US011206878B2

(12) **United States Patent**
Markison

(10) **Patent No.: US 11,206,878 B2**
(45) **Date of Patent: Dec. 28, 2021**

(54) **BODY IMPACT PROTECTION SYSTEM**

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(72) Inventor: **Timothy W. Markison**, Mesa, AZ (US)

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Related U.S. Application Data

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(51) **Int. Cl.**
A41D 13/015 (2006.01)
A42B 3/12 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A41D 13/015*** (2013.01); ***A41D 1/04*** (2013.01); ***A41D 13/0156*** (2013.01); ***A41D 13/0518*** (2013.01); ***A41D 13/0543*** (2013.01); ***A41D 13/065*** (2013.01); ***A41D 13/08*** (2013.01); ***A41D 31/285*** (2019.02); ***A42B 3/063*** (2013.01); ***A42B 3/121*** (2013.01); ***A42B 3/124*** (2013.01); ***A42B 3/125*** (2013.01); ***A63B 71/10*** (2013.01); ***A63B 71/1225*** (2013.01); ***B32B 3/04*** (2013.01); ***B32B 3/08*** (2013.01); ***B32B 3/28*** (2013.01); ***B32B 3/30*** (2013.01); ***B32B 5/18*** (2013.01); ***B32B 5/26*** (2013.01); ***B32B 5/32*** (2013.01); ***B32B 7/02*** (2013.01); ***B32B 7/12*** (2013.01); ***B32B 15/046*** (2013.01); ***B32B 15/06*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A41D 13/015; A41D 13/0156; F41H 1/02; A42B 3/063; A42B 3/065; A42B 3/125; B32B 2437/04; B32B 2437/56
See application file for complete search history.

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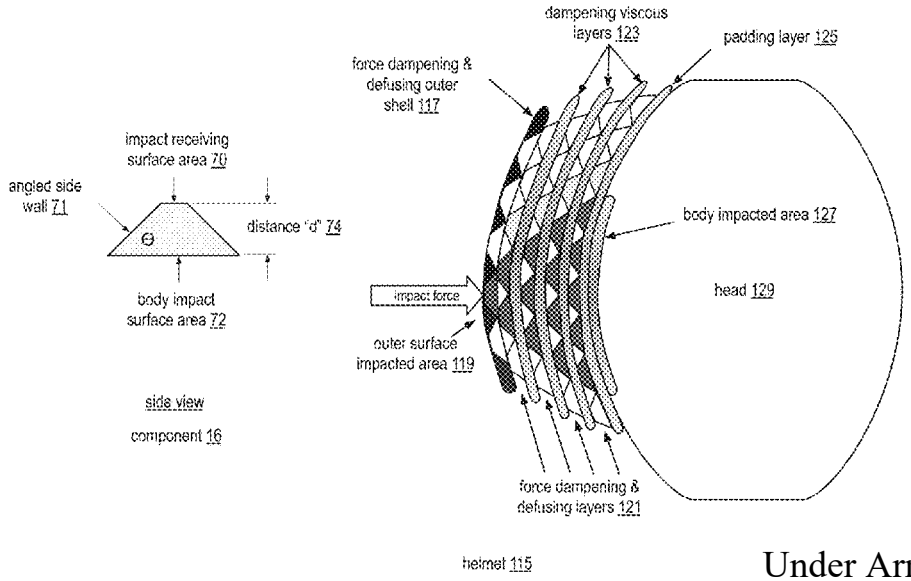
Primary Examiner — Katherine M Moran
(74) *Attorney, Agent, or Firm* — Garlick & Markison; Timothy W. Markison

(57) **ABSTRACT**

A body impact protection system includes an inner layer and an impact force dampening and defusing structure. The inner layer includes a material composition and is adjacent to a body part when the body impact protection system is worn. The impact force dampening and defusing structure is juxtaposed to the inner layer and includes a plurality of components. The components function to reduce pressure on the body part from an impact force on a layer by layer basis. Each layer of the system dampens and defuses the impact force such that, by the time it reaches the body part, it has been substantially attenuated and spread over a large area.

17 Claims, 56 Drawing Sheets



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Under Armour v. Athalonz
IPR2024-00640

(51) **Int. Cl.**

B32B 15/06	(2006.01)
B32B 25/04	(2006.01)
B32B 27/32	(2006.01)
B32B 3/04	(2006.01)
B32B 5/32	(2006.01)
B32B 25/10	(2006.01)
B32B 21/04	(2006.01)
B32B 21/08	(2006.01)
B32B 27/40	(2006.01)
B32B 5/18	(2006.01)
B32B 3/08	(2006.01)
B32B 15/14	(2006.01)
B32B 15/20	(2006.01)
B32B 21/02	(2006.01)
B32B 27/12	(2006.01)
B32B 15/18	(2006.01)
B32B 27/28	(2006.01)
B32B 7/12	(2006.01)
B32B 15/10	(2006.01)
B32B 15/04	(2006.01)
B32B 27/06	(2006.01)
B32B 27/08	(2006.01)
B32B 27/36	(2006.01)
B32B 15/095	(2006.01)
B32B 3/28	(2006.01)
B32B 15/082	(2006.01)
B32B 15/09	(2006.01)
B32B 15/085	(2006.01)
B32B 5/26	(2006.01)
B32B 25/08	(2006.01)
A41D 31/28	(2019.01)
B32B 7/02	(2019.01)
B32B 21/10	(2006.01)
A41D 1/04	(2006.01)
A41D 13/05	(2006.01)
A41D 13/06	(2006.01)
A41D 13/08	(2006.01)
A63B 71/10	(2006.01)
A63B 71/12	(2006.01)
F41H 1/02	(2006.01)
A42B 3/06	(2006.01)
B32B 3/30	(2006.01)
A63B 102/18	(2015.01)
A63B 71/00	(2006.01)

(52) **U.S. Cl.**

CPC ***B32B 15/082*** (2013.01); ***B32B 15/085*** (2013.01); ***B32B 15/09*** (2013.01); ***B32B 15/095*** (2013.01); ***B32B 15/10*** (2013.01); ***B32B 15/14*** (2013.01); ***B32B 15/18*** (2013.01); ***B32B 15/20*** (2013.01); ***B32B 21/02*** (2013.01); ***B32B 21/045*** (2013.01); ***B32B 21/047*** (2013.01); ***B32B 21/08*** (2013.01); ***B32B 21/10*** (2013.01); ***B32B 25/042*** (2013.01); ***B32B 25/045*** (2013.01); ***B32B 25/08*** (2013.01); ***B32B 25/10*** (2013.01); ***B32B 27/065*** (2013.01); ***B32B 27/08*** (2013.01); ***B32B 27/12*** (2013.01); ***B32B 27/283*** (2013.01); ***B32B 27/32*** (2013.01); ***B32B 27/36*** (2013.01); ***B32B 27/40*** (2013.01); ***F41H 1/02*** (2013.01); *A63B 2071/0072* (2013.01); *A63B 2071/125* (2013.01); *A63B 2071/1208* (2013.01); *A63B 2071/1241* (2013.01); *A63B 2071/1258* (2013.01); *A63B 2071/1266* (2013.01); *A63B 2071/1275* (2013.01); *A63B 2102/18* (2015.10); *B32B 2250/03* (2013.01); *B32B 2250/04* (2013.01); *B32B 2250/05* (2013.01); *B32B 2260/021* (2013.01); *B32B 2260/046* (2013.01); *B32B 2260/048* (2013.01); *B32B 2262/101* (2013.01); *B32B 2266/12* (2016.11); *B32B 2307/546* (2013.01); *B32B 2307/558* (2013.01); *B32B 2307/56* (2013.01); *B32B 2307/732* (2013.01); *B32B 2437/04* (2013.01); *B32B 2571/00* (2013.01)

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2018/0304598	A1 *	10/2018	Drzal	B32B 27/20

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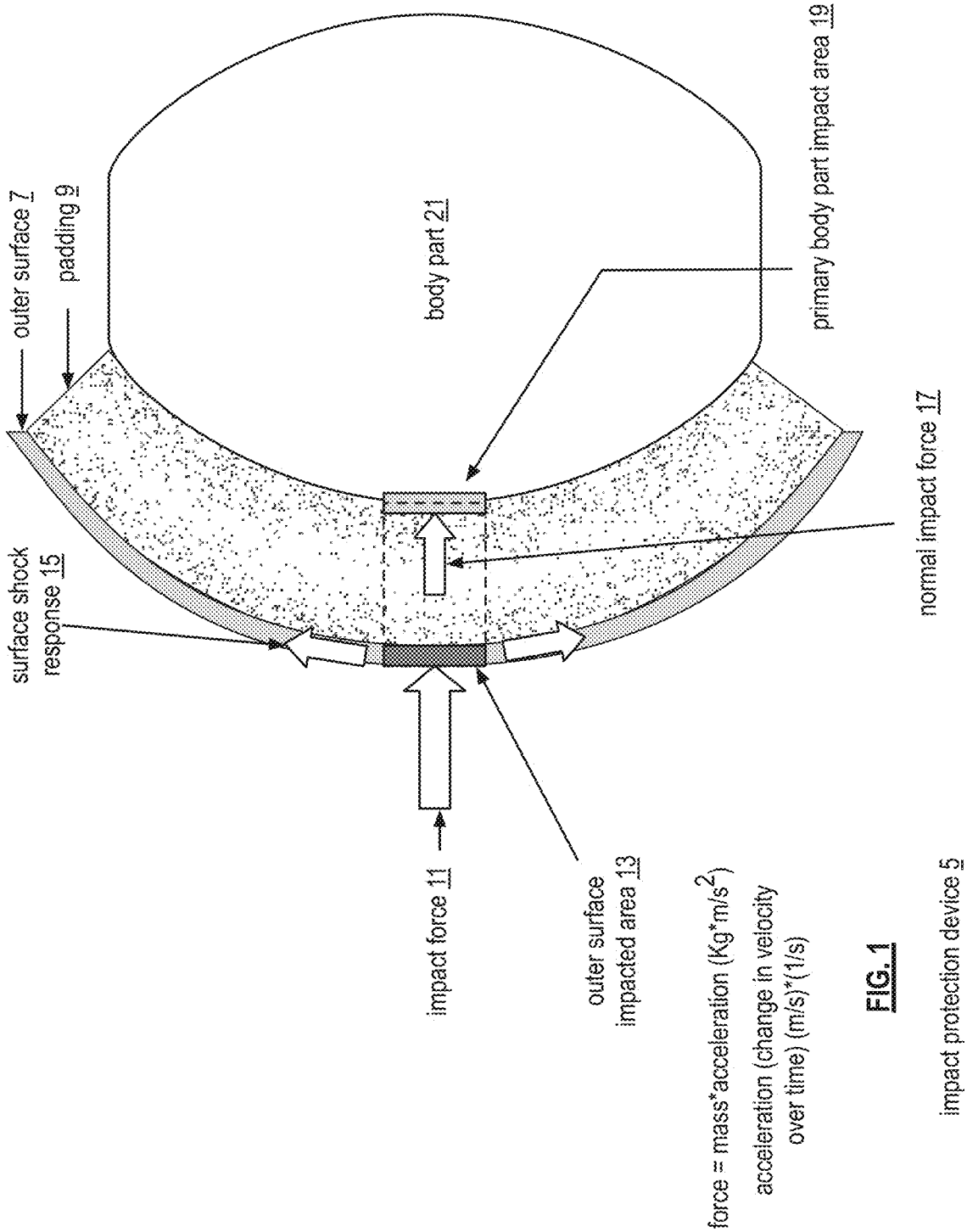


FIG. 1

impact protection device 5

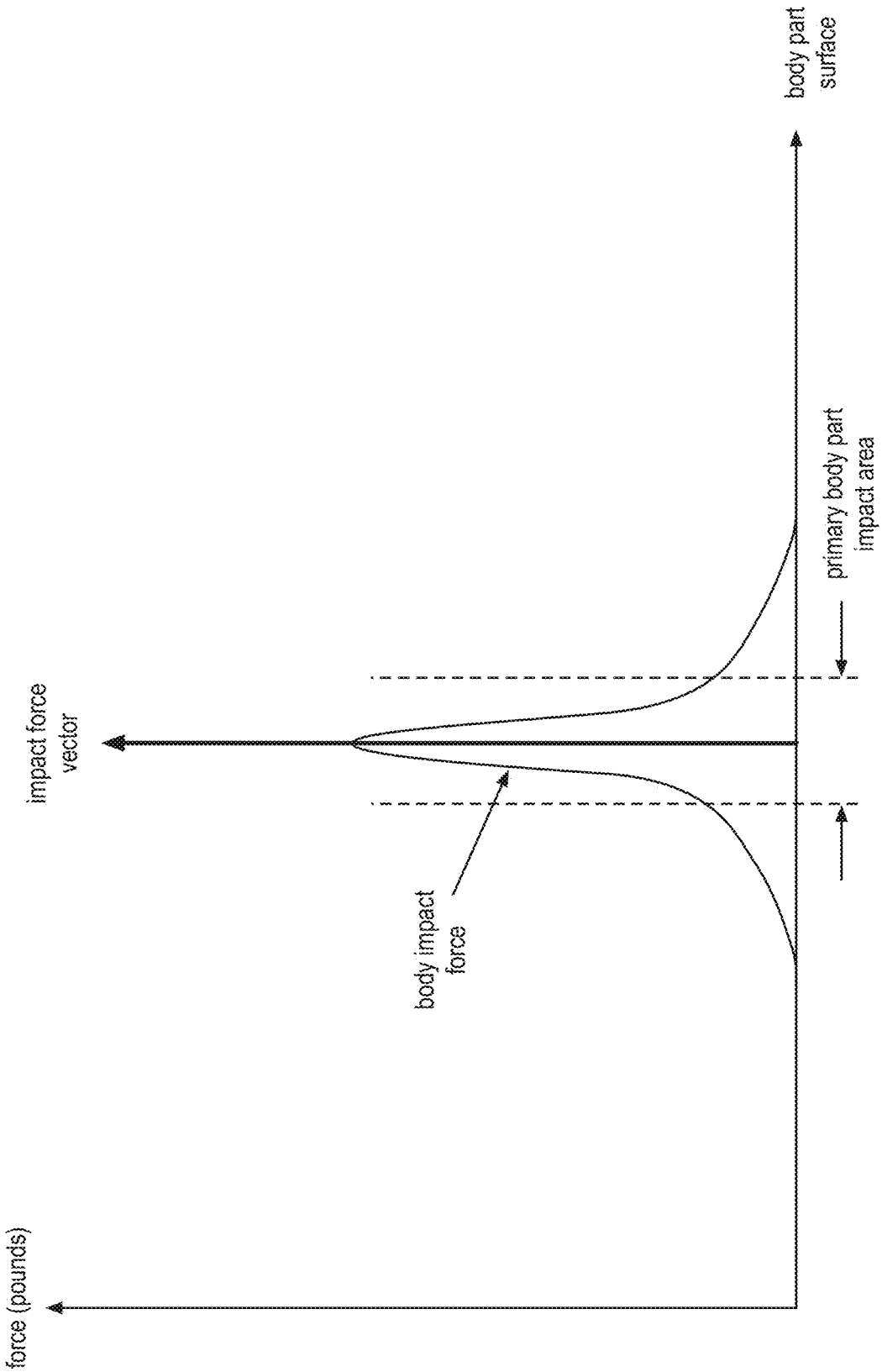

force (pounds)
impact force vector
body impact force
primary body part impact area
body part surface

