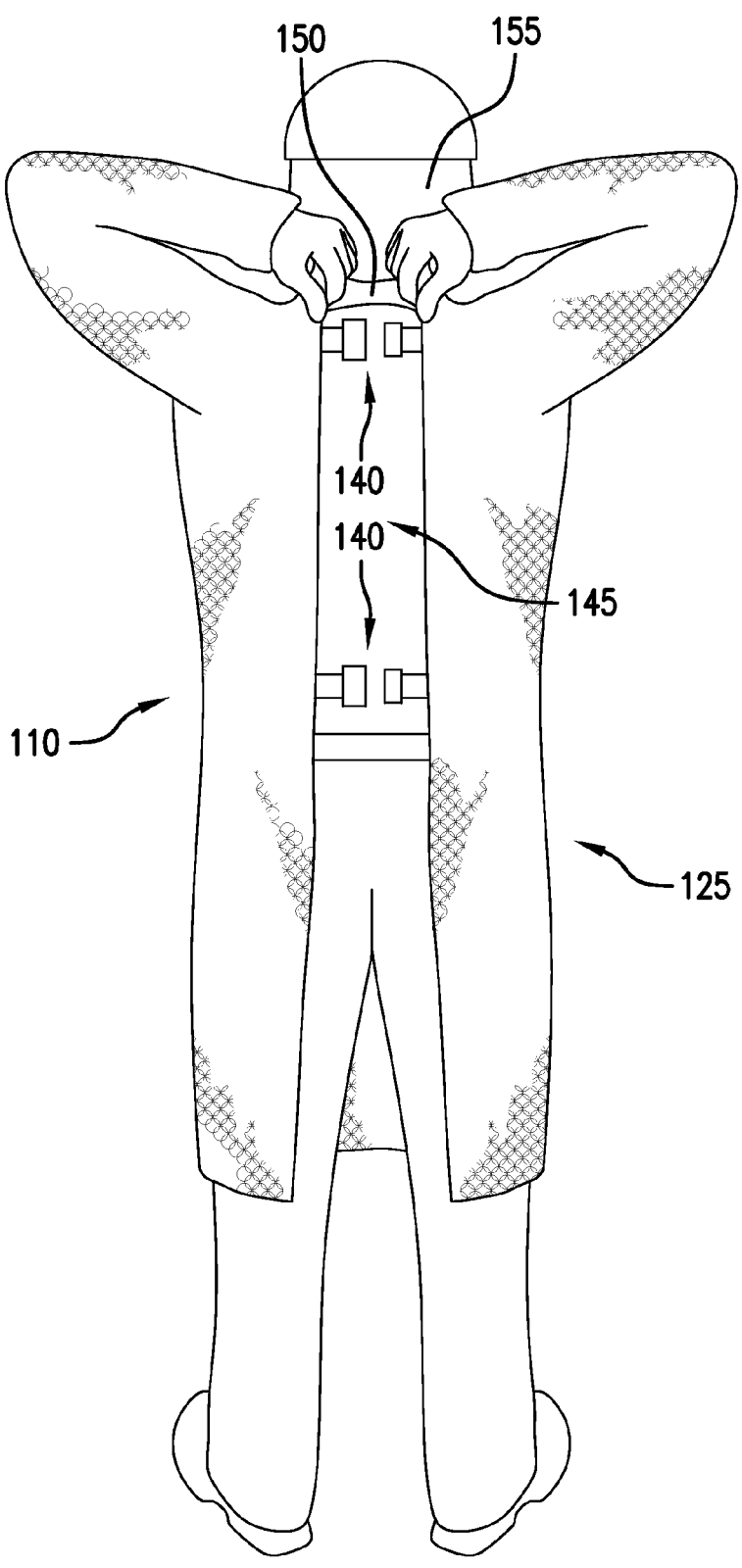


FIG. 1B

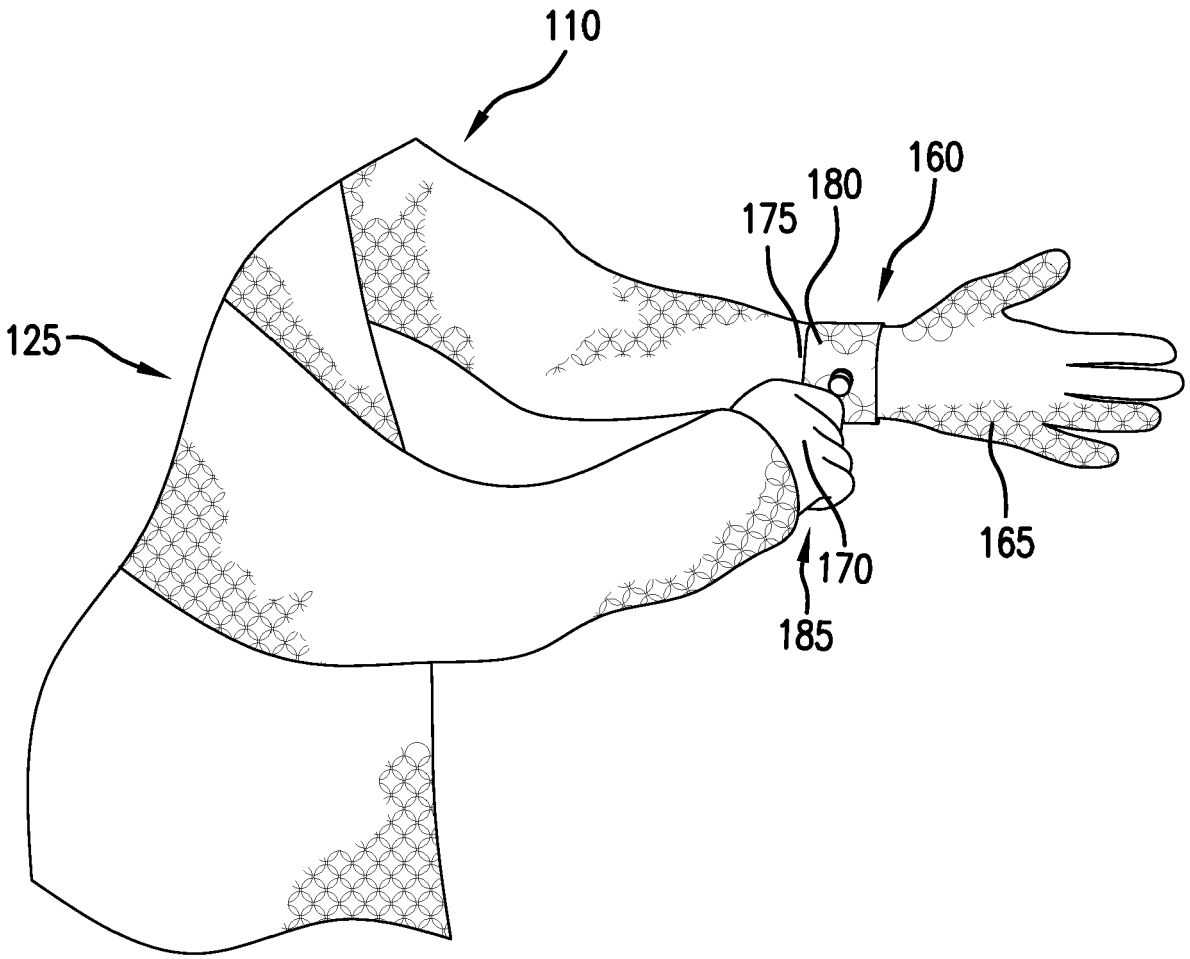


FIG. 1C

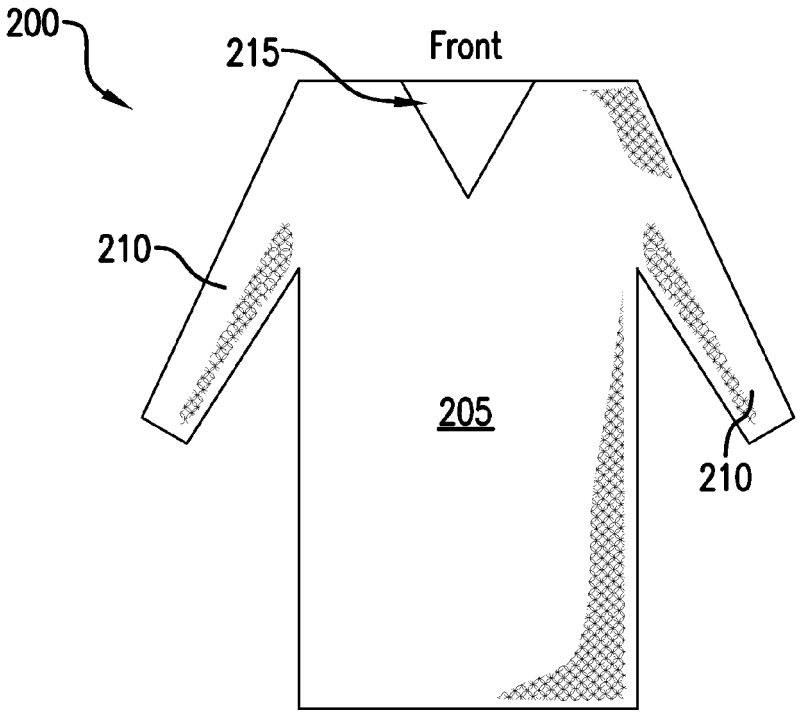