FIG. 2

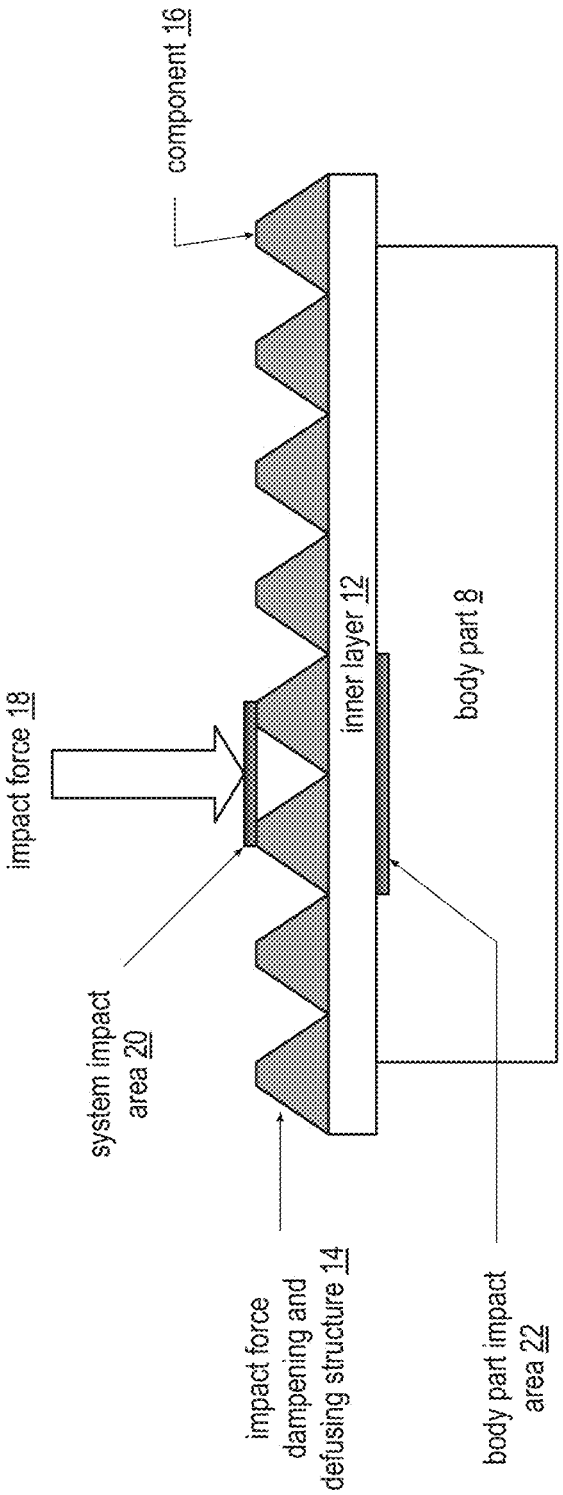


FIG. 3
body impact protection system 10

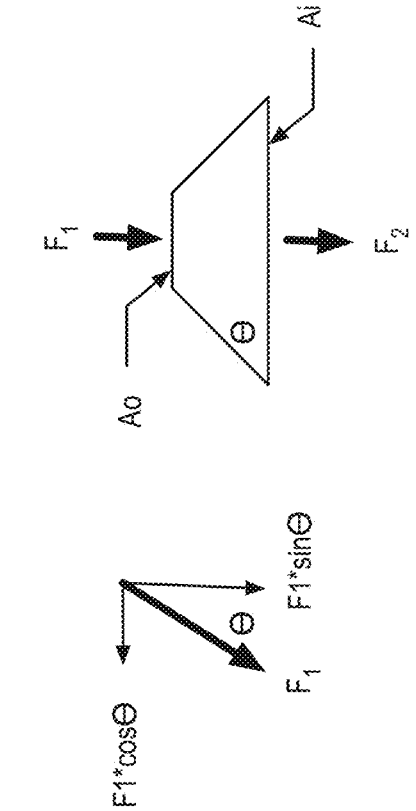


FIG. 5
side view

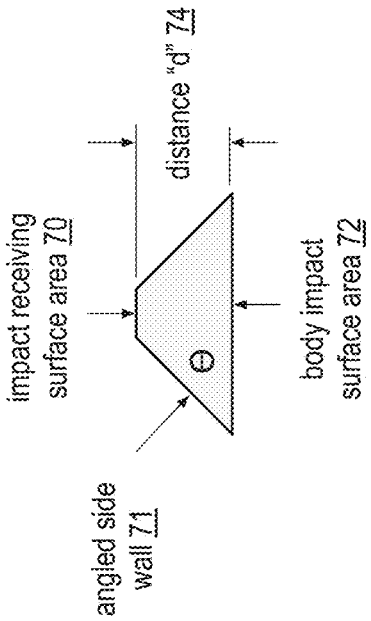


FIG. 4
side view
component 16

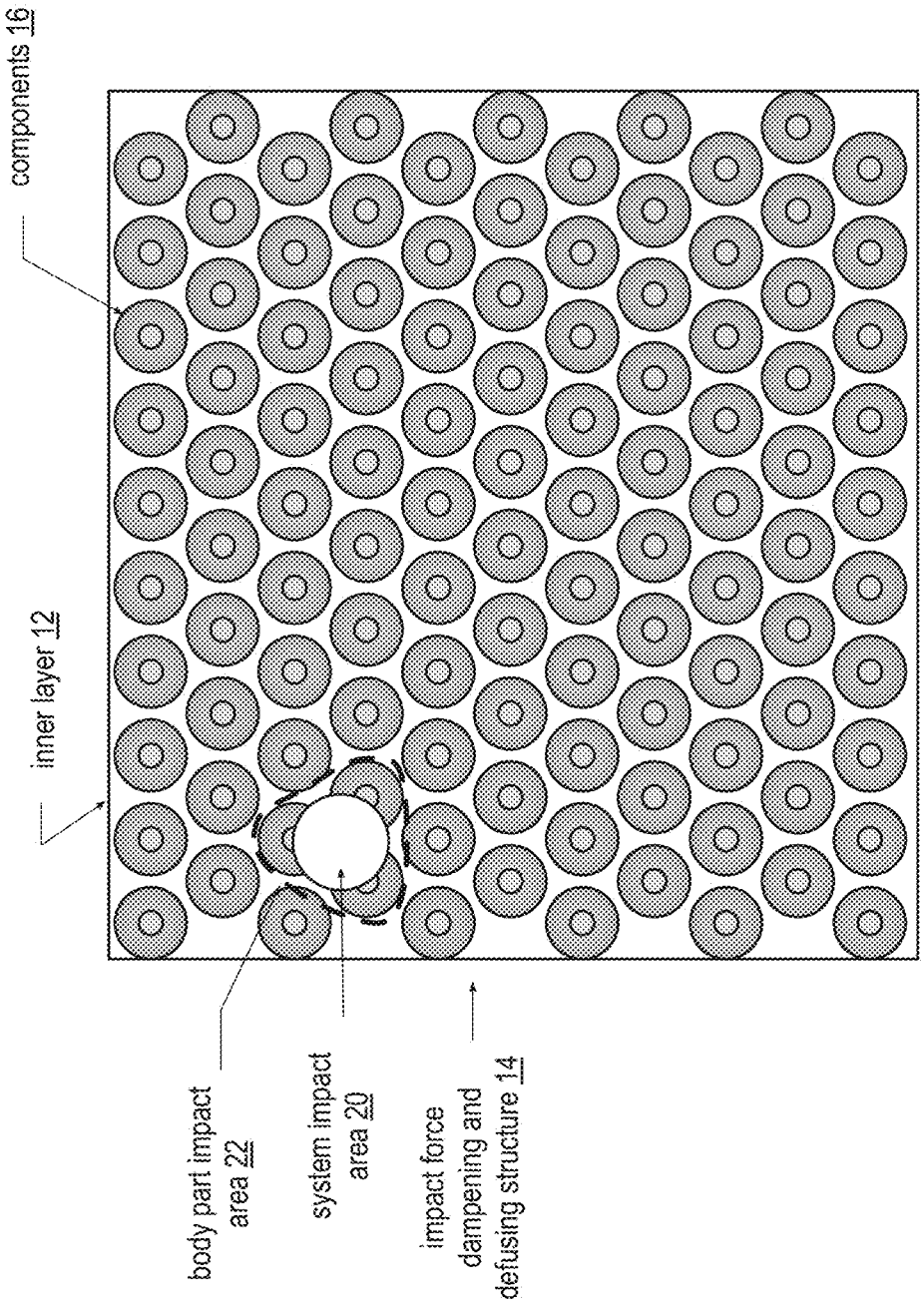

components 16
inner layer 12
body part impact area 22
system impact area 20
impact force dampening and defusing structure 14

FIG. 6

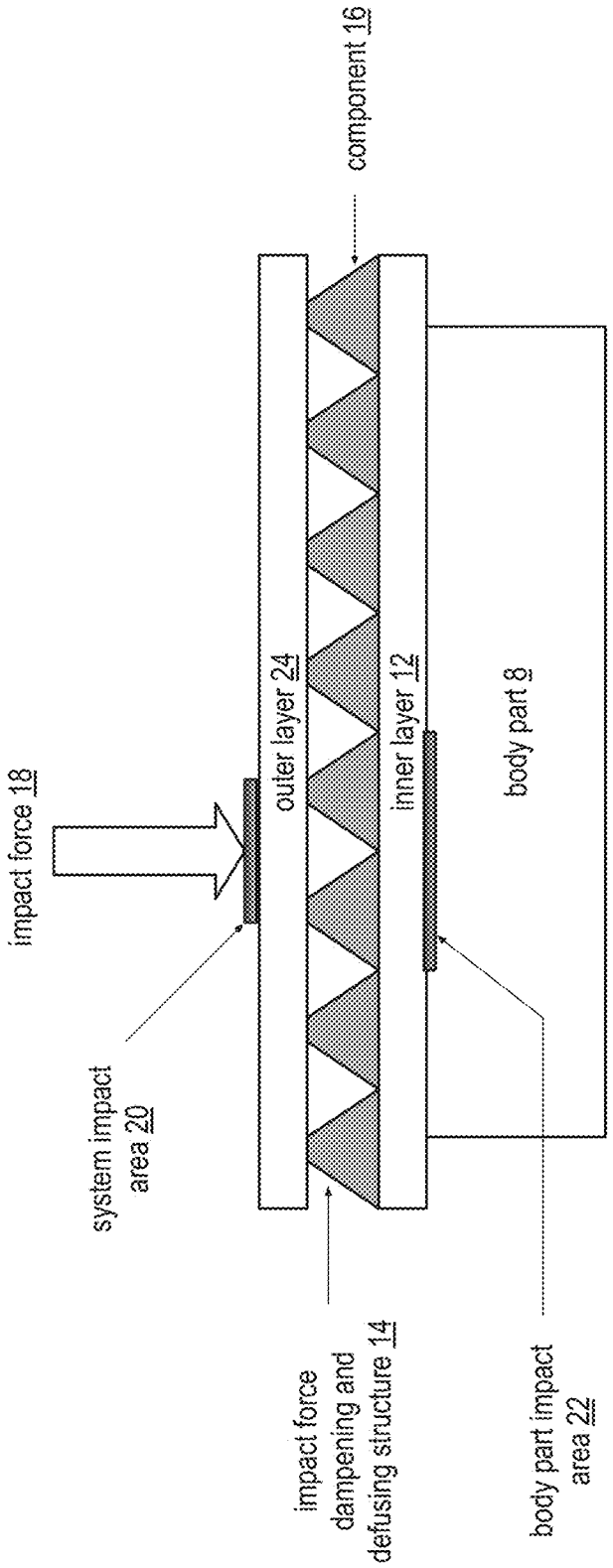


FIG. 7
body impact protection system 10

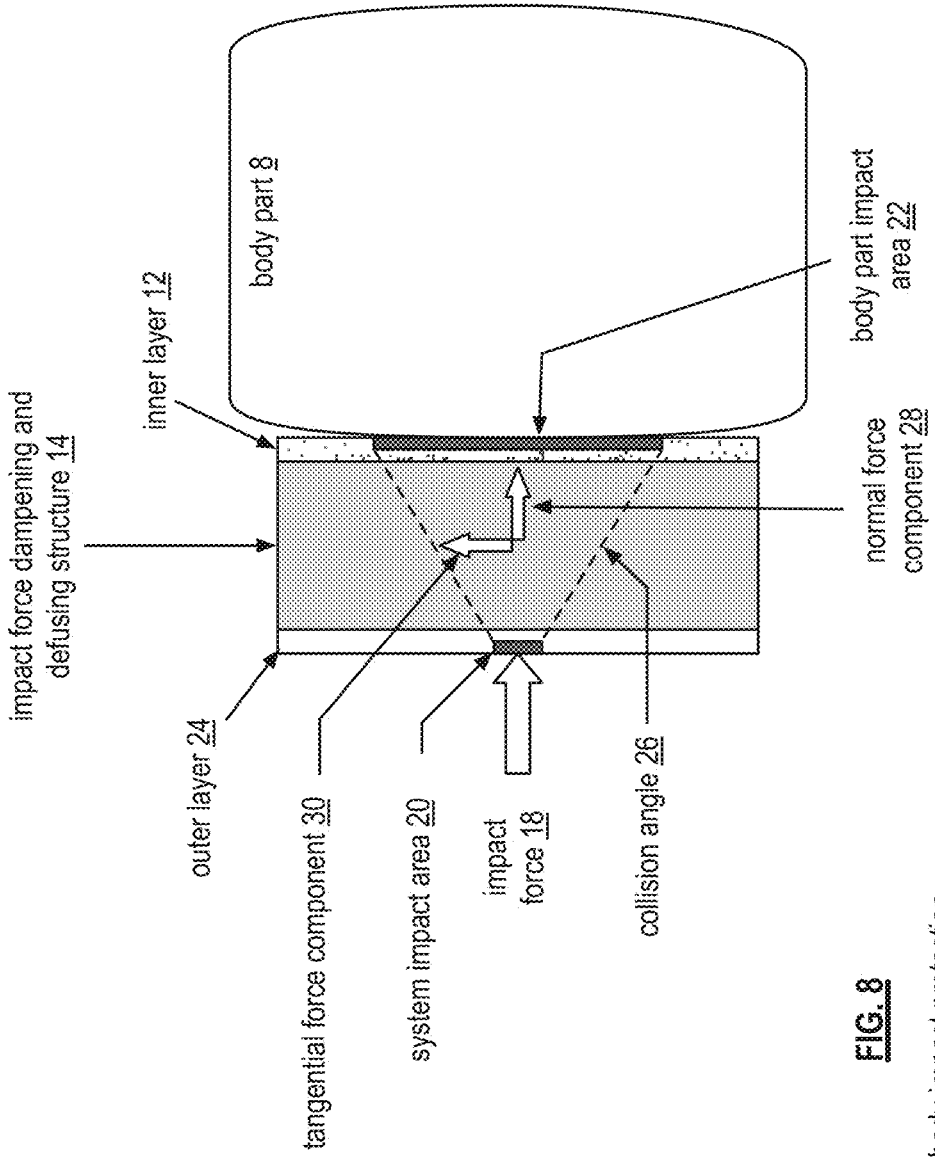


FIG. 8

body impact protection system 10

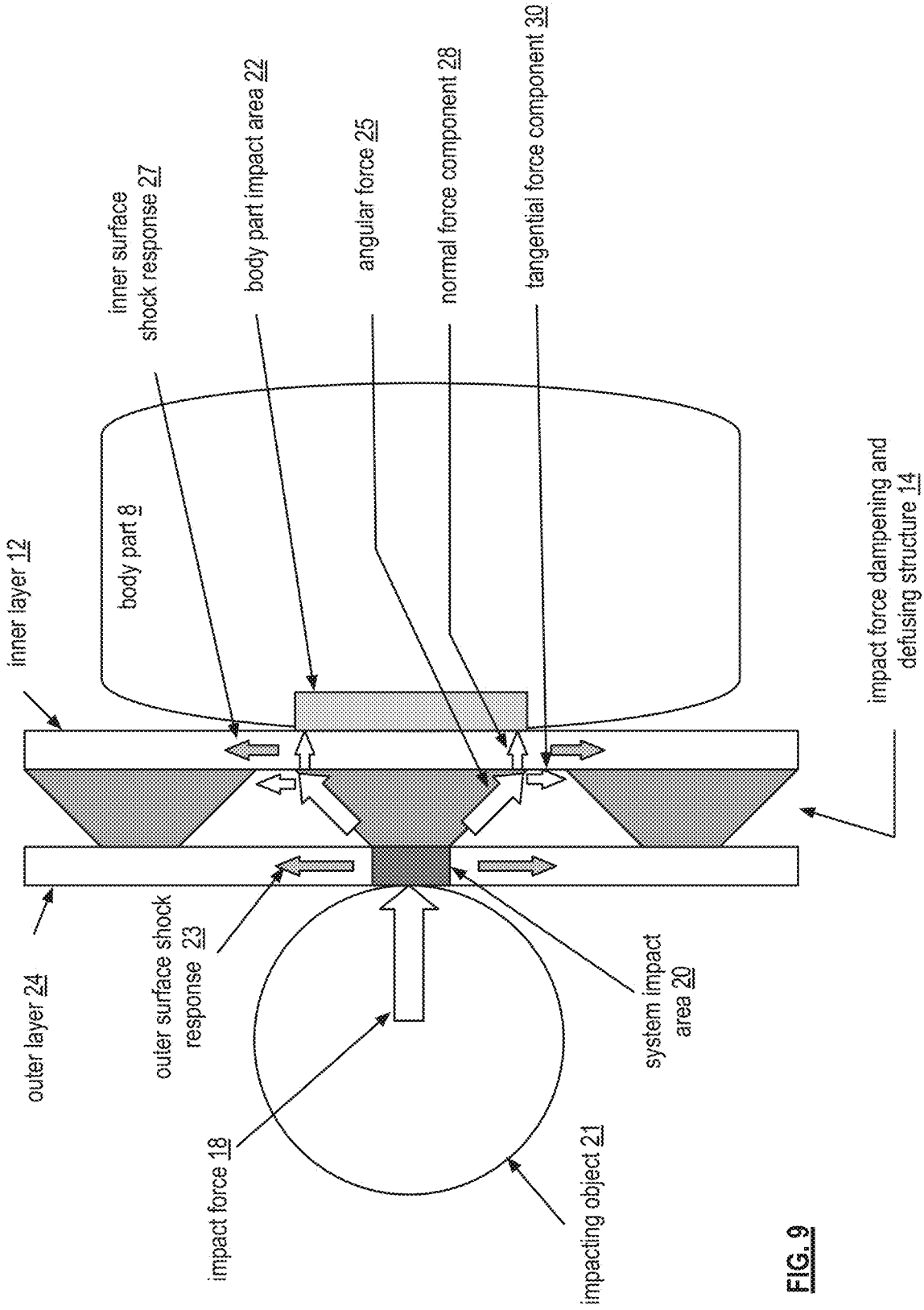

inner surface shock response 27
body part impact area 22
angular force 25
normal force component 28
tangential force component 30
body part 8
inner layer 12
impact force dampening and defusing structure 14
outer layer 24
outer surface shock response 23
system impact area 20
impact force 18
impacting object 21

FIG. 9

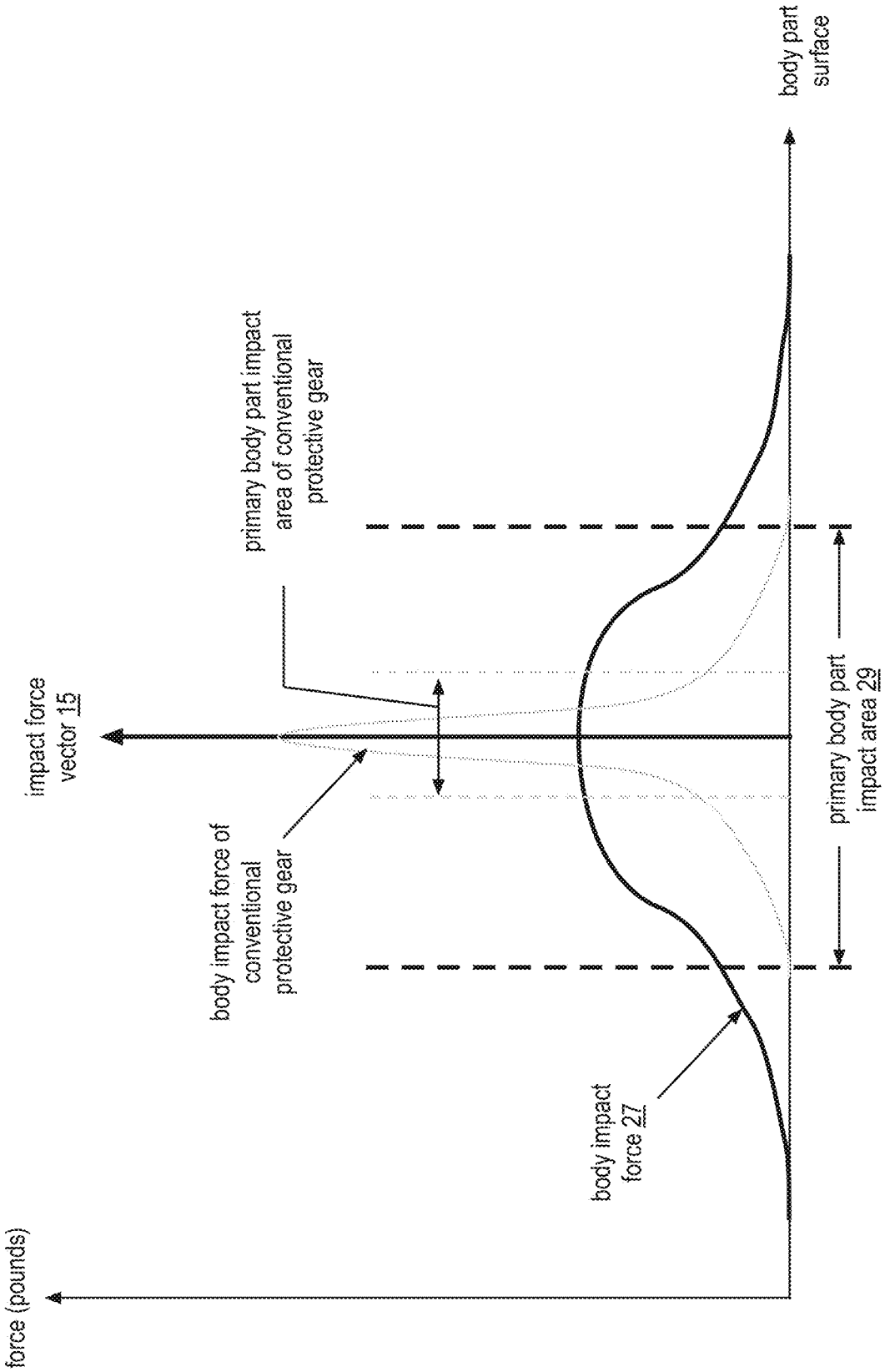

force (pounds)
impact force vector 15
body impact force of conventional protective gear
primary body part impact area of conventional protective gear
body impact force 27
primary body part impact area 29
body part surface