FIG.2A

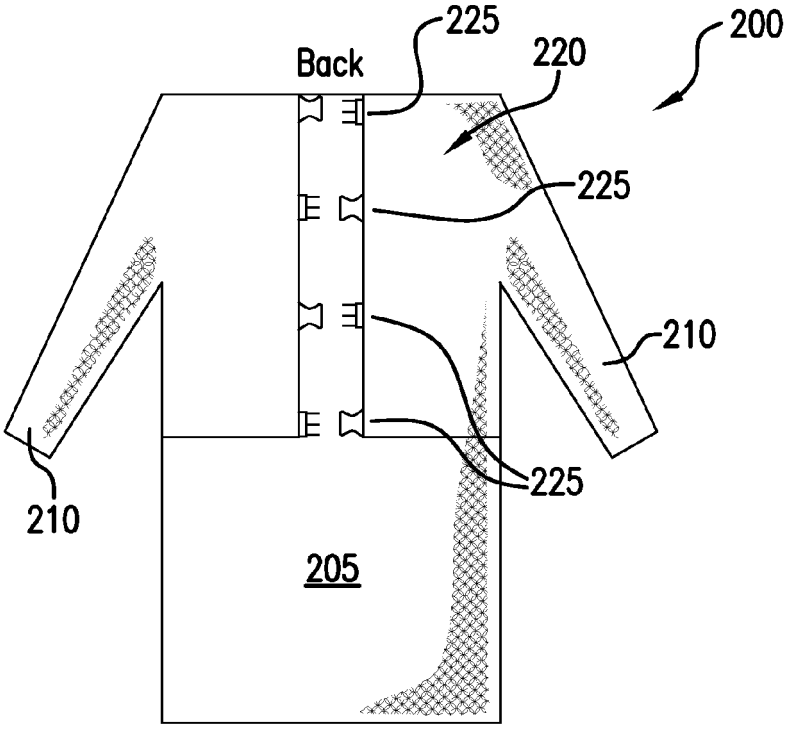


FIG.2B

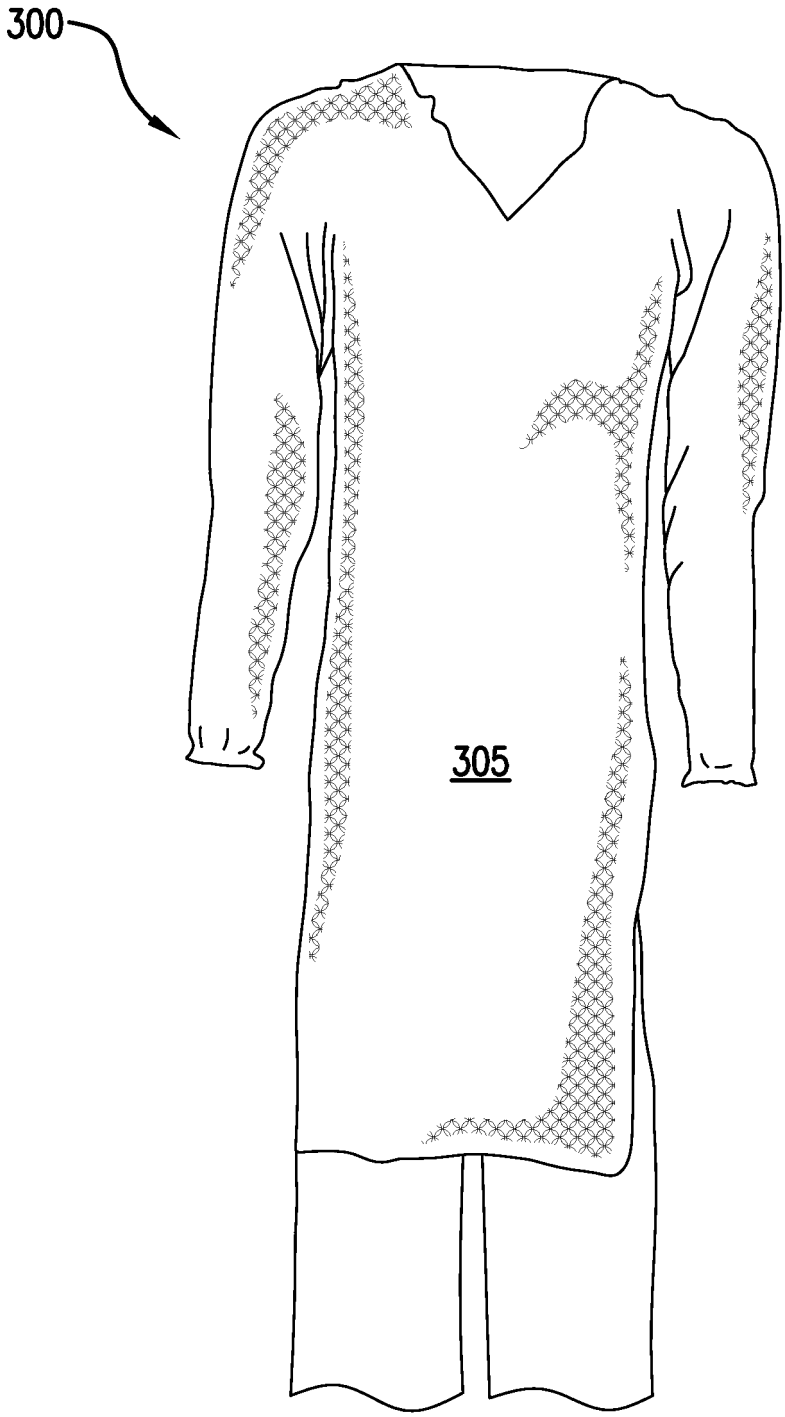


FIG.3

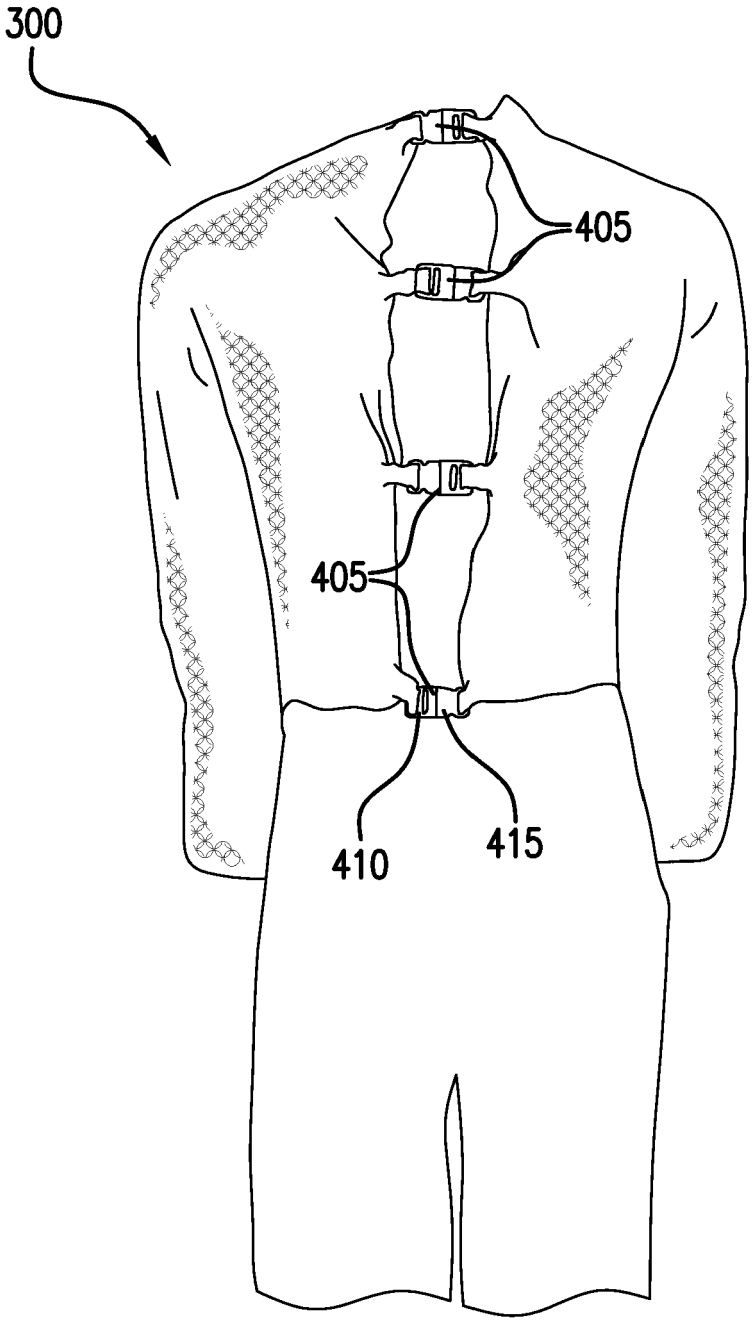