FIG. 10

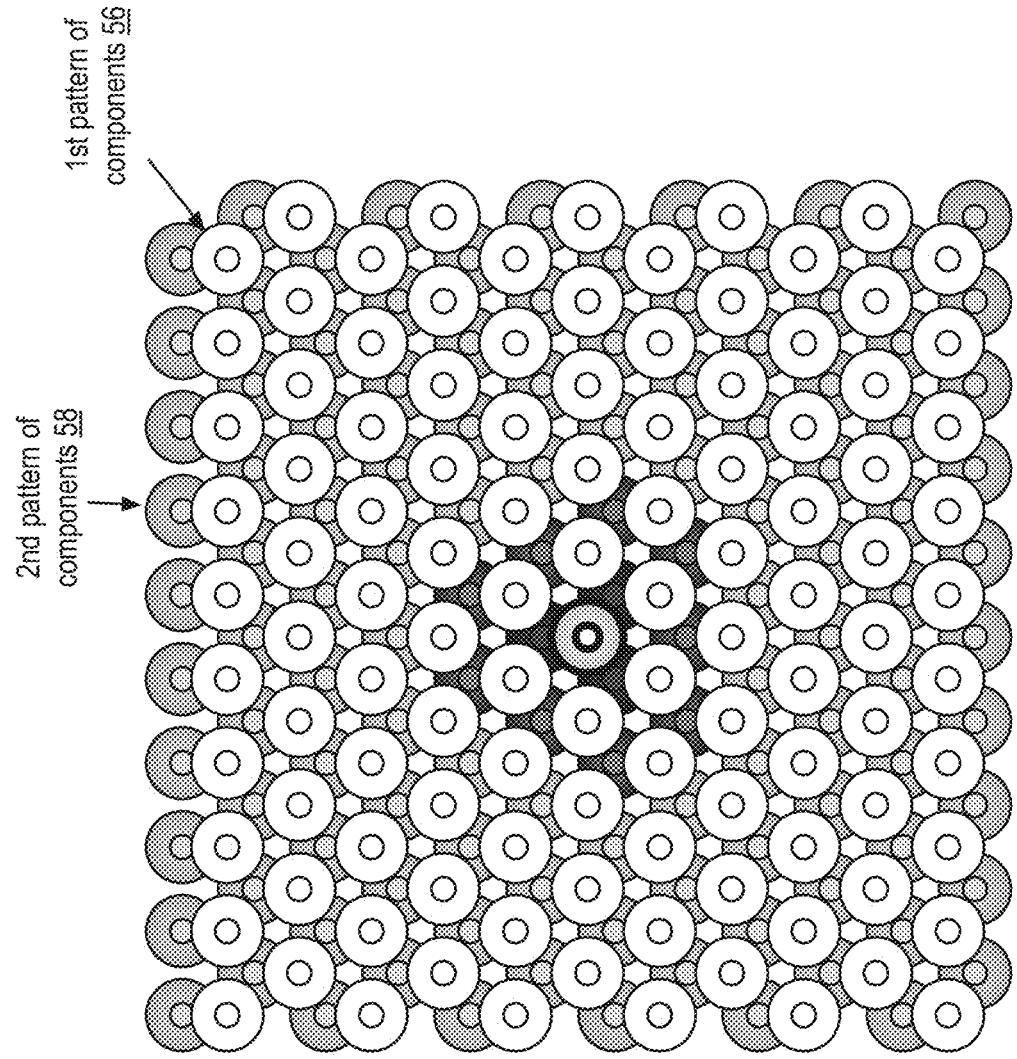
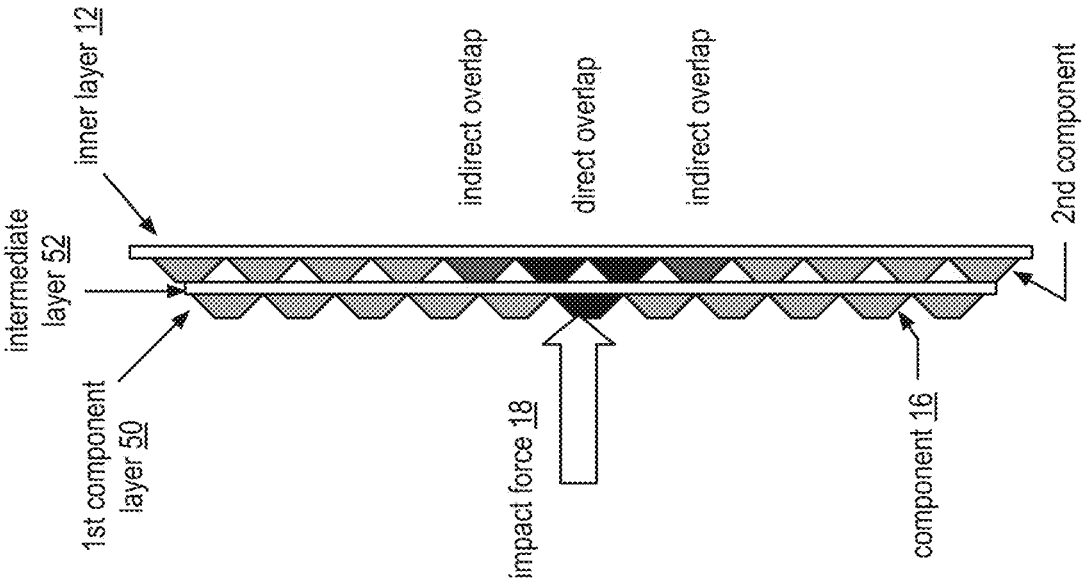

1st pattern of components 56
2nd pattern of components 58

FIG. 12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intermediate layer 52
1st component layer 50
indirect overlap
direct overlap
indirect overlap
impact force 18
component 16
2nd component layer 54

FIG. 11

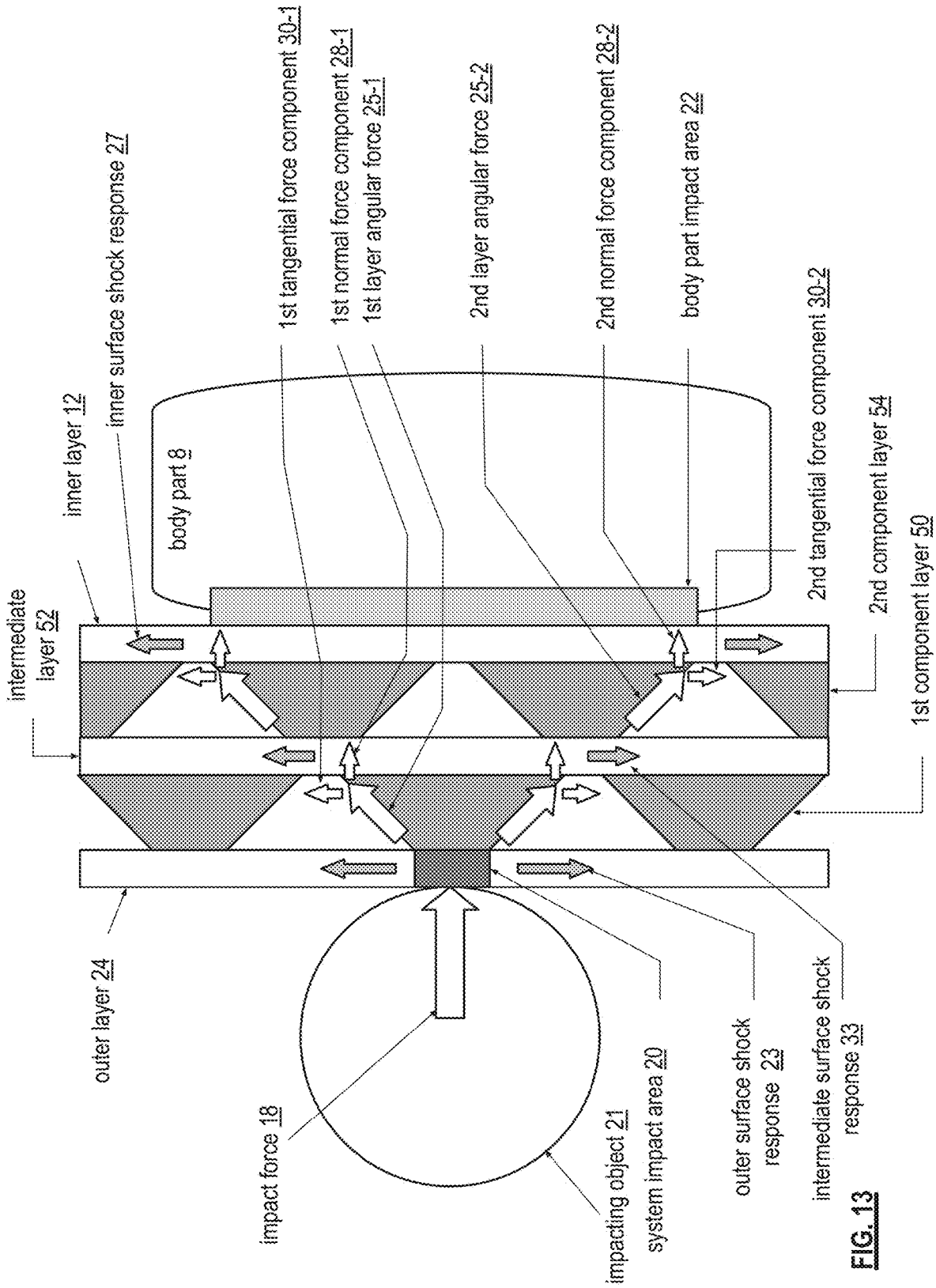

1st tangential force component 30-1
1st normal force component 28-1
1st layer angular force 25-1
2nd layer angular force 25-2
2nd normal force component 28-2
body part impact area 22
inner surface shock response 27
inner layer 12
body part 8
2nd tangential force component 30-2
2nd component layer 54
intermediate layer 52
1st component layer 50
outer layer 24
impact force 18
impacting object 21
system impact area 20
outer surface shock response 23
intermediate surface shock response 33

FIG. 13

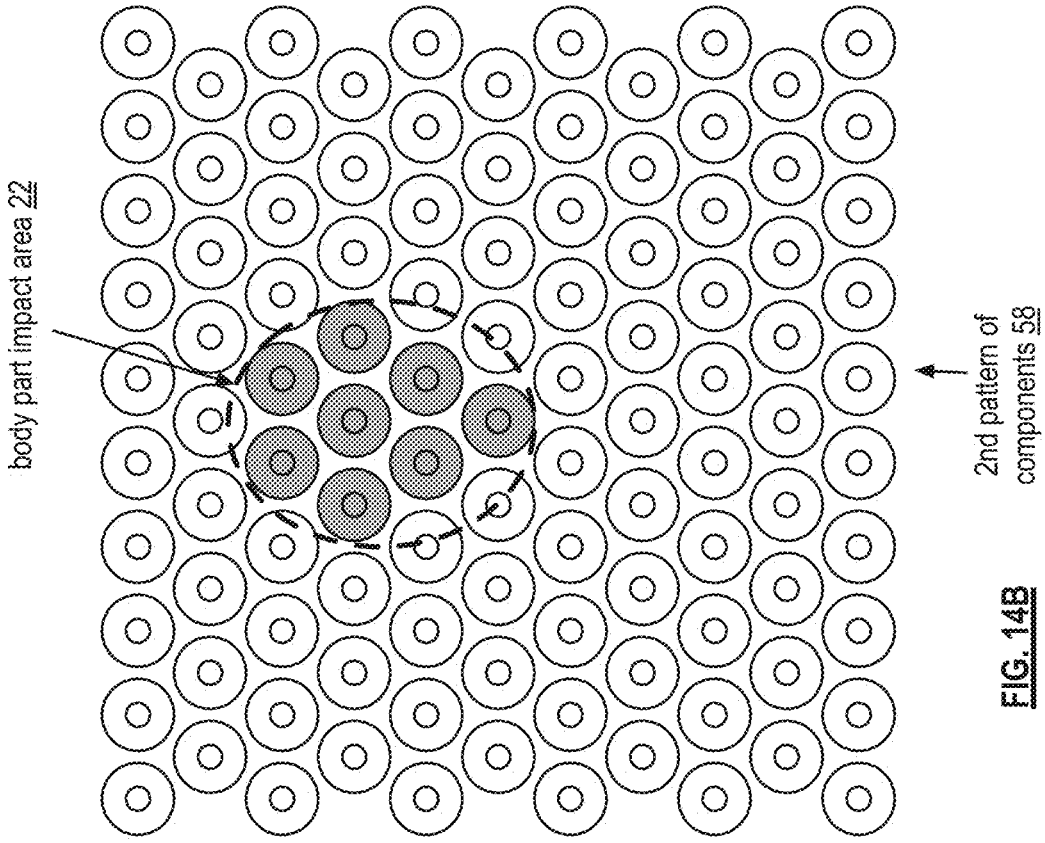


FIG. 14B

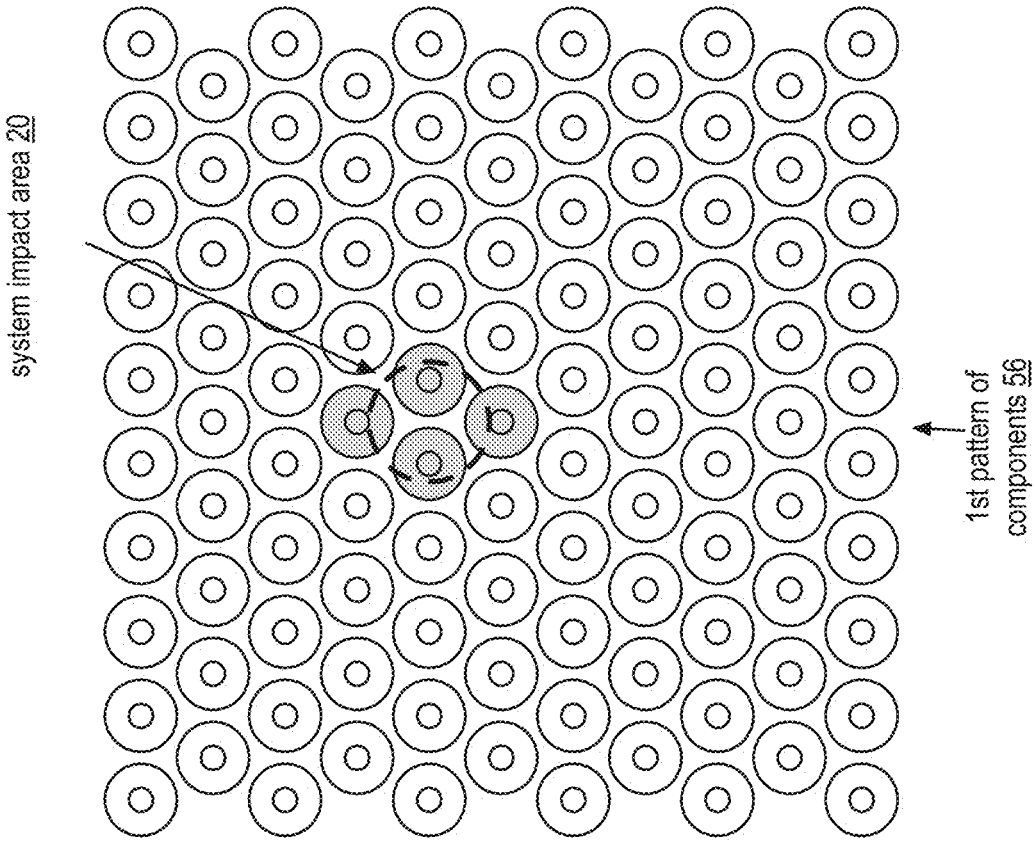


FIG. 14A

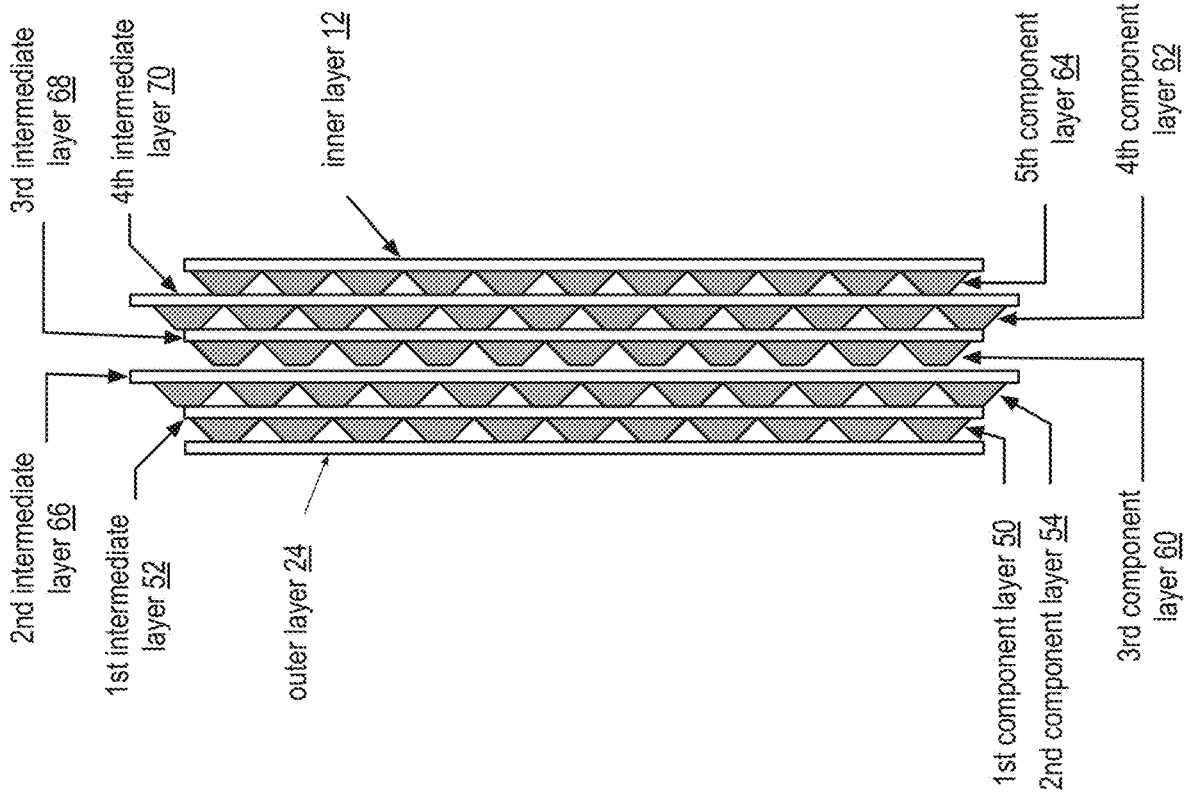

3rd intermediate layer 68
4th intermediate layer 70
inner layer 12
5th component layer 64
4th component layer 62
2nd intermediate layer 66
1st intermediate layer 52
outer layer 24
1st component layer 50
2nd component layer 54
3rd component layer 60

FIG. 15

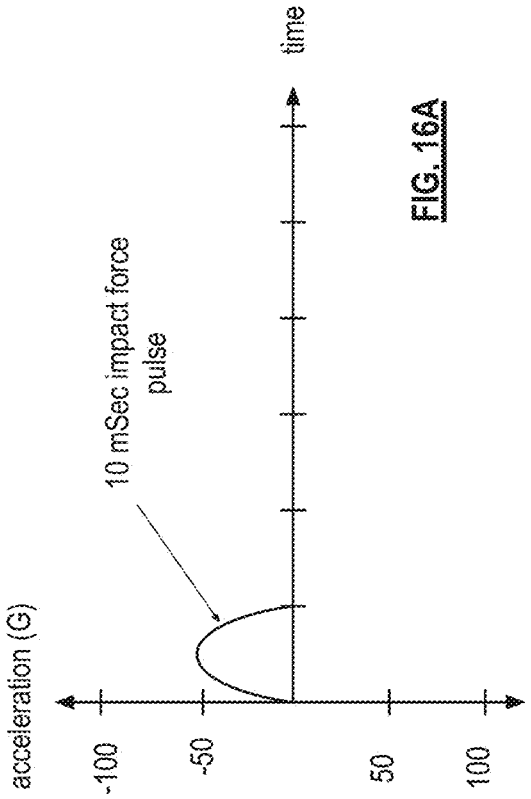


FIG. 16A

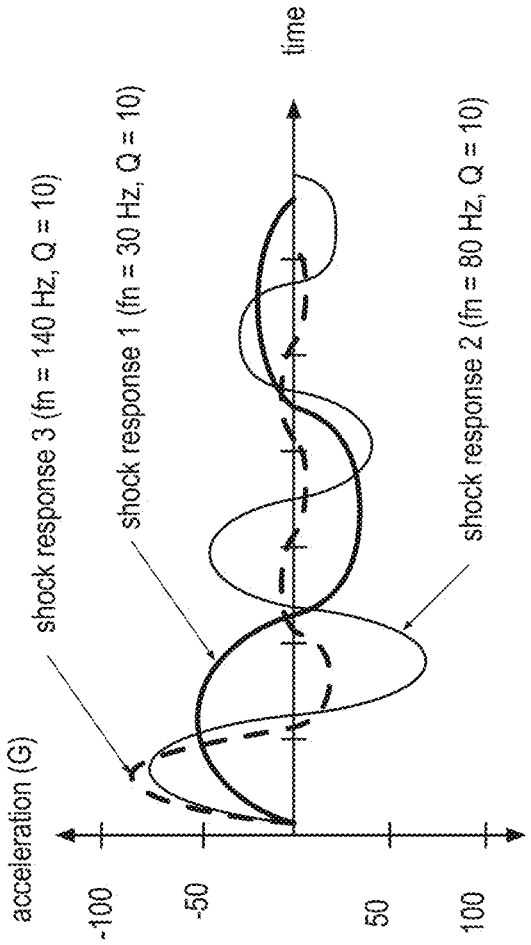


FIG. 16B

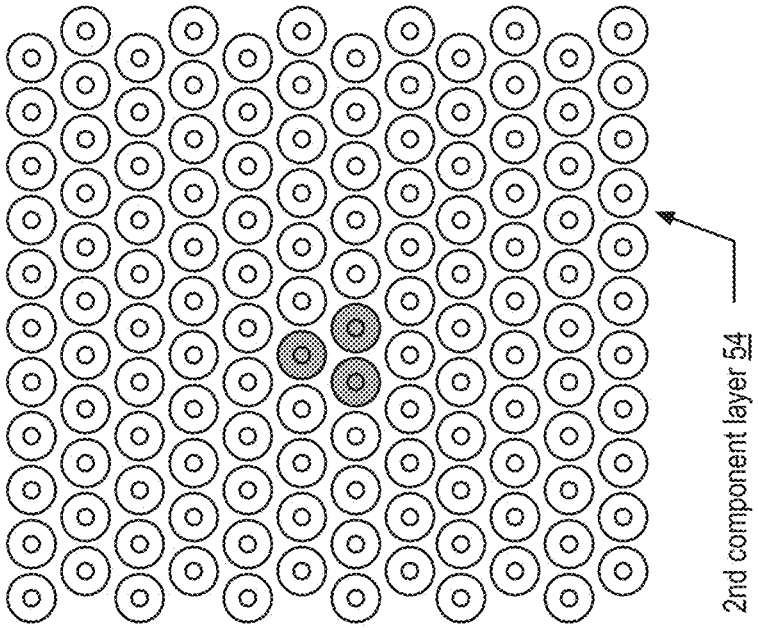


FIG. 17B

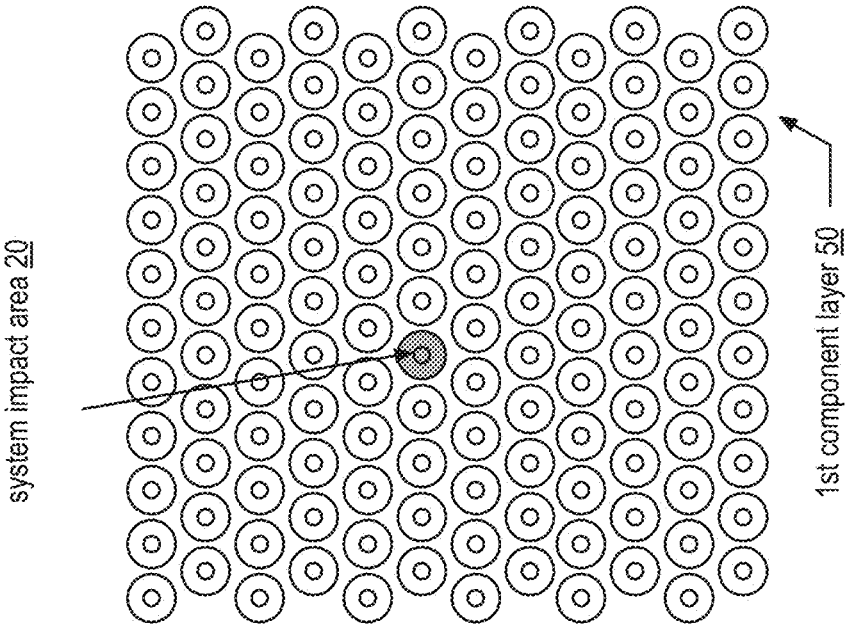


FIG. 17A

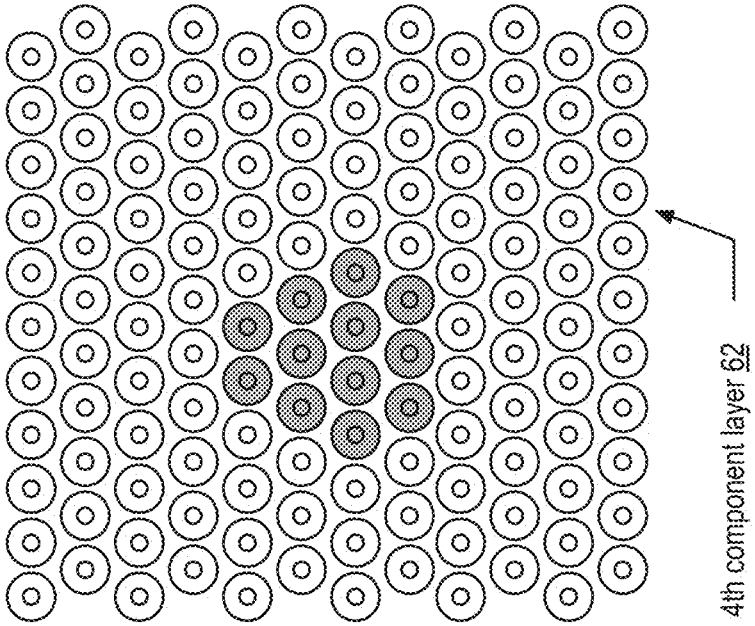


FIG. 17D

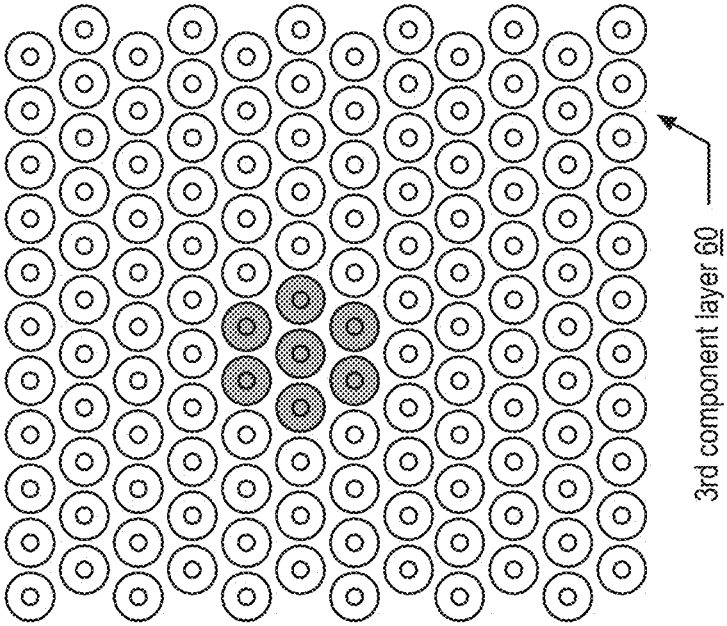


FIG. 17C

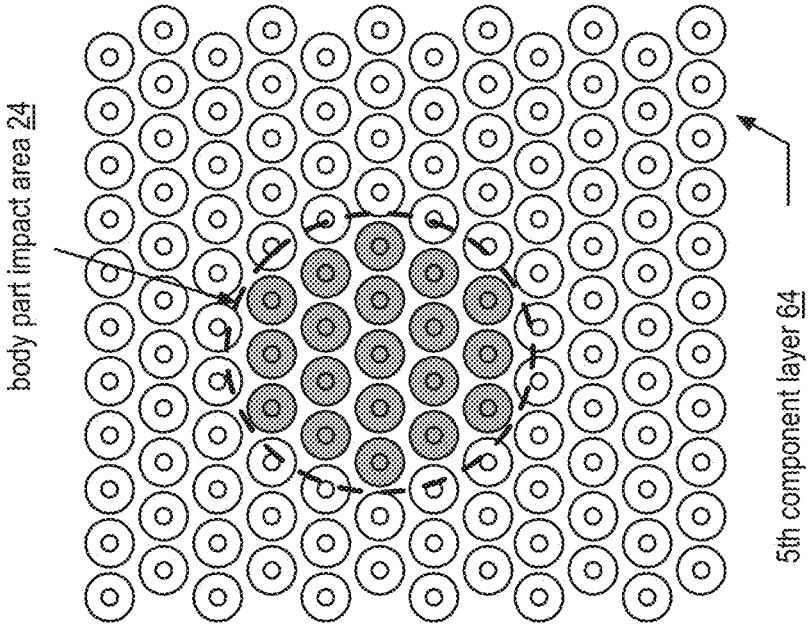


FIG. 17E

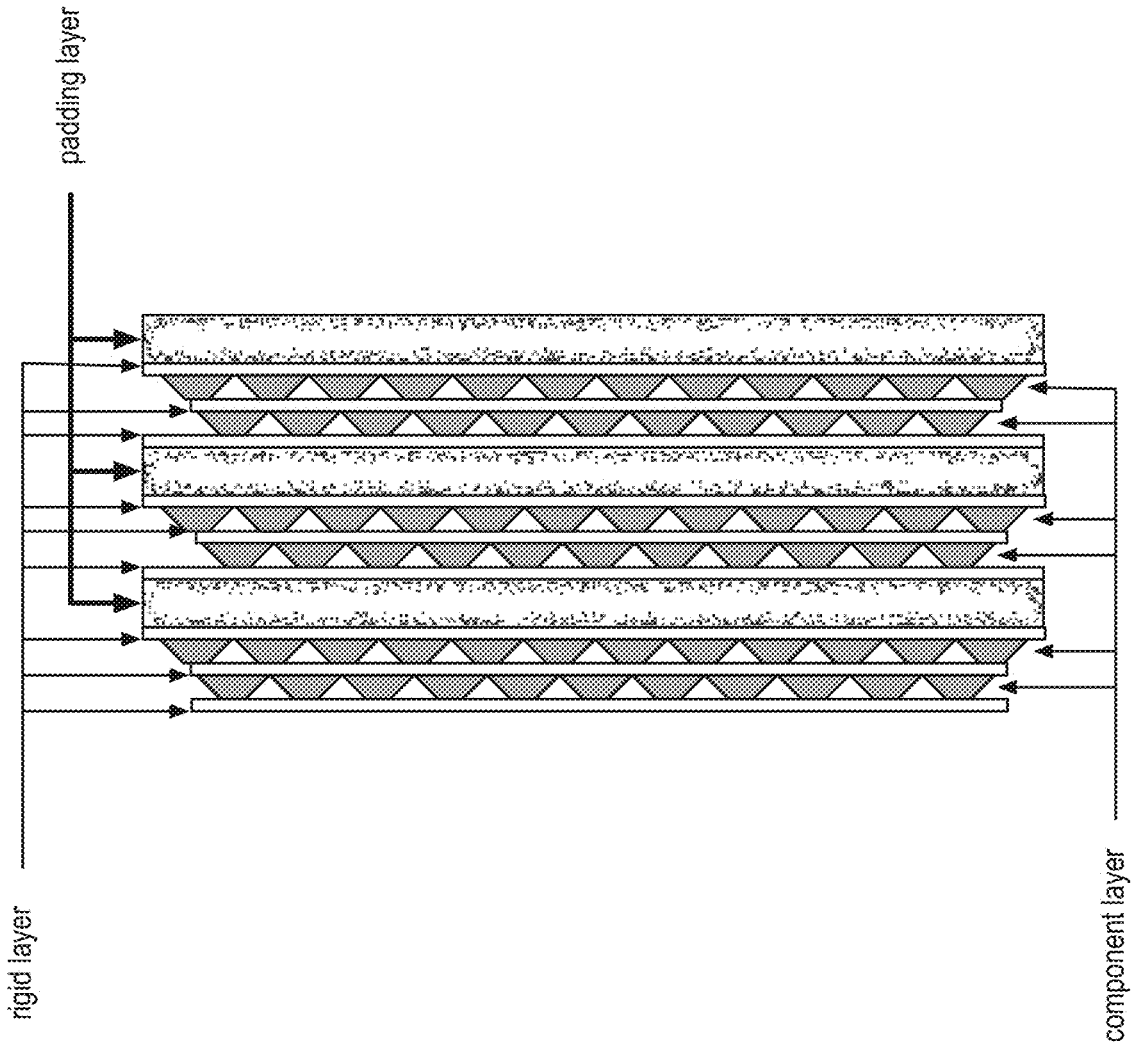


FIG. 18

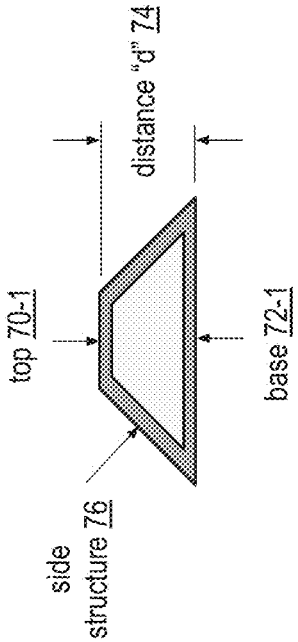


FIG. 20
side view

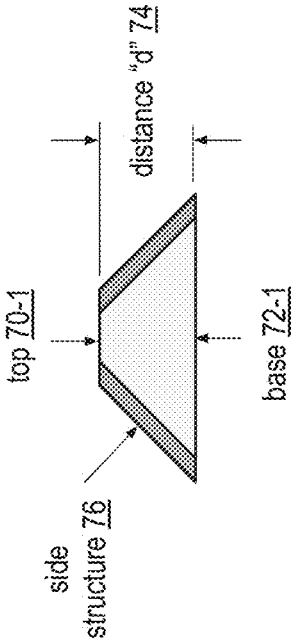


FIG. 19
side view

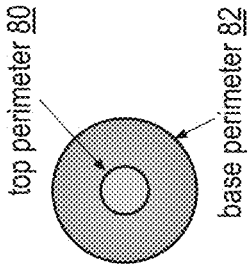


FIG. 21A
top view

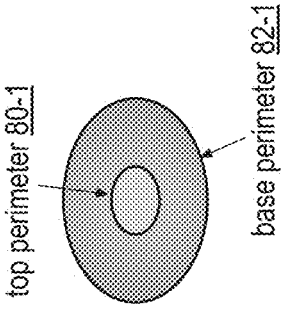


FIG. 21B
top view

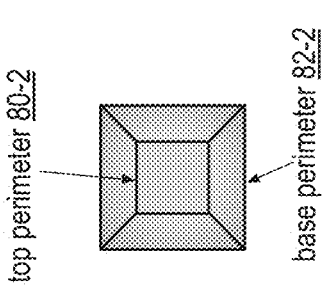


FIG. 21C
top view

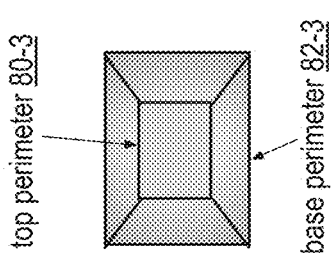


FIG. 21D
top view

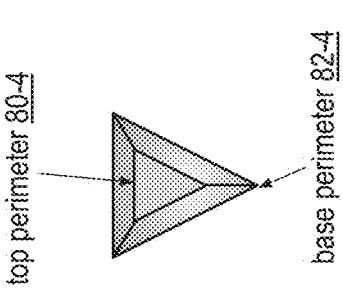


FIG. 21E
top view

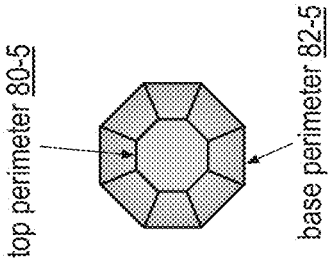


FIG. 21F
top view