FIG.4

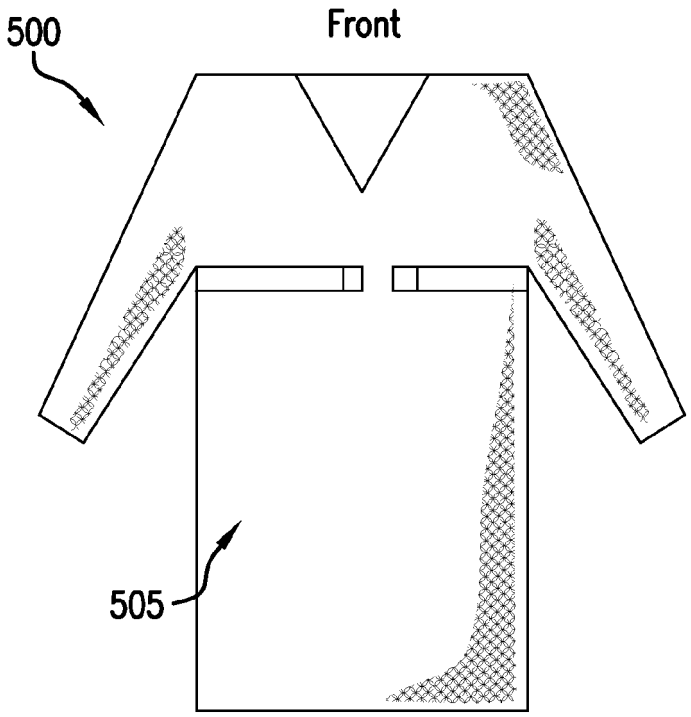


FIG.5A

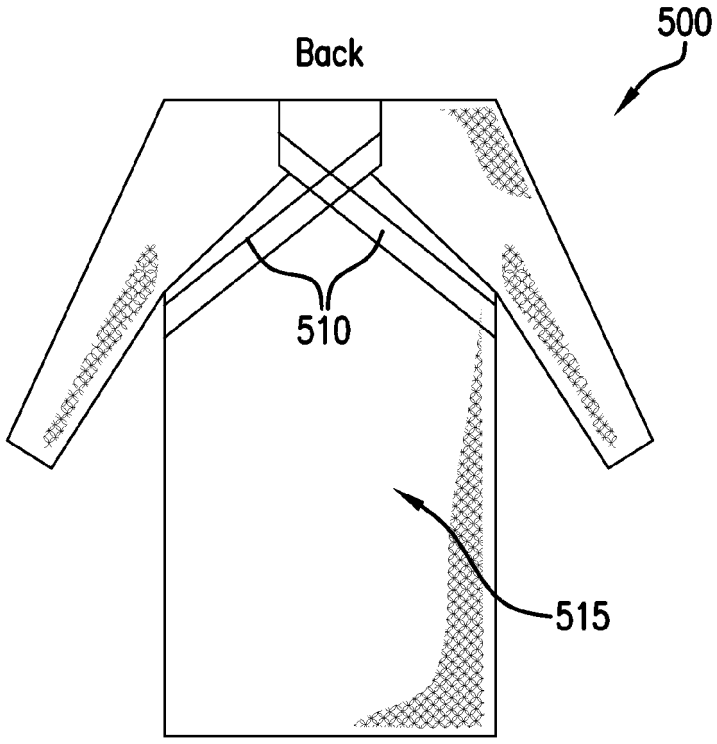


FIG.5B

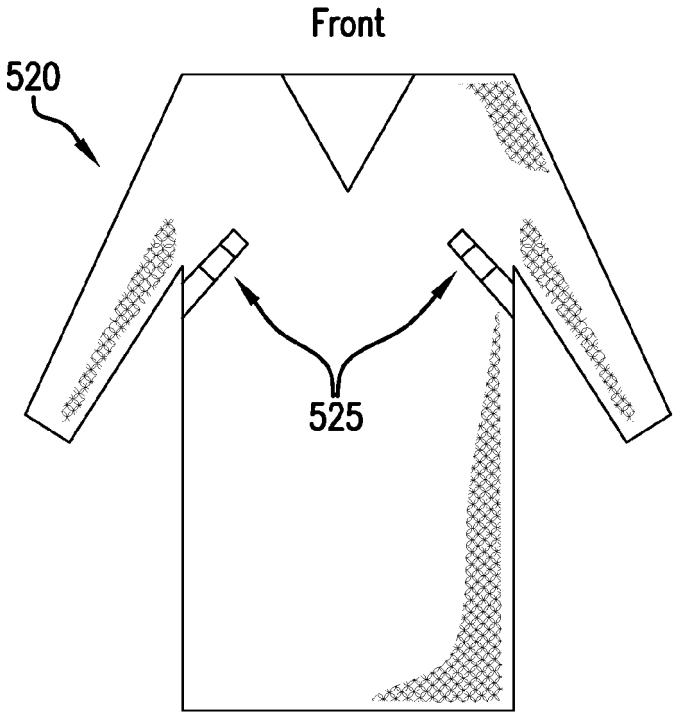


FIG.5C

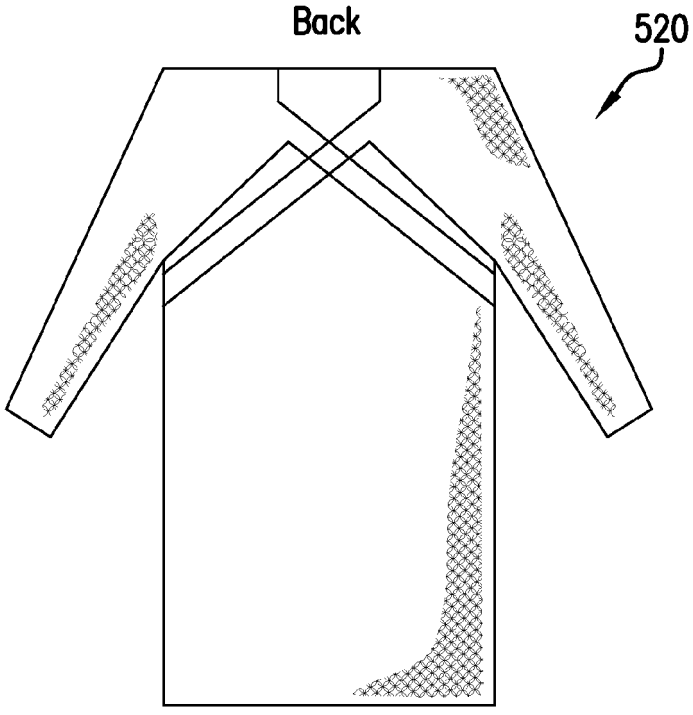


FIG.5D

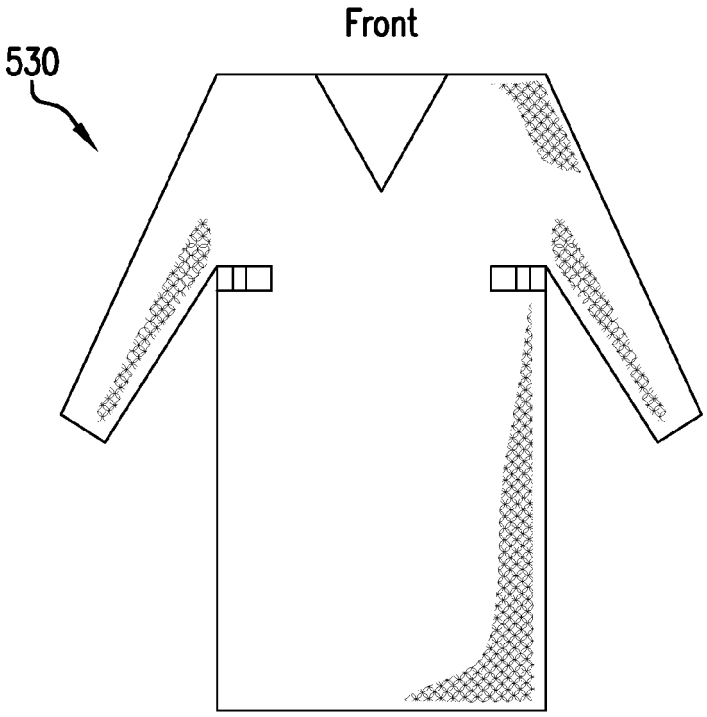


FIG.5E

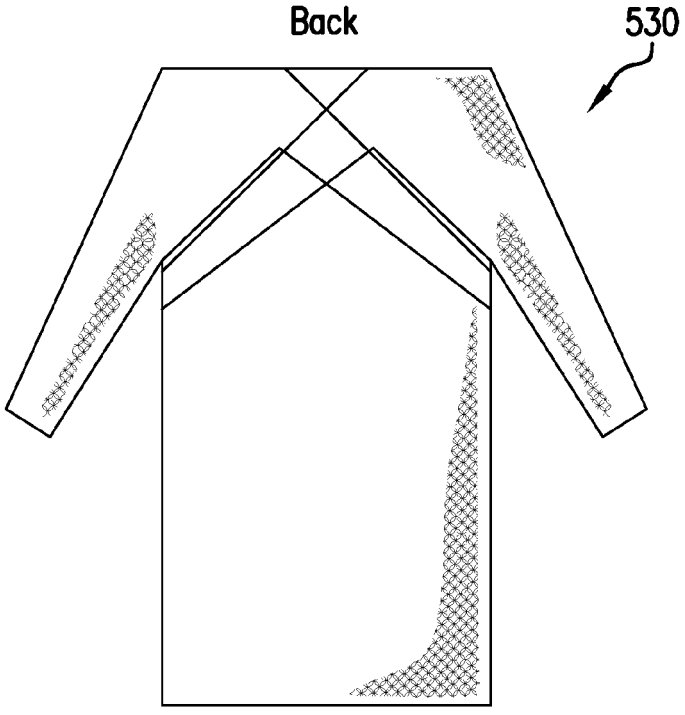