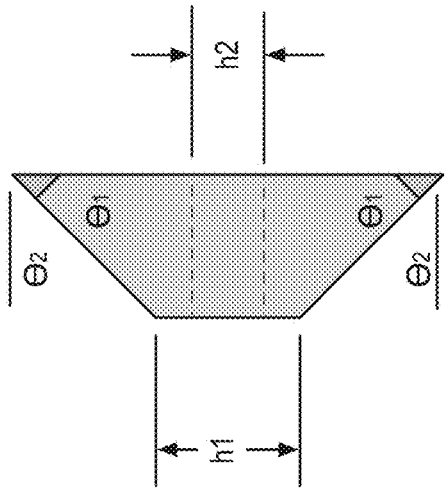


FIG. 21H
side view

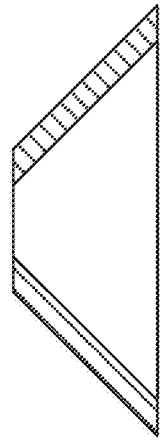


FIG. 21J-2
cross section view

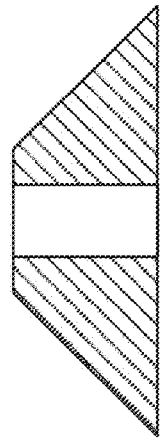


FIG. 21J-1
cross section view

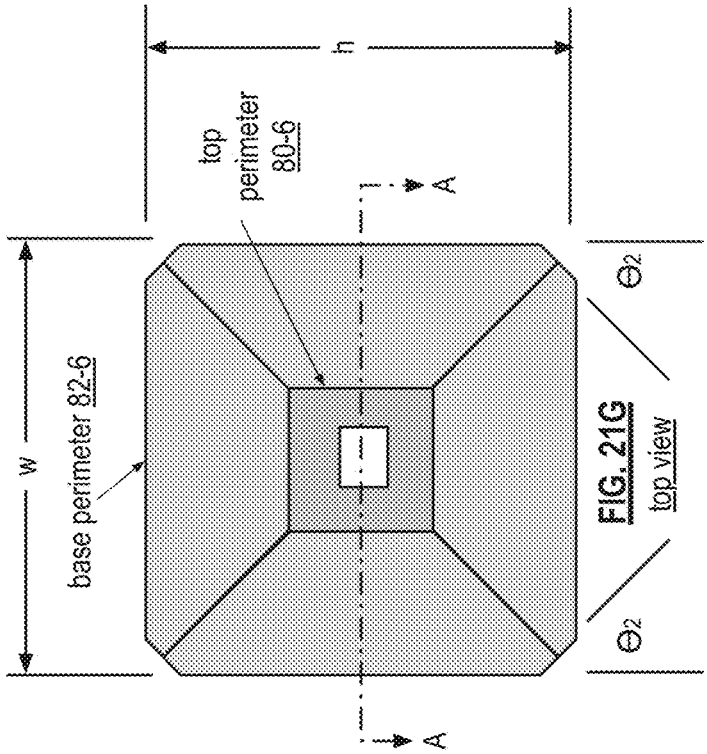


FIG. 21G
top view

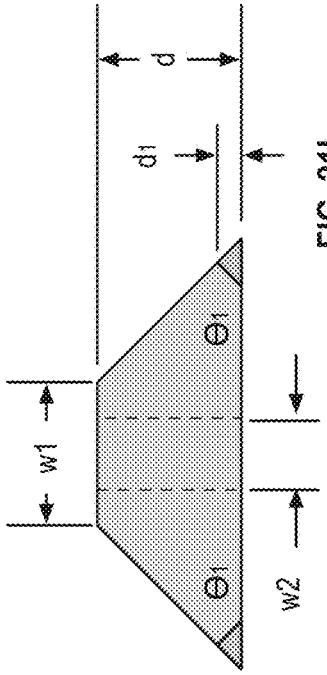


FIG. 21I
front view

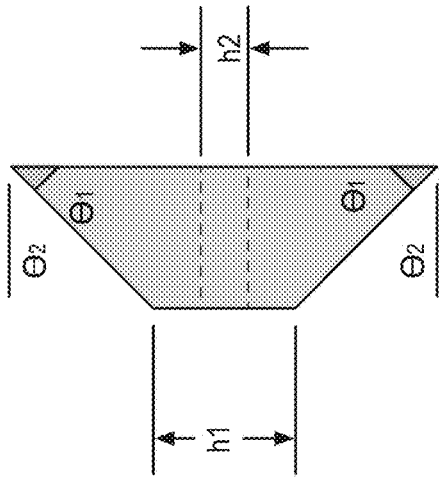


FIG. 21L
side view

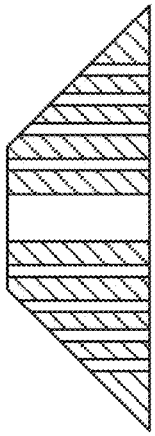


FIG. 21N
cross section view

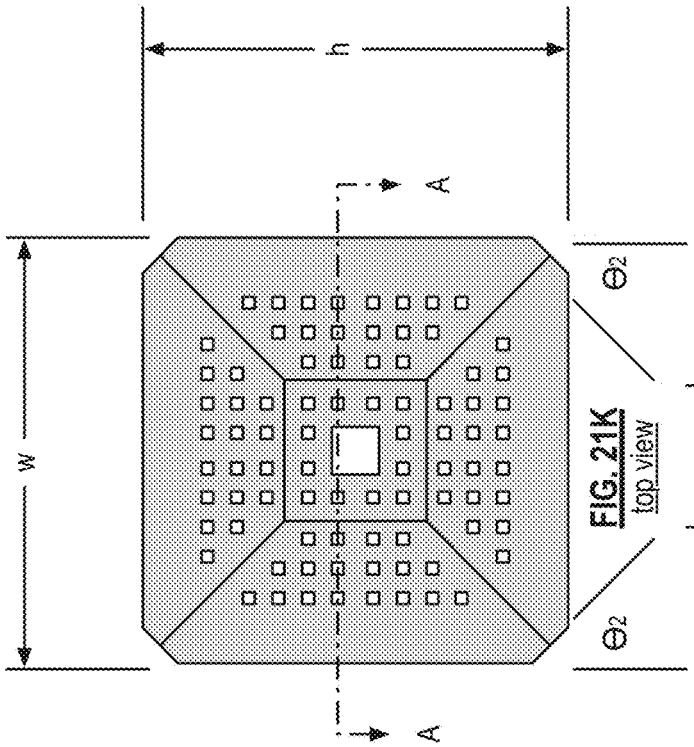


FIG. 21K
top view

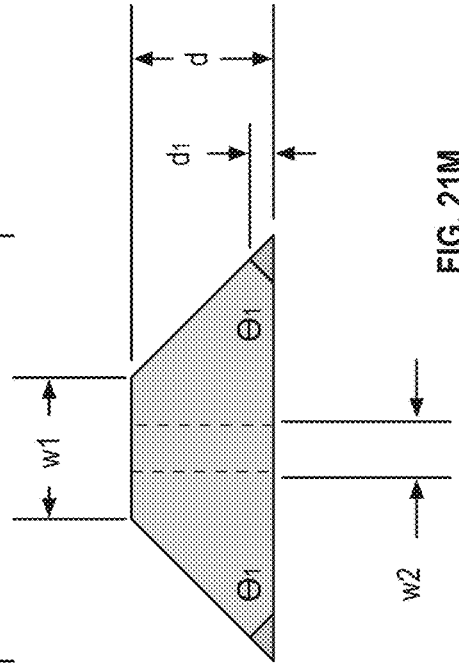


FIG. 21M
front view

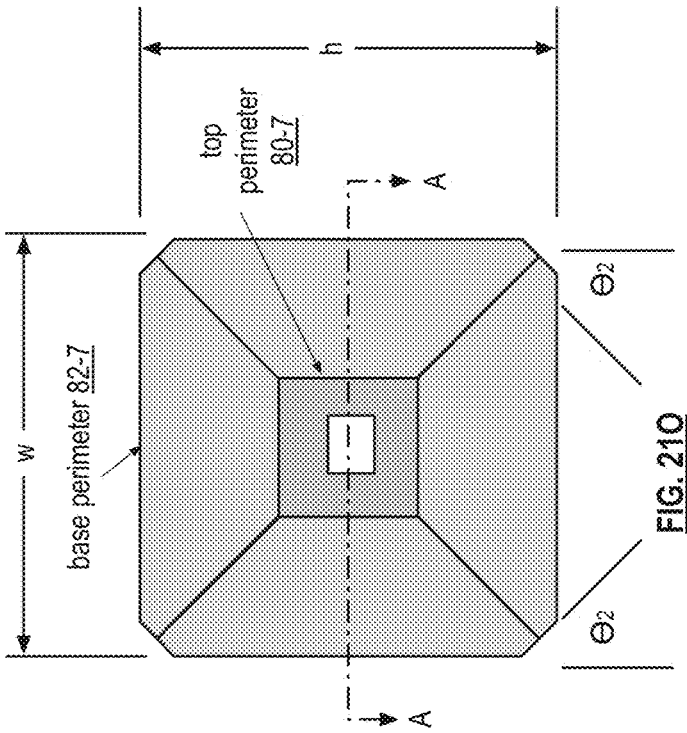


FIG. 21O
top view

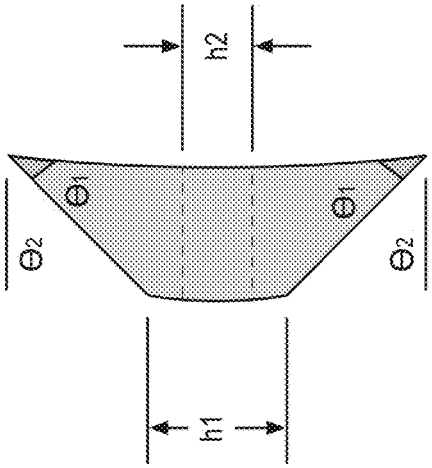


FIG. 21Q
side view

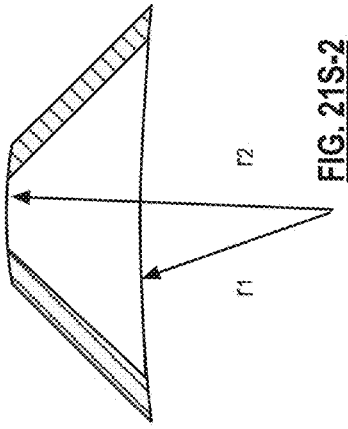


FIG. 21S-2
cross section view

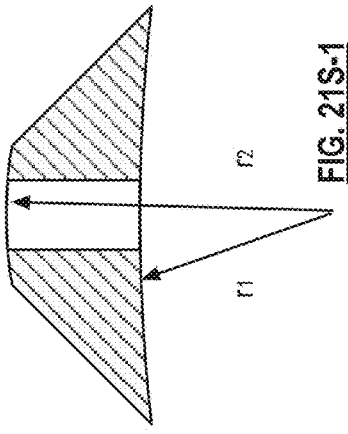


FIG. 21S-1
cross section view

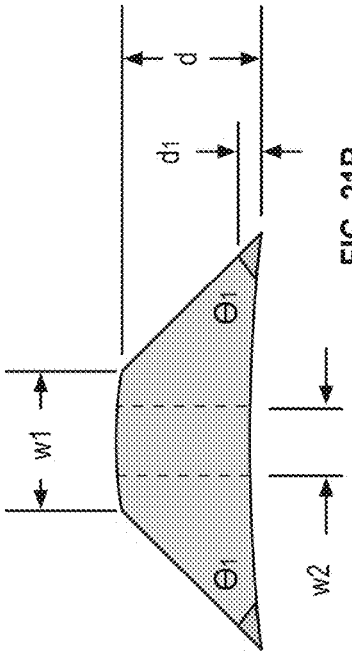


FIG. 21R
front view

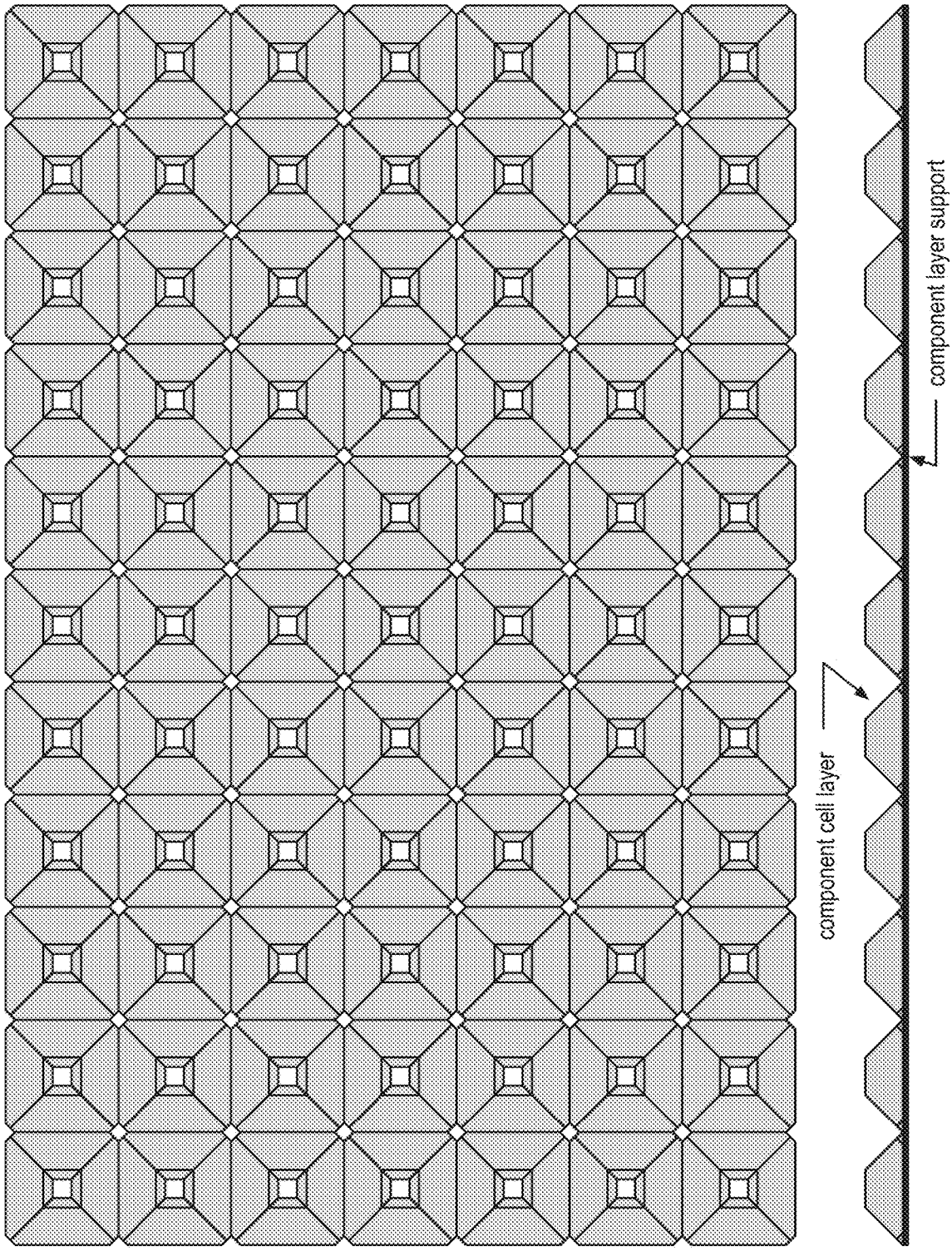