FIG.5F

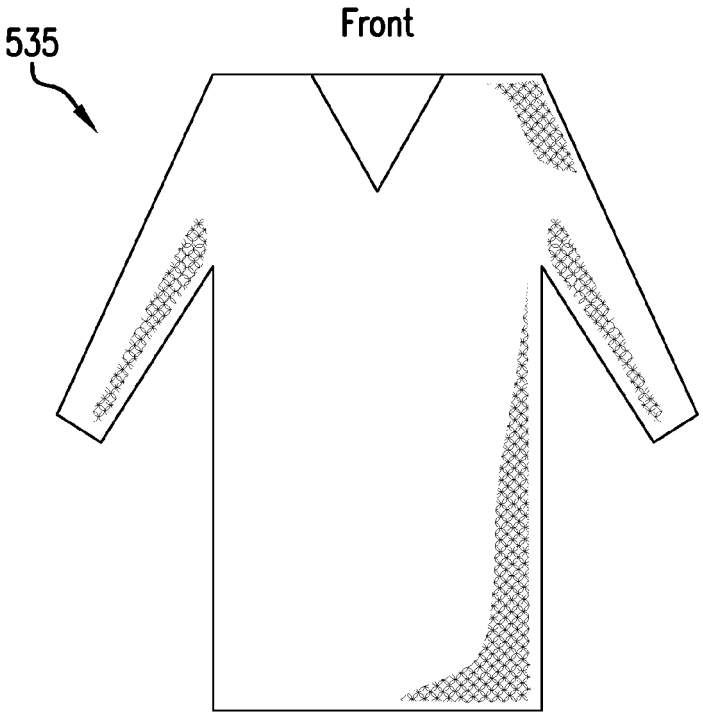


FIG.5G

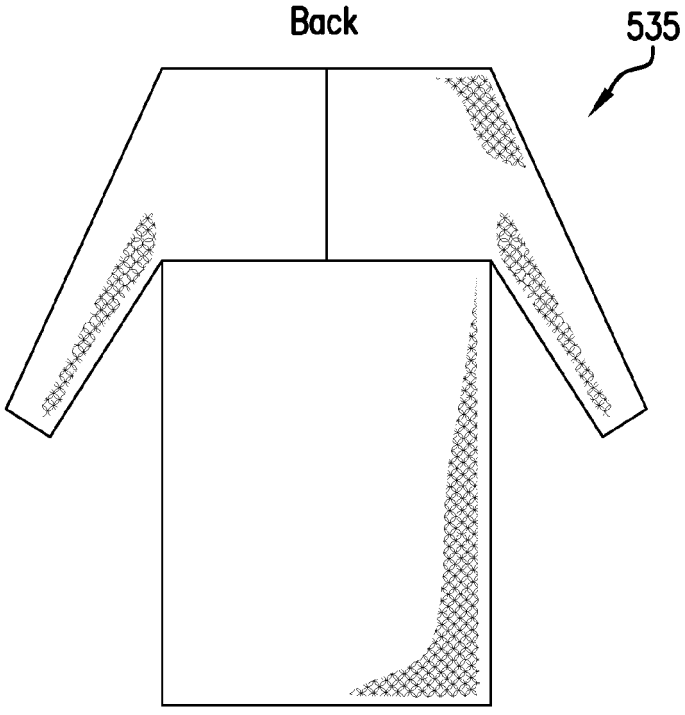


FIG.5H

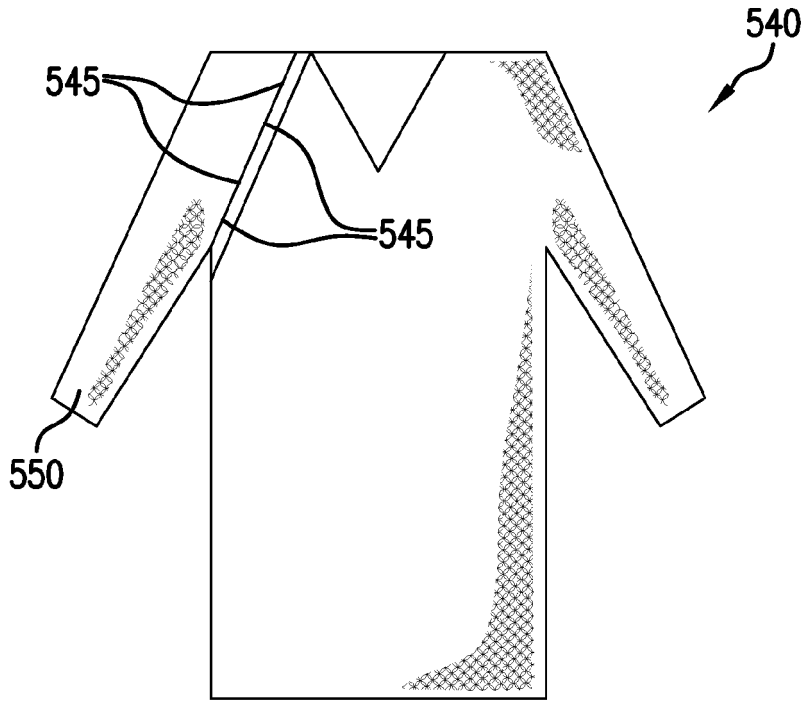