FIG. 21T

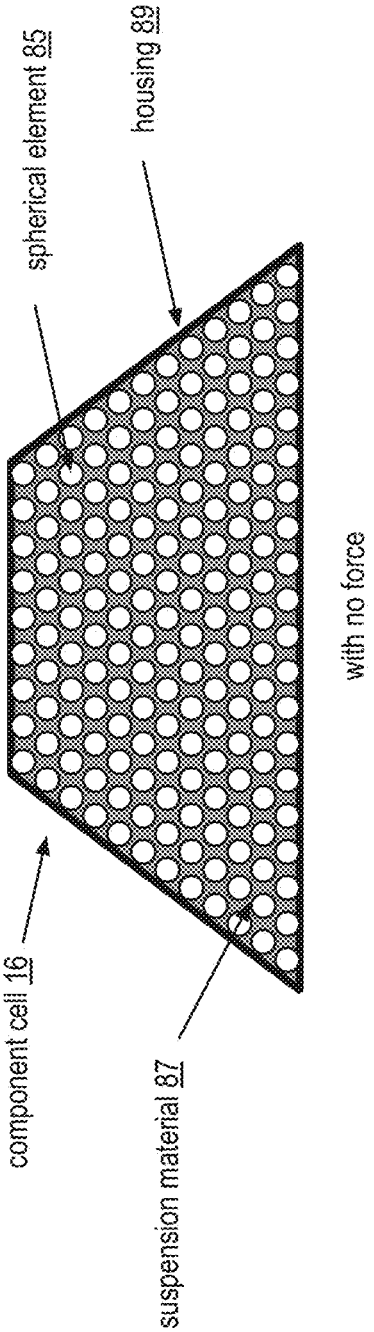


FIG. 21U

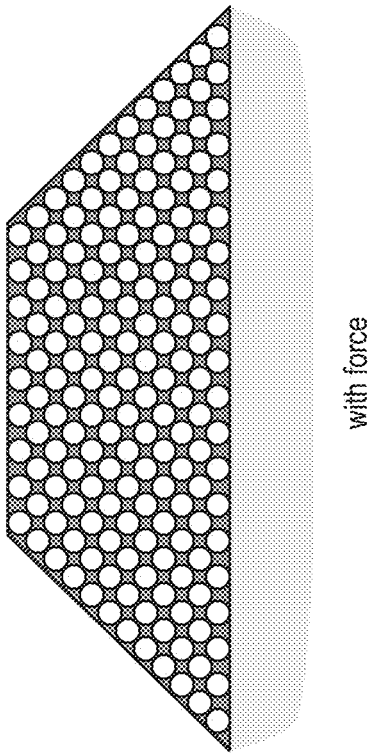


FIG. 21V

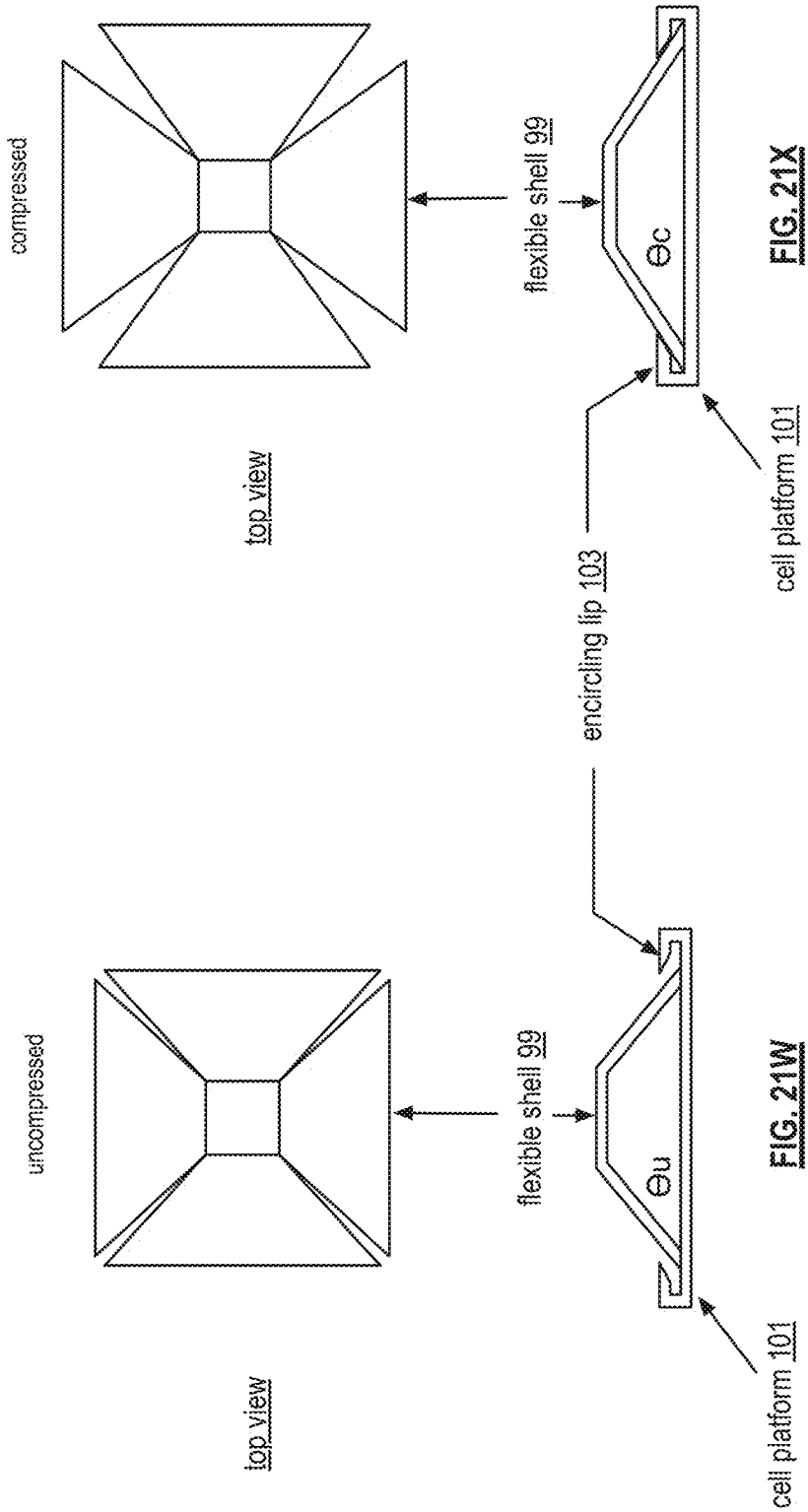


FIG. 21X

FIG. 21W

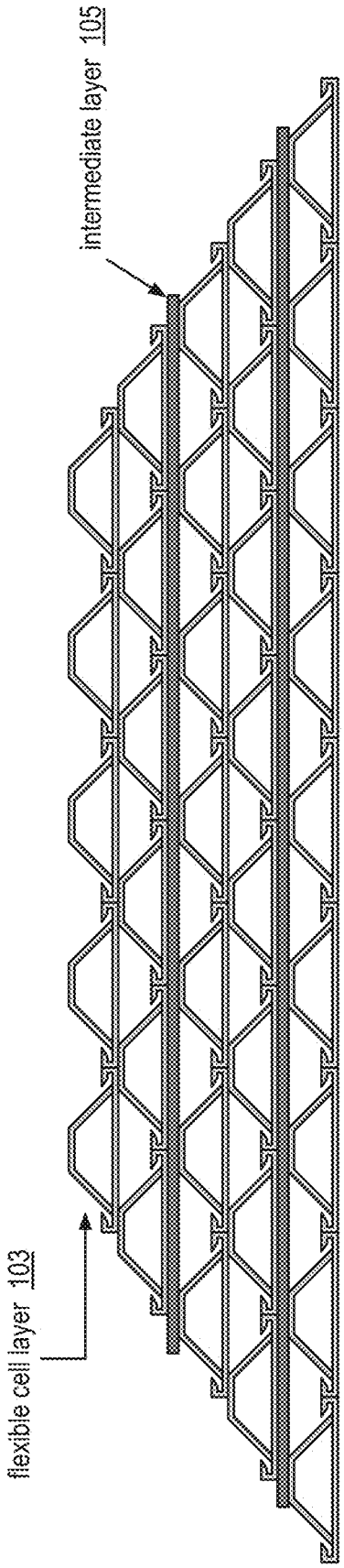


FIG. 21Y

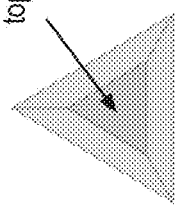


FIG. 21Z
top view

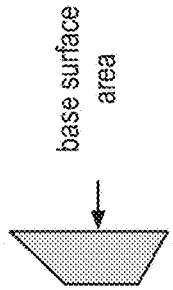


FIG. 21AA
side view

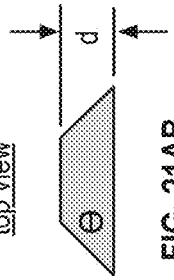


FIG. 21AB
front view

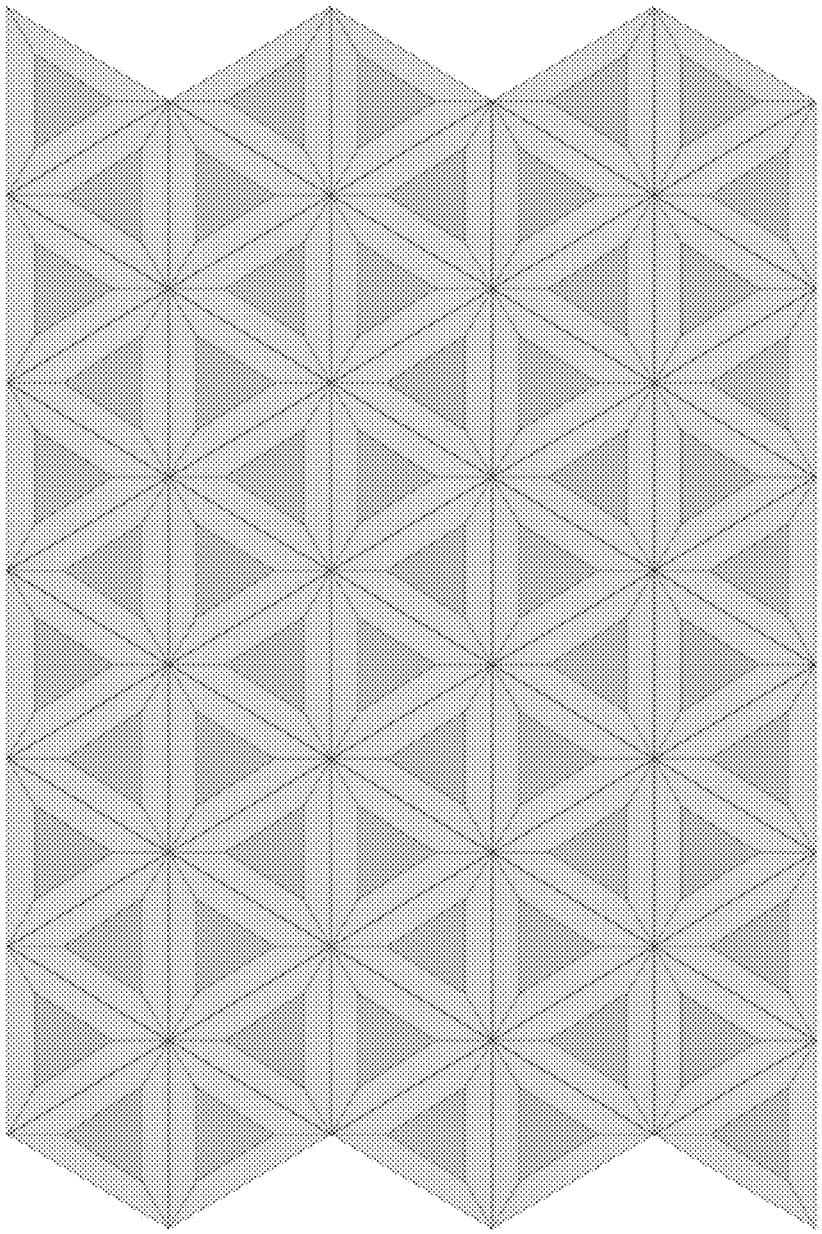


FIG. 21AC

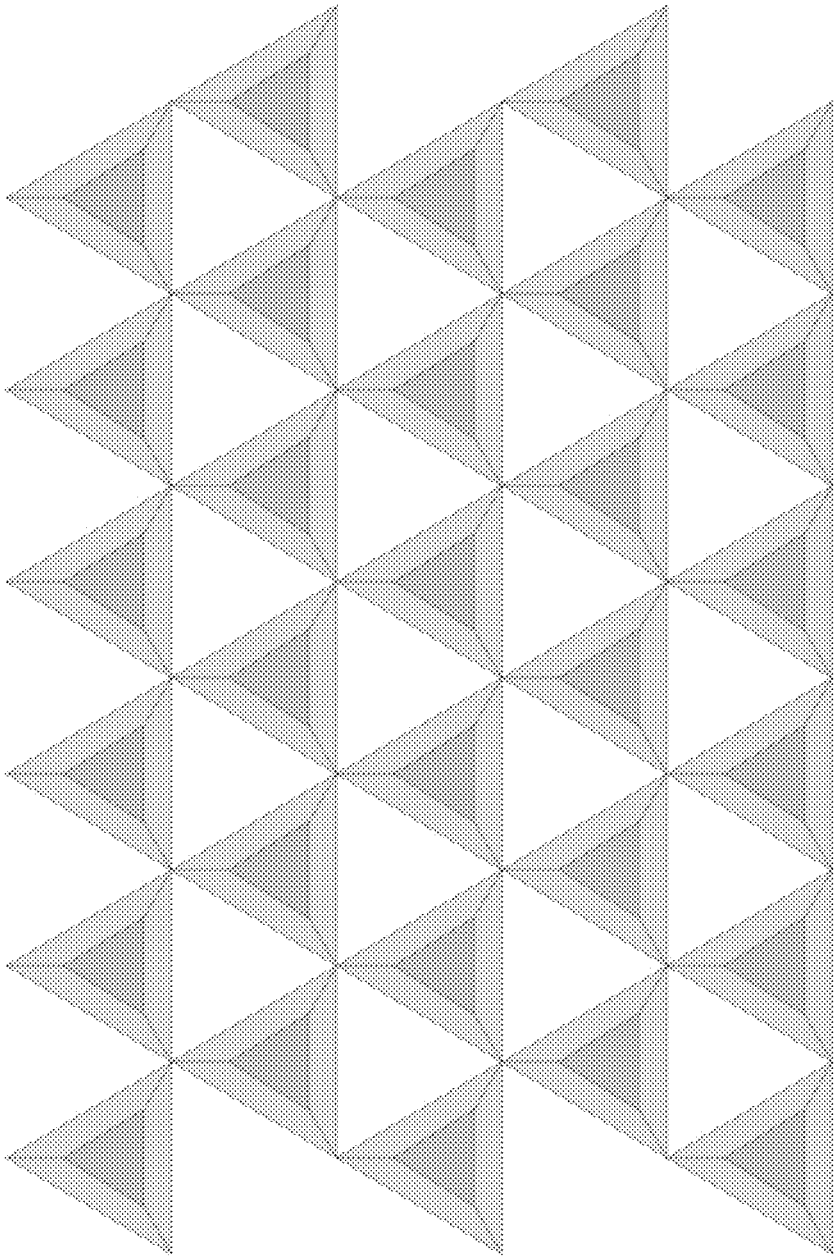


FIG. 21AD

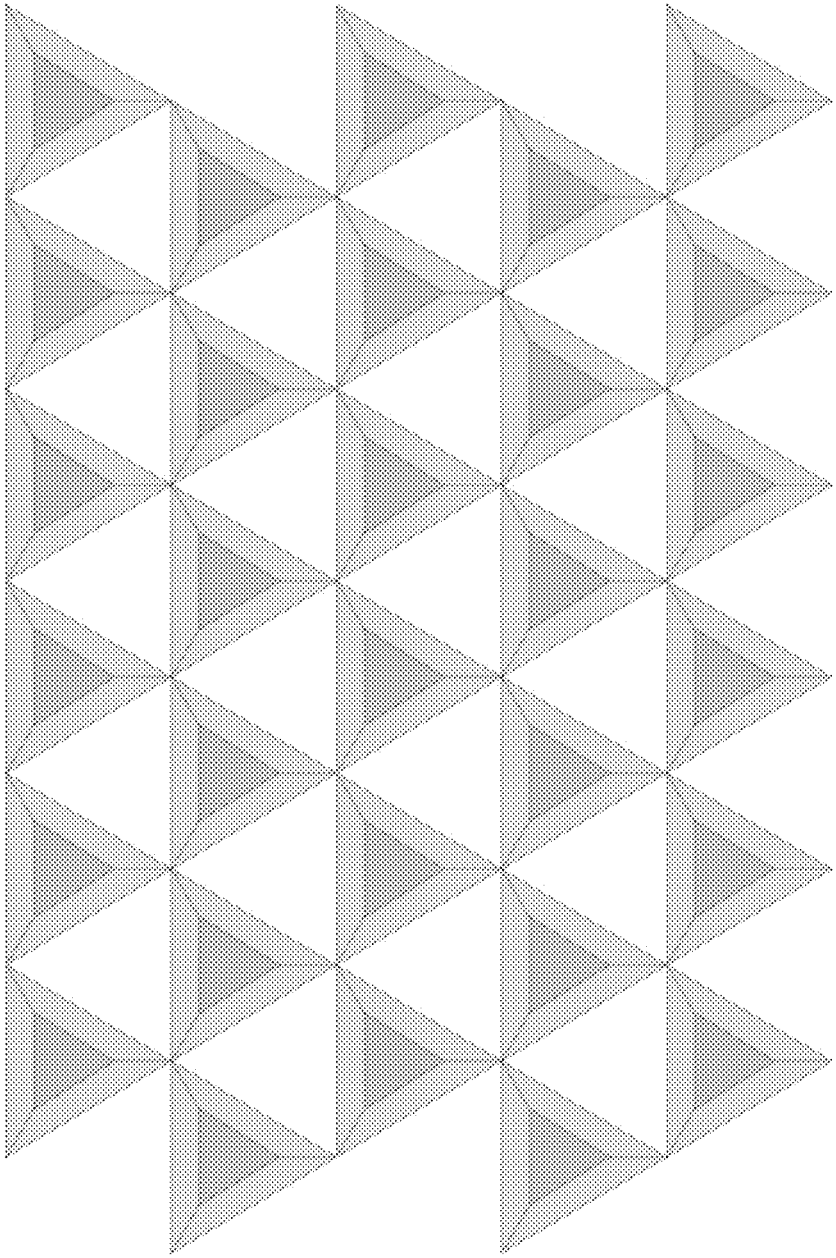


FIG. 21AE

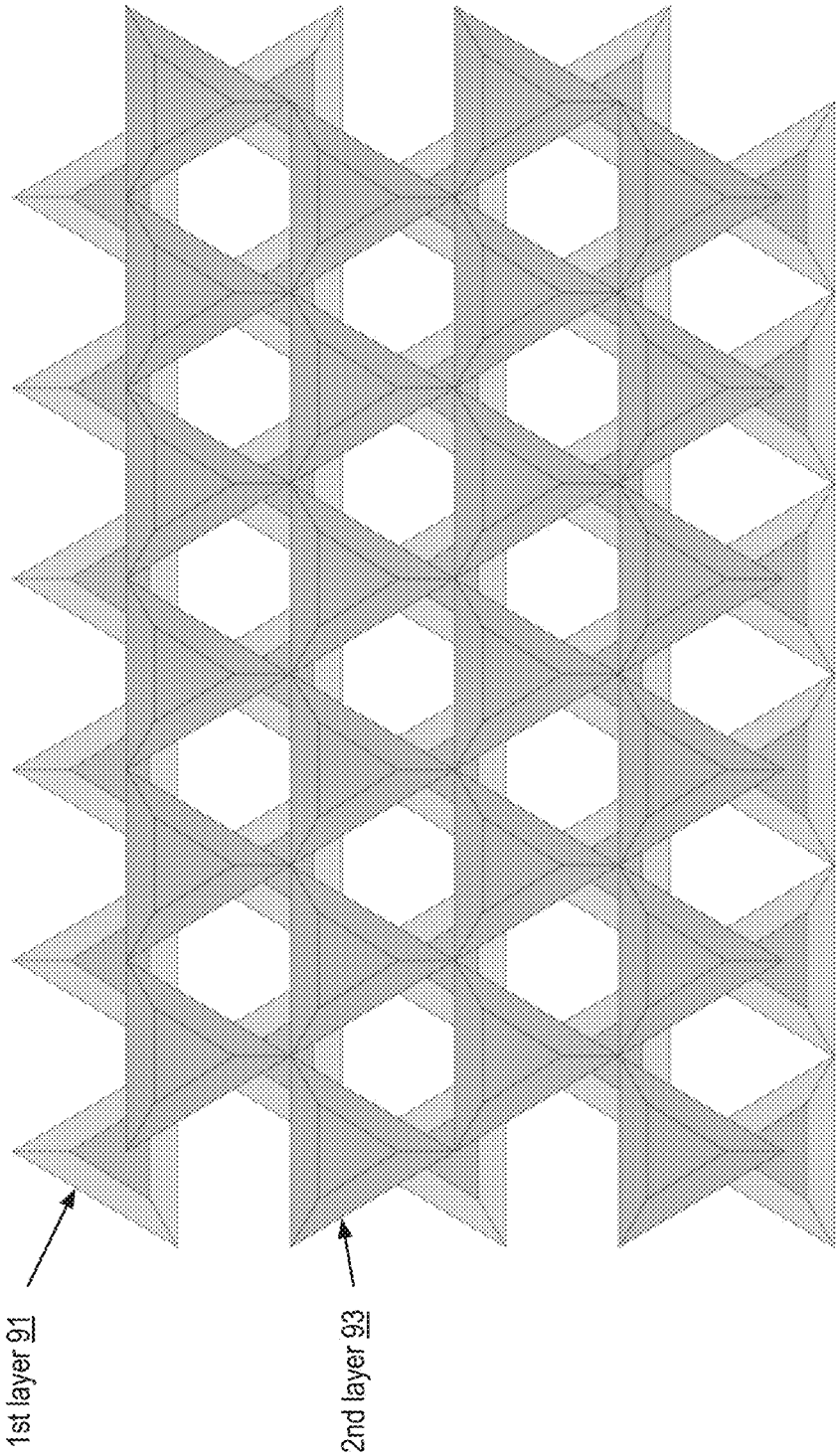


FIG. 21AF

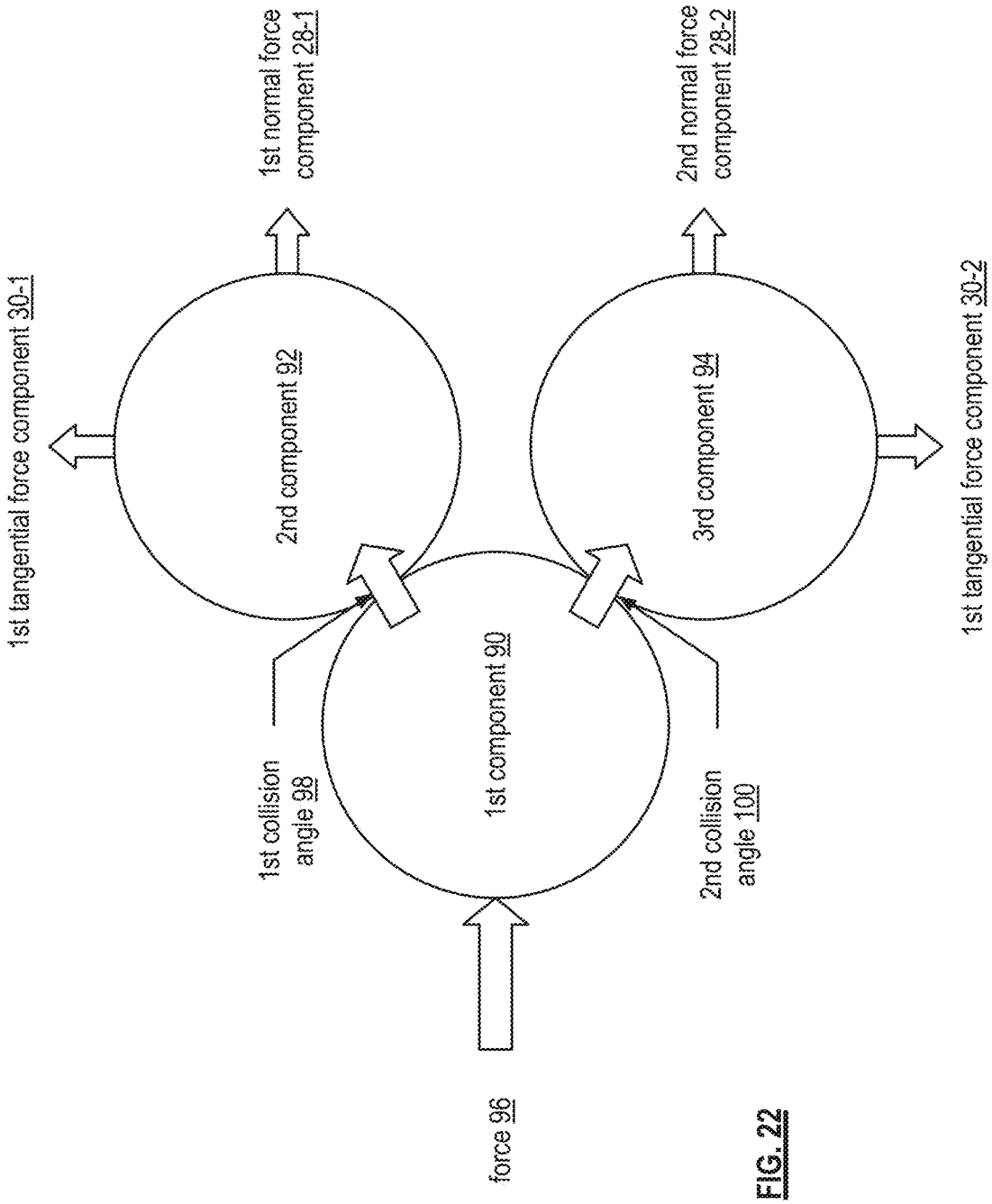

1st tangential force component 30-1
1st normal force component 28-1
2nd normal force component 28-2
1st tangential force component 30-2
2nd component 92
3rd component 94
1st collision angle 98
1st component 90
2nd collision angle 100
force 96

FIG. 22

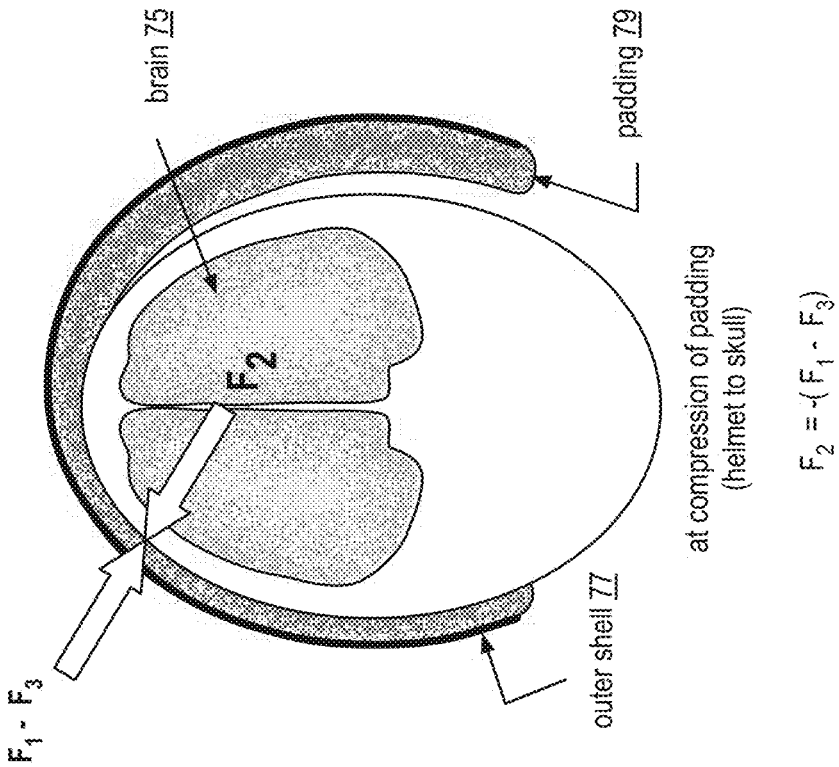


FIG. 23B

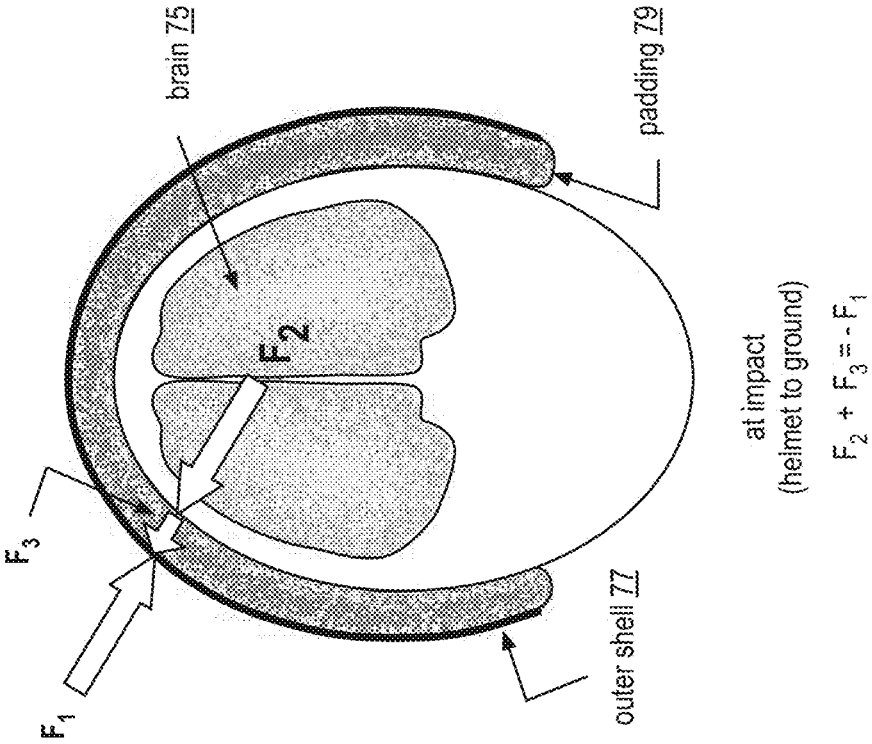


FIG. 23A

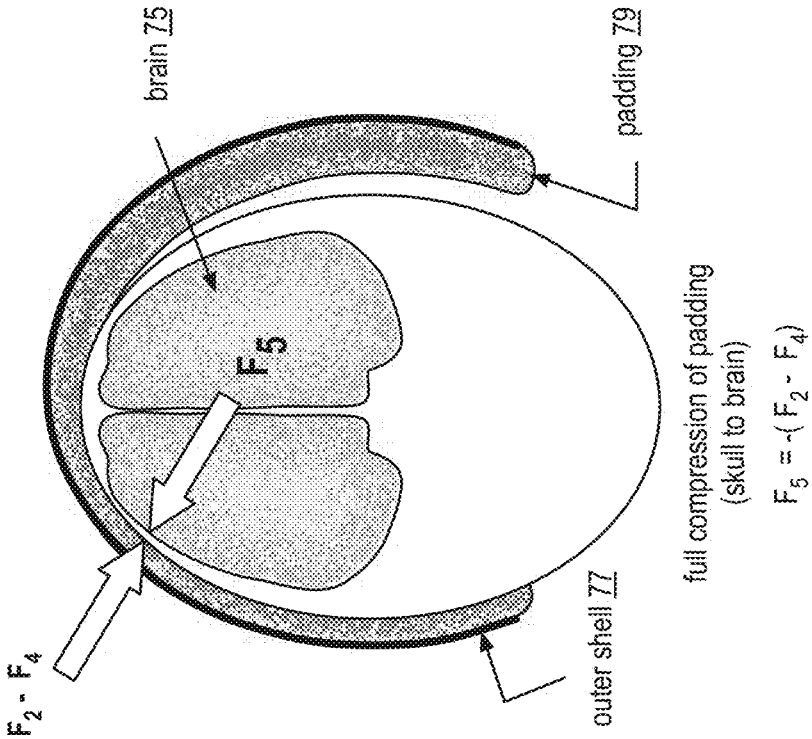

$F_2 - F_4$
brain 75
F_5
outer shell 77
padding 79
full compression of padding
(skull to brain)
$F_5 = -(F_2 - F_4)$

FIG. 23C

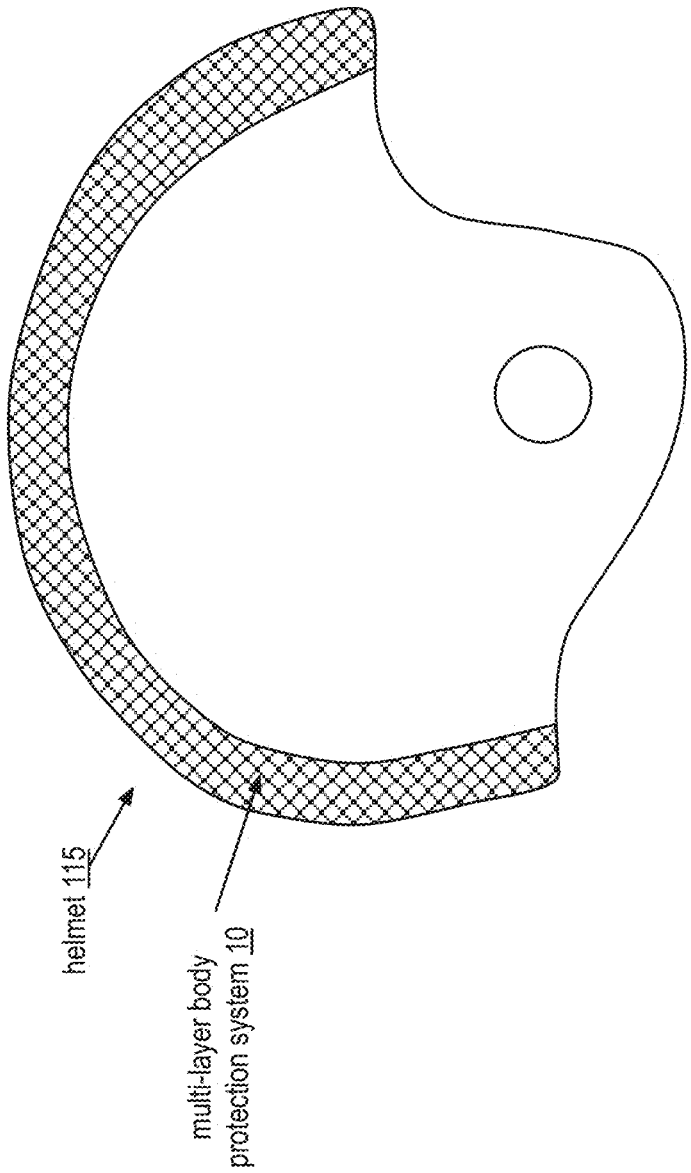


FIG. 23D

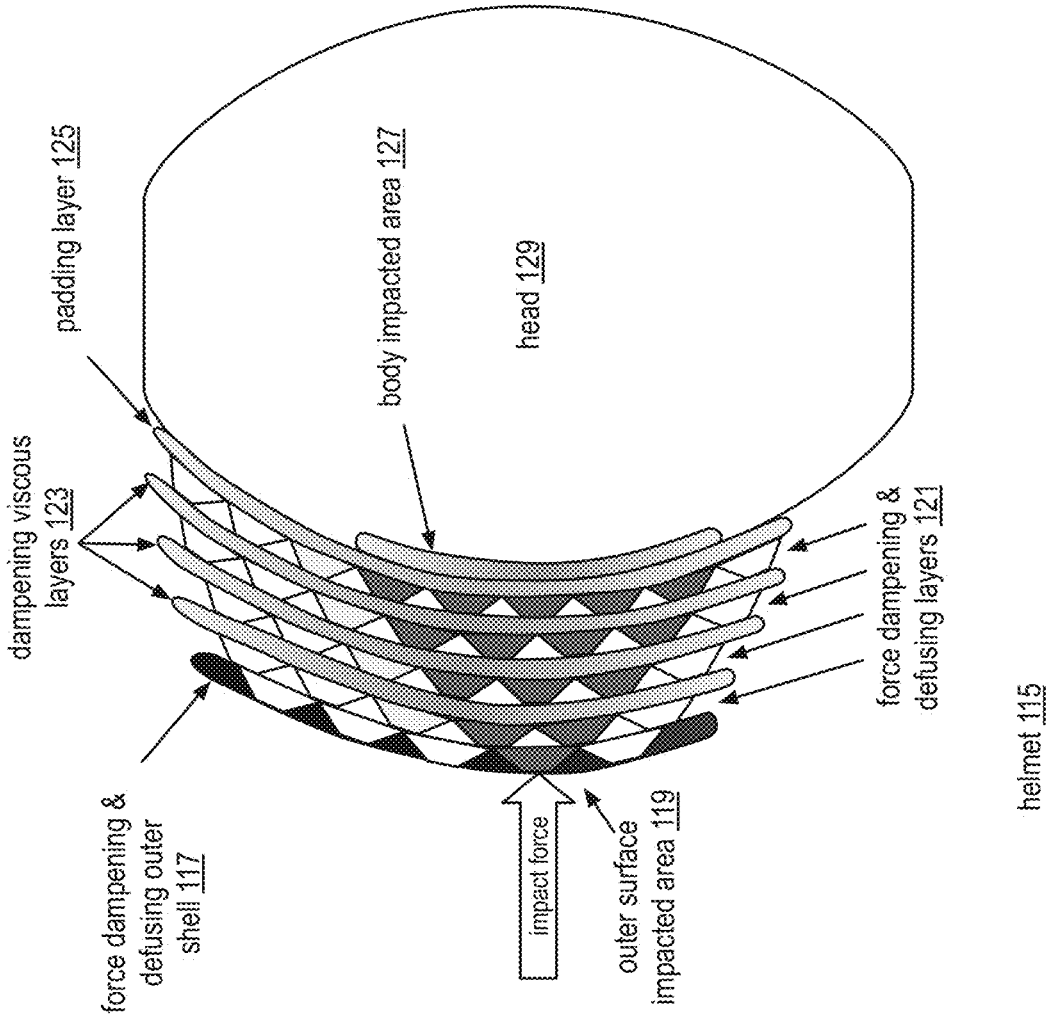

padding layer 125
dampening viscous layers 123
force dampening & defusing outer shell 117
body impacted area 127
head 129
impact force
outer surface impacted area 119
force dampening & defusing layers 121
helmet 115