FIG.5I

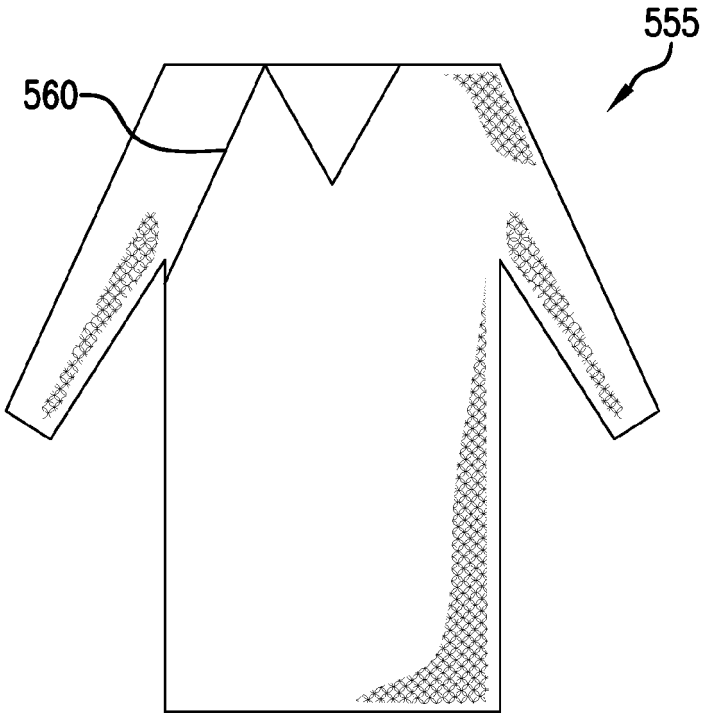


FIG.5J

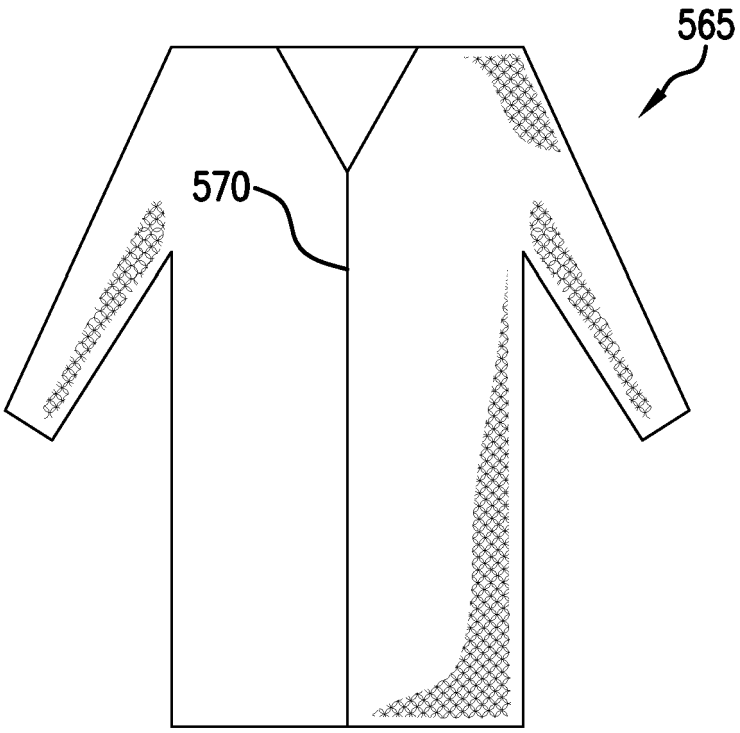


FIG.5K

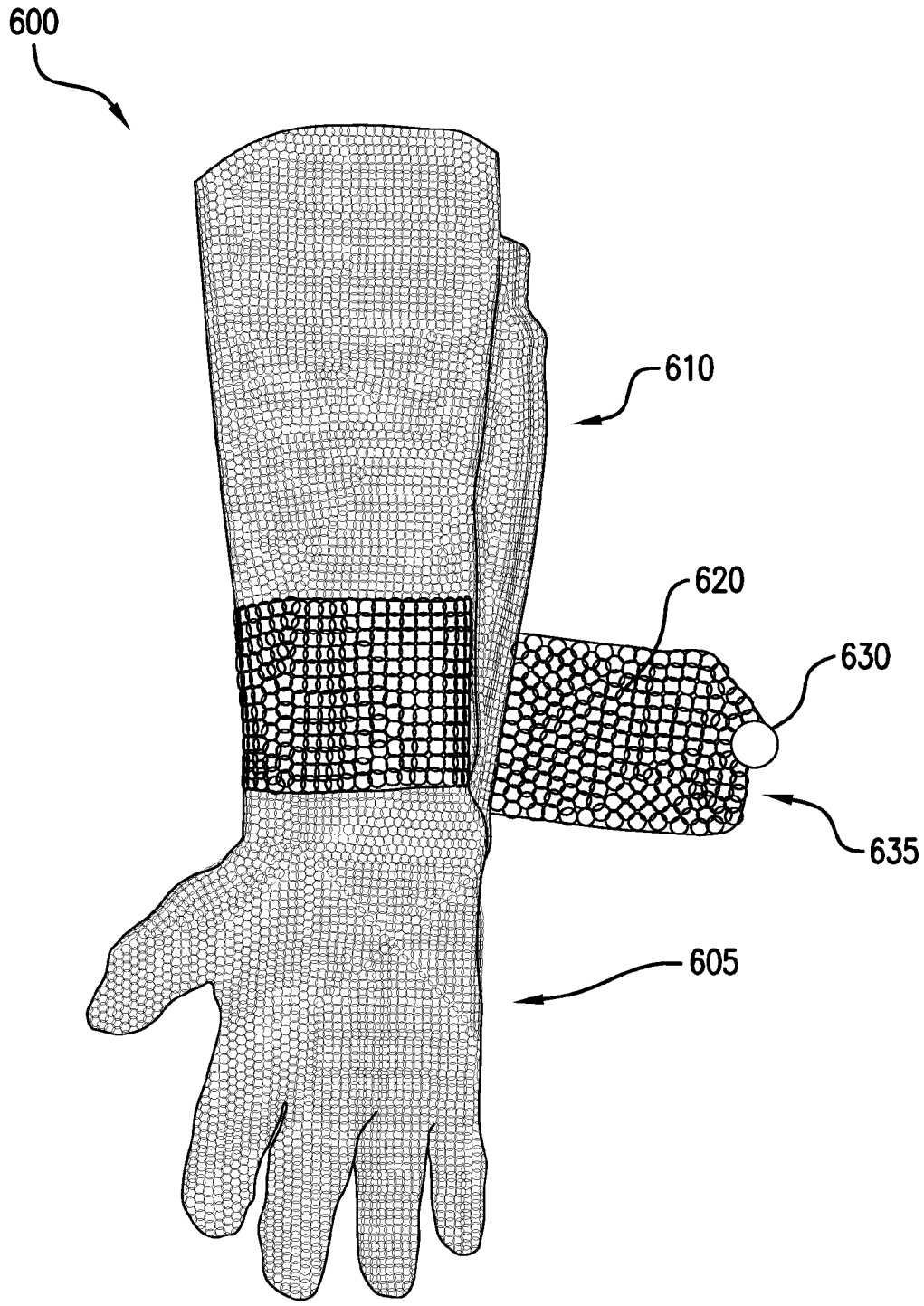


FIG.6

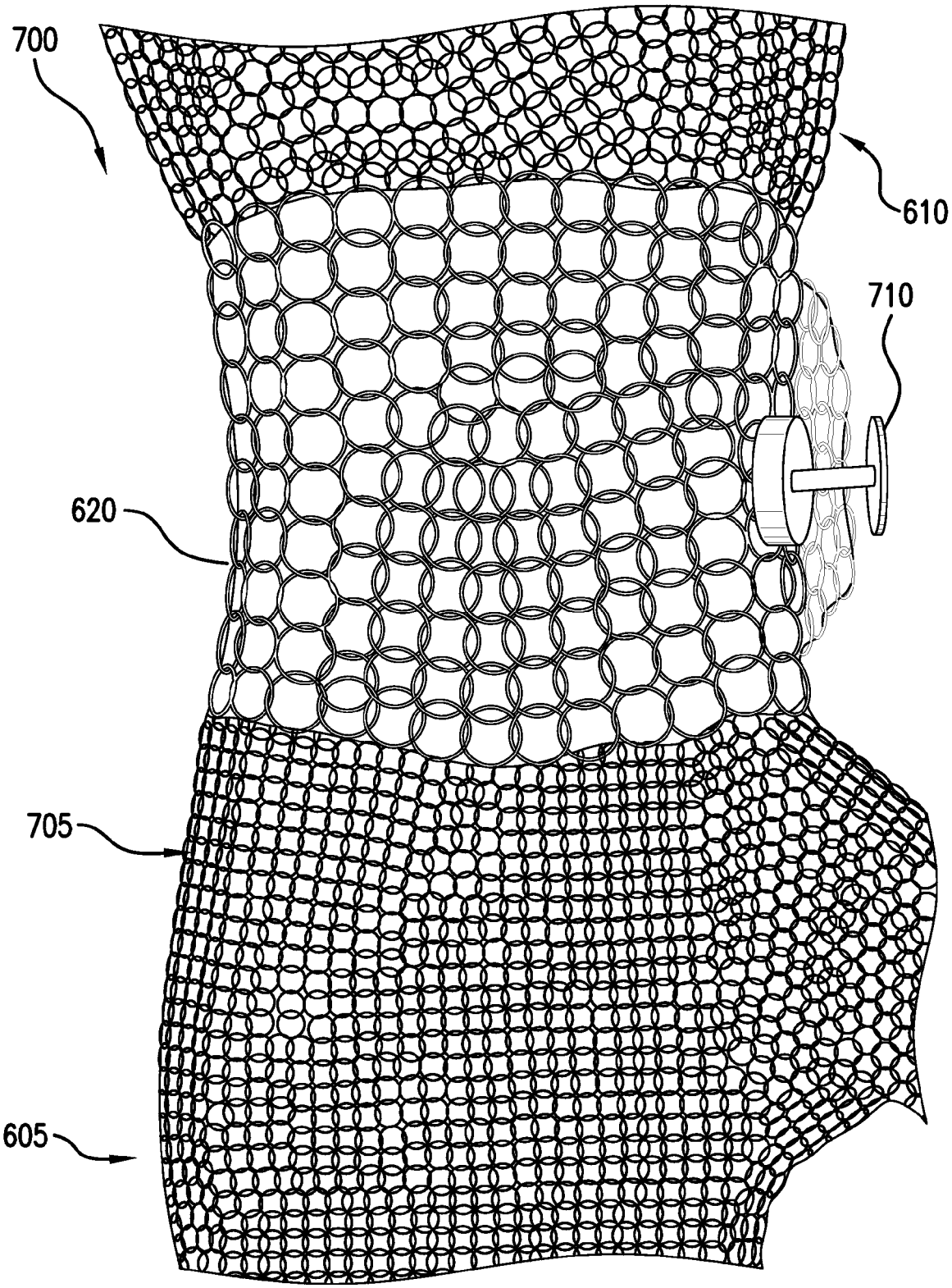


FIG.7

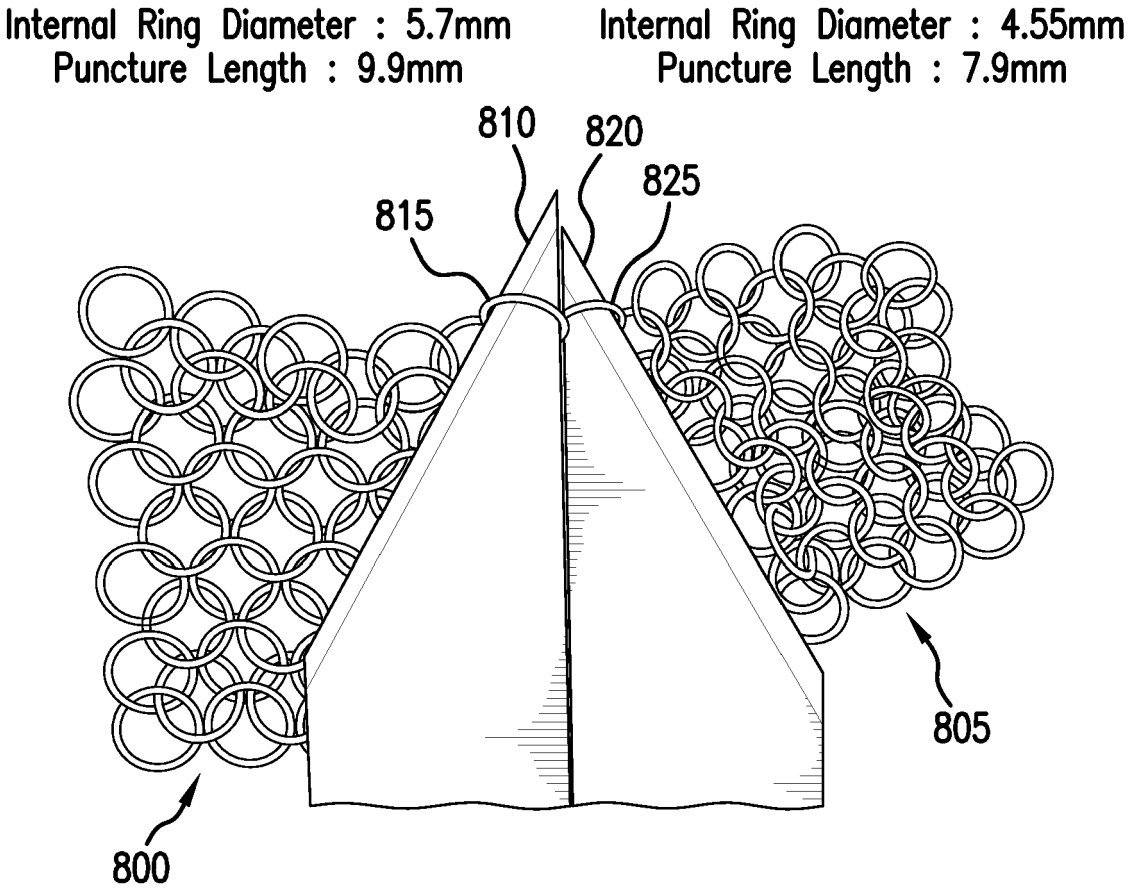
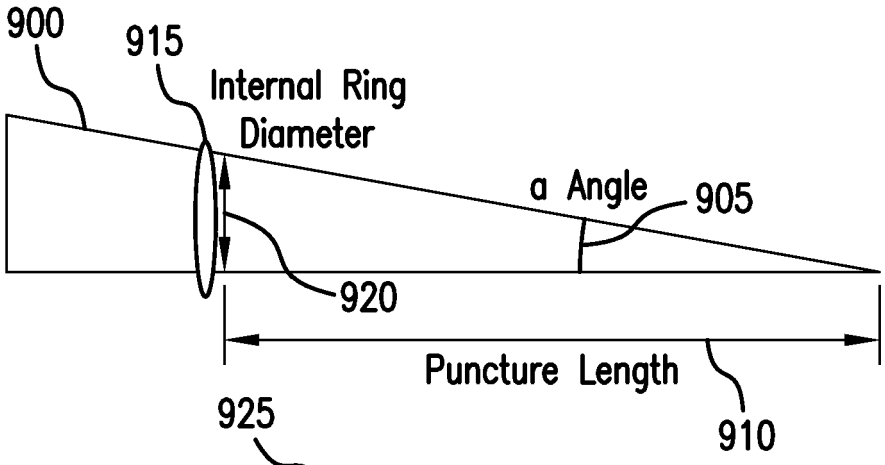

Internal Ring Diameter : 5.7mm
Puncture Length : 9.9mm
Internal Ring Diameter : 4.55mm
Puncture Length : 7.9mm
810
820
825
815
805
800

FIG.8



925

α°	Internal Ring Diameter (mm)	Puncture Length (mm)	
30	5,7	9,9	
30	4,75	8,2	−17%

FIG.9

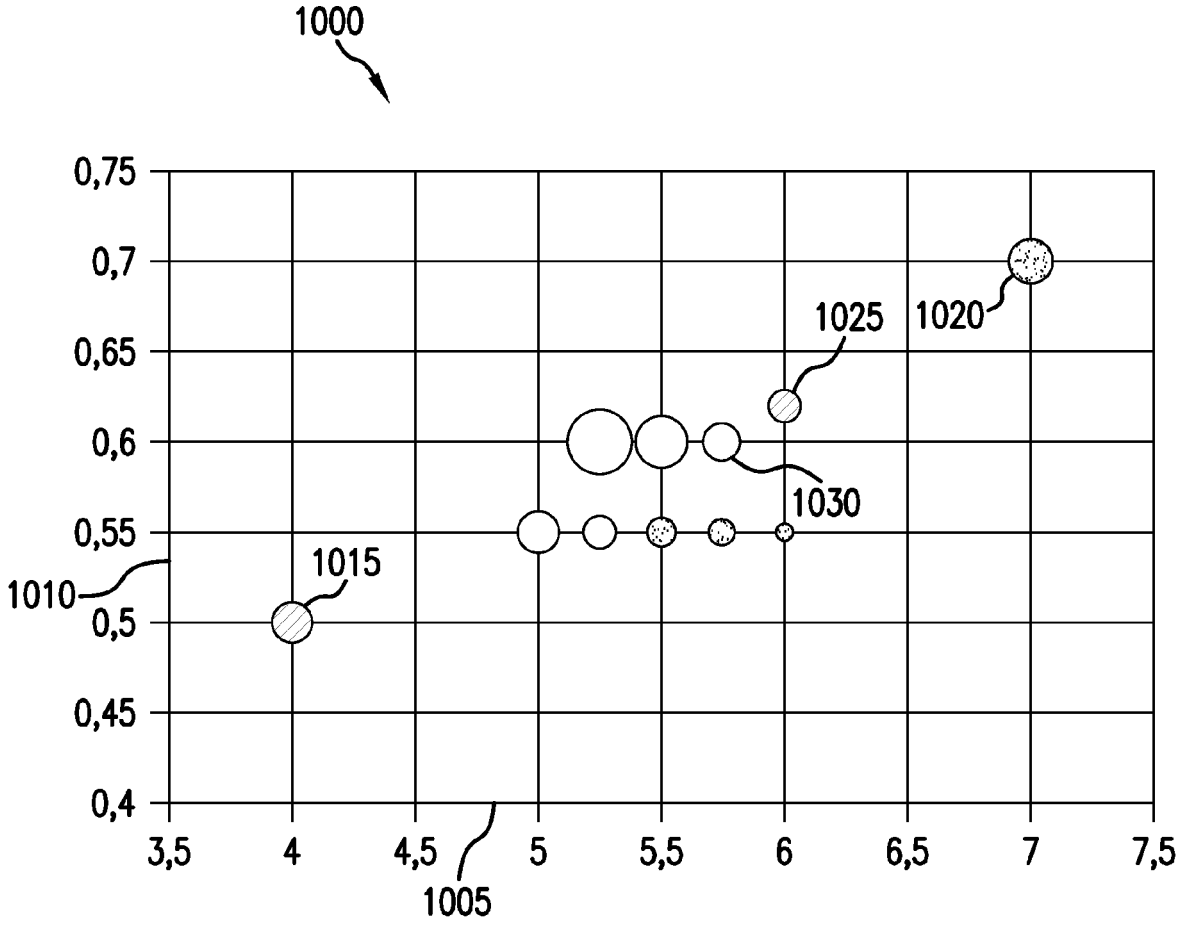

1000
0,75
0,7
0,65
0,6
0,55
0,5
0,45
0,4
3,5
4
4,5
5
5,5
6
6,5
7
7,5
1005
1010
1015
1020
1025
1030

FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 0390

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	CH 204 829 A (E. BRECHBÜHL) 31 May 1939 (1939-05-31) * page 1, column 1, line 19 - column 2, line 20 *	1,4,8,17	INV. A41D13/04 A41D19/015 A41F1/00
A	DE 93 12 870 U1 (P. HEILEMANN) 9 December 1993 (1993-12-09) * page 6 *	1,8,17	
A	FR 2 933 575 A1 (SPERIAN PROTECTION GLOVES PLANCHER BAS) 15 January 2010 (2010-01-15) * page 3, line 10 - line 18 *	1,8,17	
A	DE 299 10 449 U1 (ZIEGLER MECHANISCHE WERKSTATT, METALLGEWEBE UND ARBEITSSCHUTZ GMBH) 5 August 1999 (1999-08-05) * page 3, line 11 - line 23 *	9,17	
A	DE 44 16 389 A1 (FRIEDRICH MÜNCH GMBH & CO KG) 16 November 1995 (1995-11-16) * column 4, line 17 - column 5, line 1 *	9,17	TECHNICAL FIELDS SEARCHED (IPC) A41D A41F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 June 2014	Goodall, Colin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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D : document cited in the application
L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)

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Office européen des brevets

Application Number
EP 14 15 0390

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 14 15 0390

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-8, 17-20

   A metal-mesh tunic and a metal-mesh protective outfit comprising such a metal-mesh tunic

   ---

2. claims: 9-16

   A metal-mesh glove

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 15 0390

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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06-06-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CH 204829 A	31-05-1939	NONE	
DE 9312870 U1	09-12-1993	DE 9312870 U1	09-12-1993
		FR 2709234 A1	03-03-1995
		GB 2281191 A	01-03-1995
FR 2933575 A1	15-01-2010	NONE	
DE 29910449 U1	05-08-1999	NONE	
DE 4416389 A1	16-11-1995	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2011061886 W **[0026]**
- FR 2898250 **[0028]**