FIG. 23E

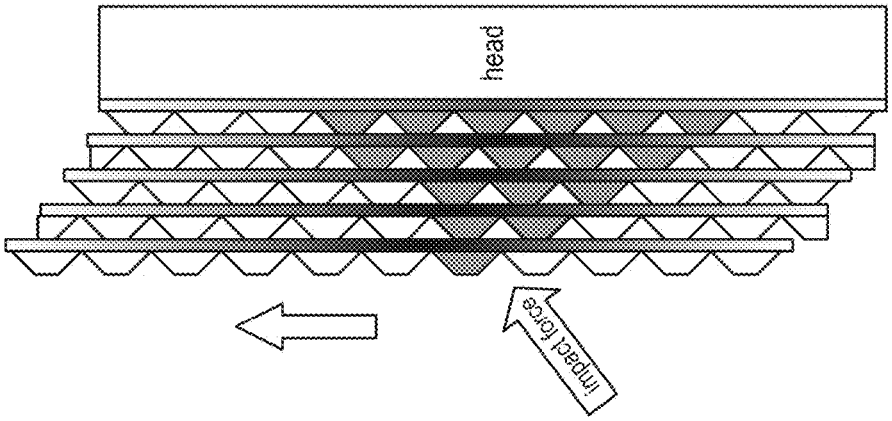


FIG. 23G

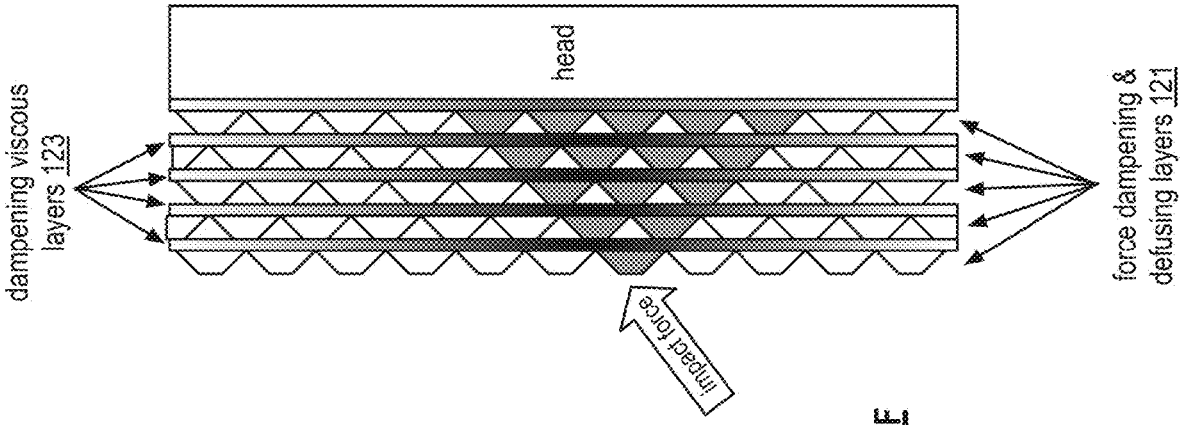


FIG. 23F

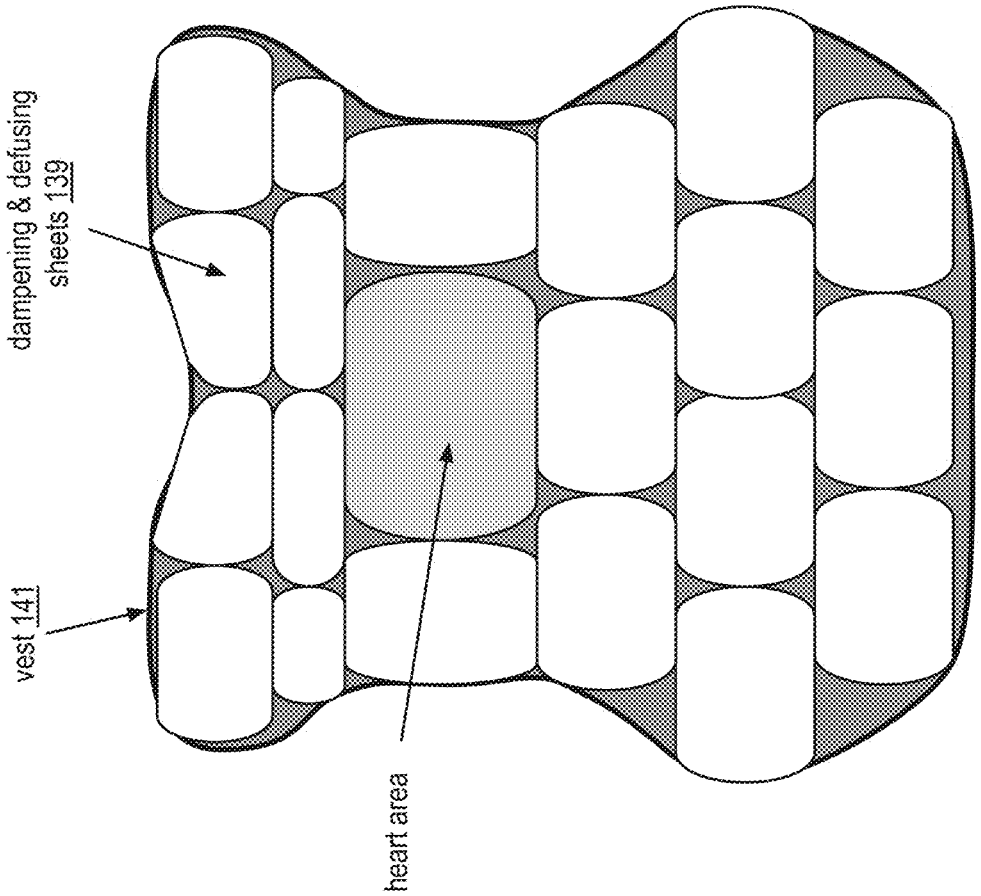


FIG. 24B
chest protector 135

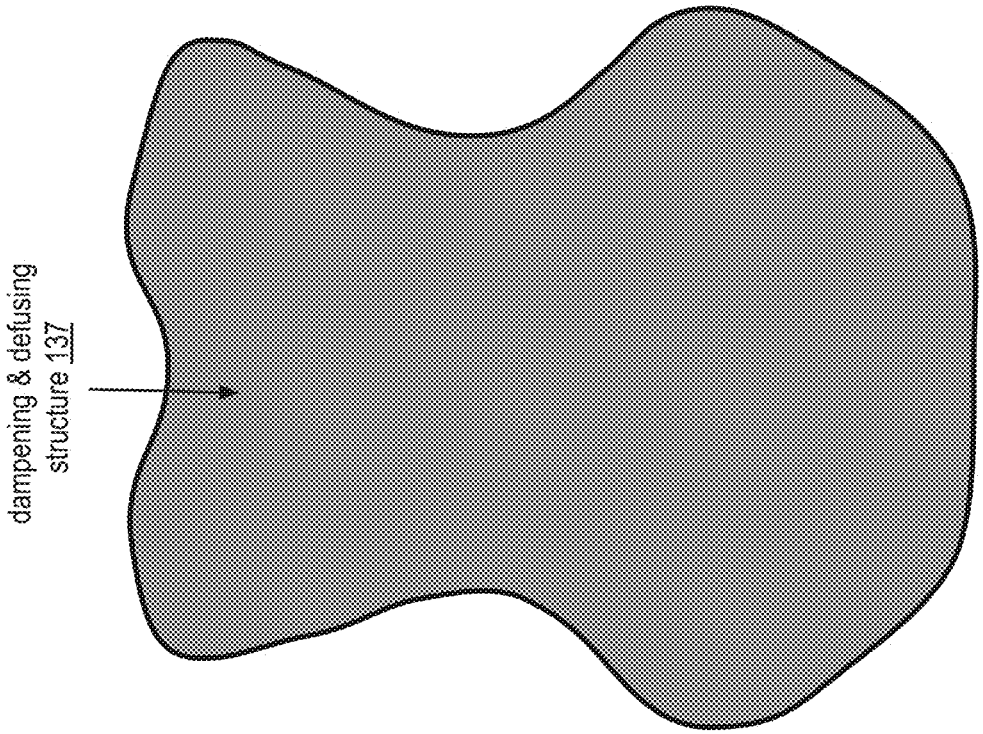


FIG. 24A
chest protector 135

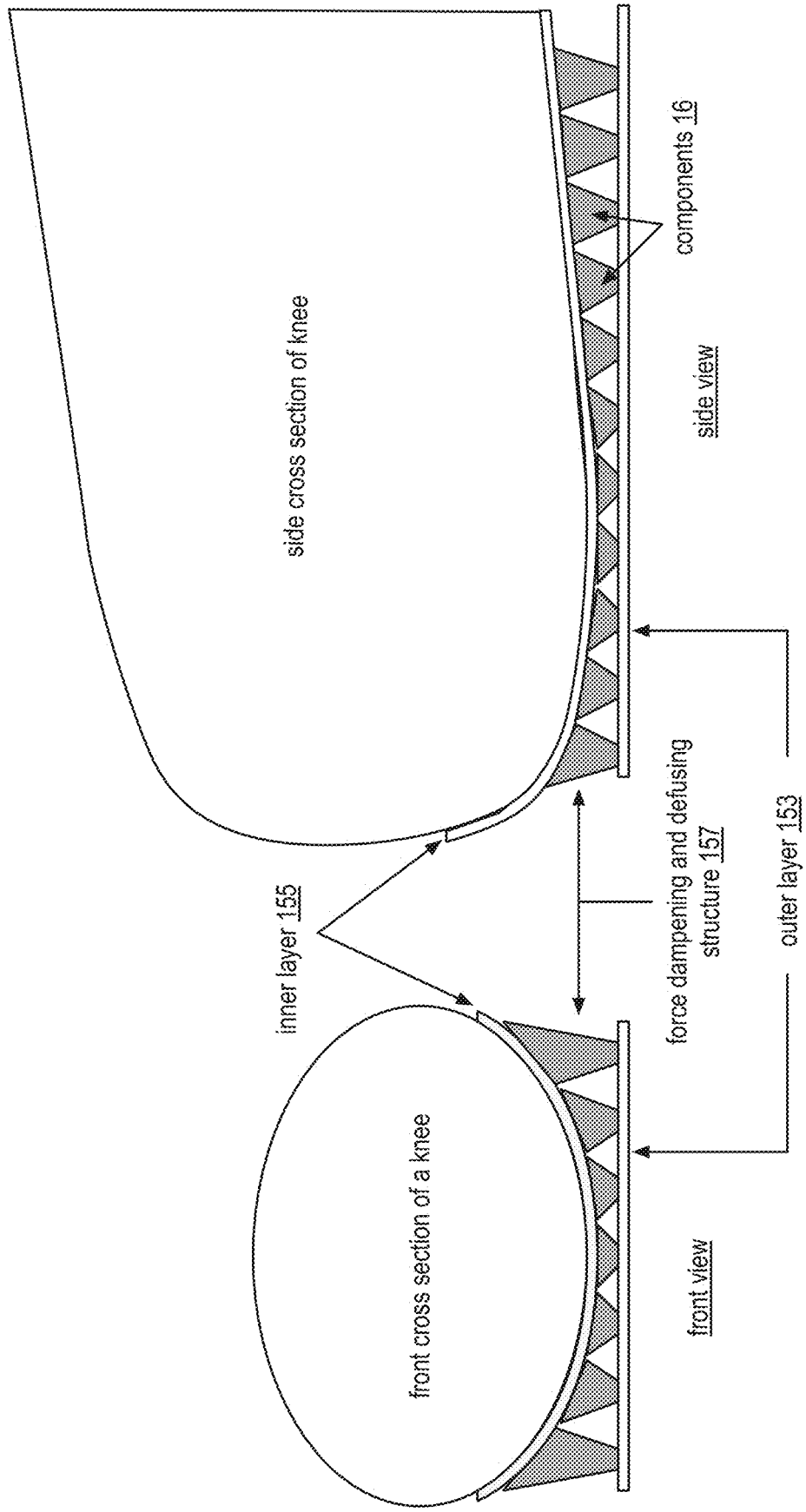


FIG. 25
knee protection apparatus 151

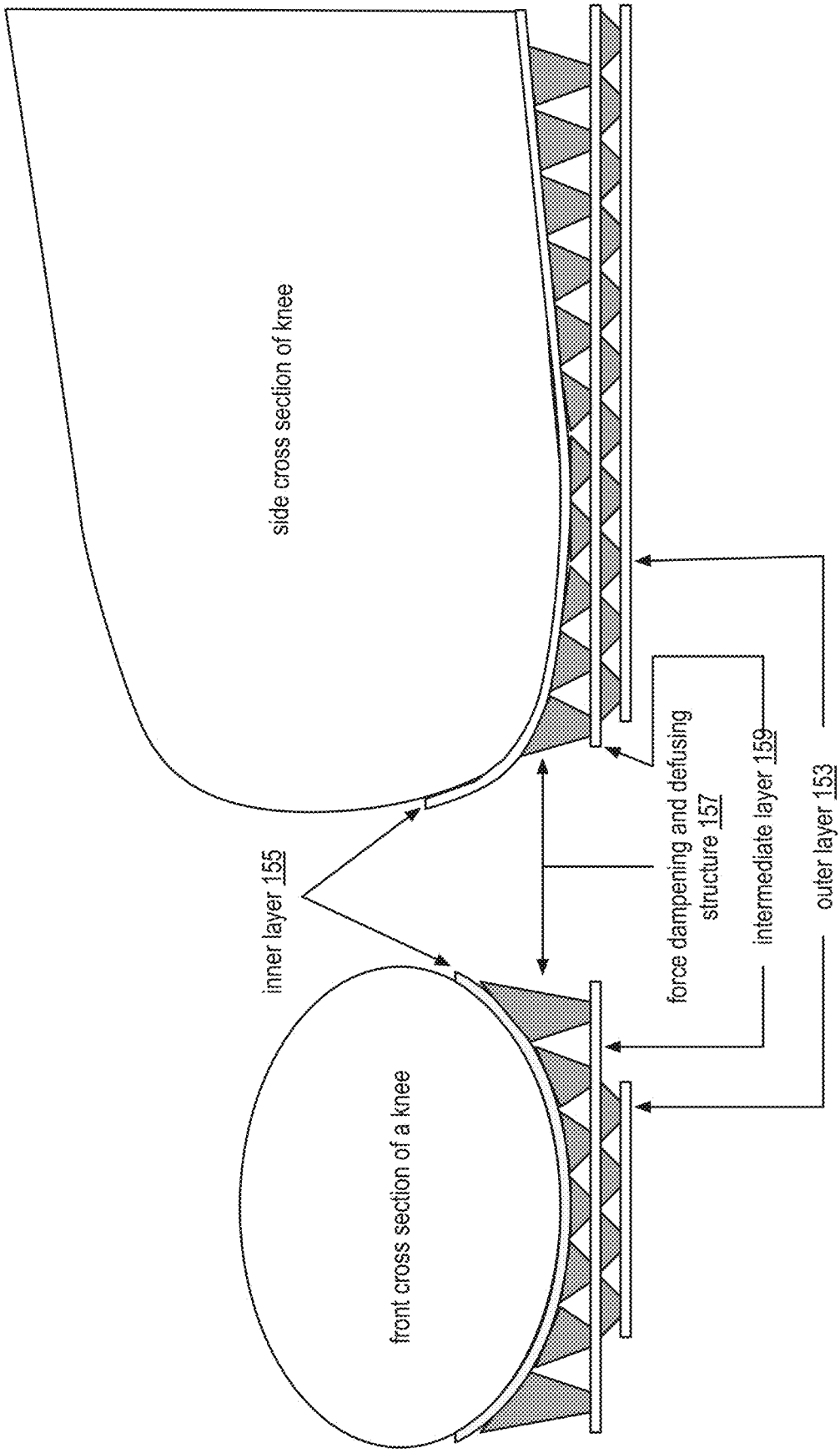


FIG. 26
knee protection apparatus 151

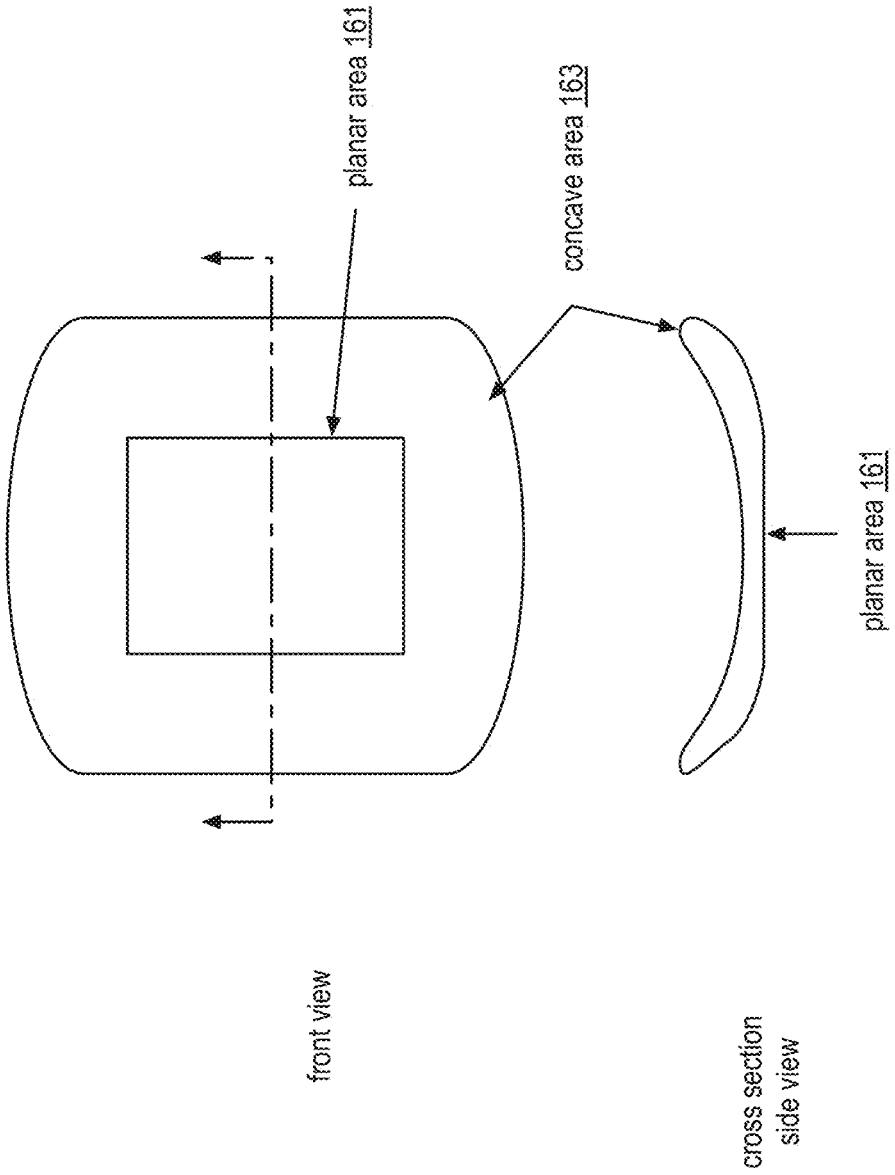


FIG. 27
outer layer 153

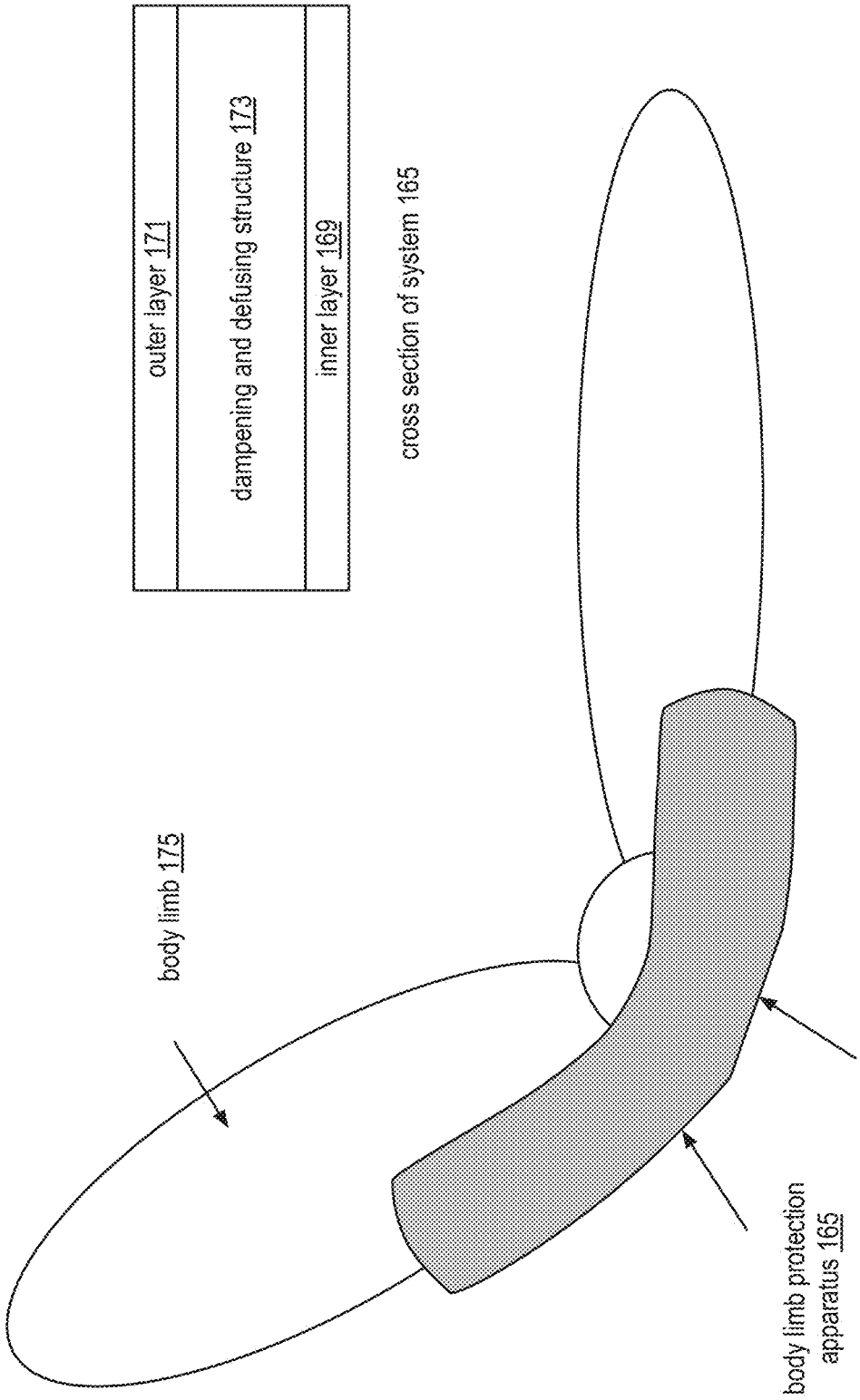

outer layer 171
dampening and defusing structure 173
inner layer 169
cross section of system 165
body limb 175
planar area 167
body limb protection apparatus 165

FIG. 28

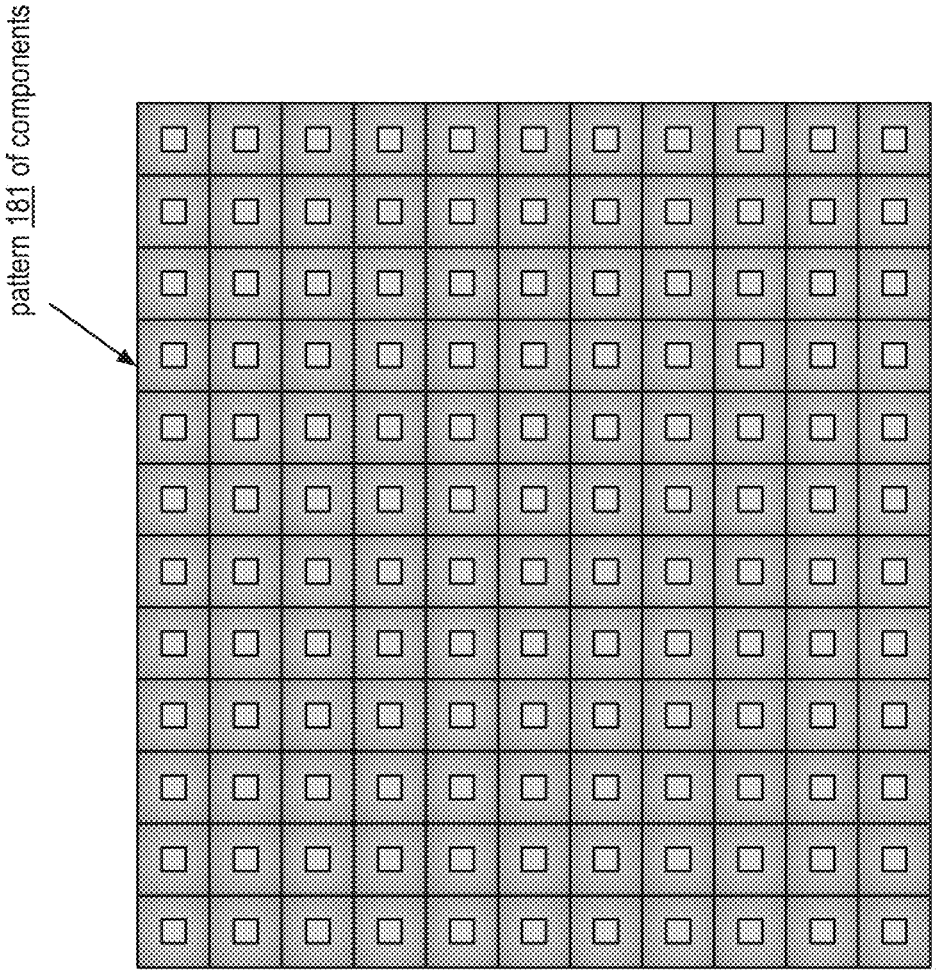


FIG. 29B

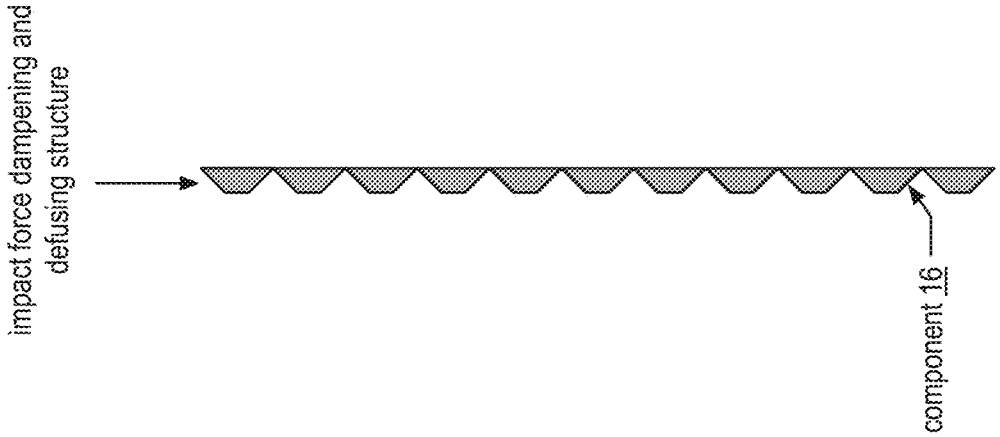


FIG. 29A

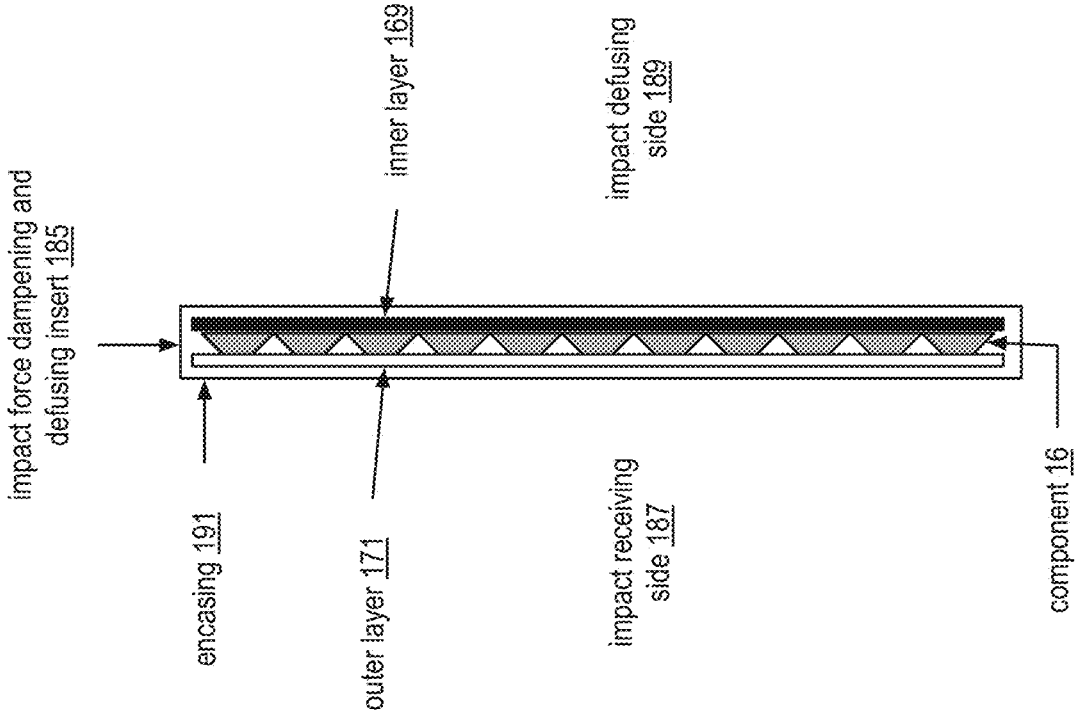

impact force dampening and defusing insert 185
encasing 191
outer layer 171
inner layer 169
impact receiving side 187
impact defusing side 189
component 16

FIG. 30

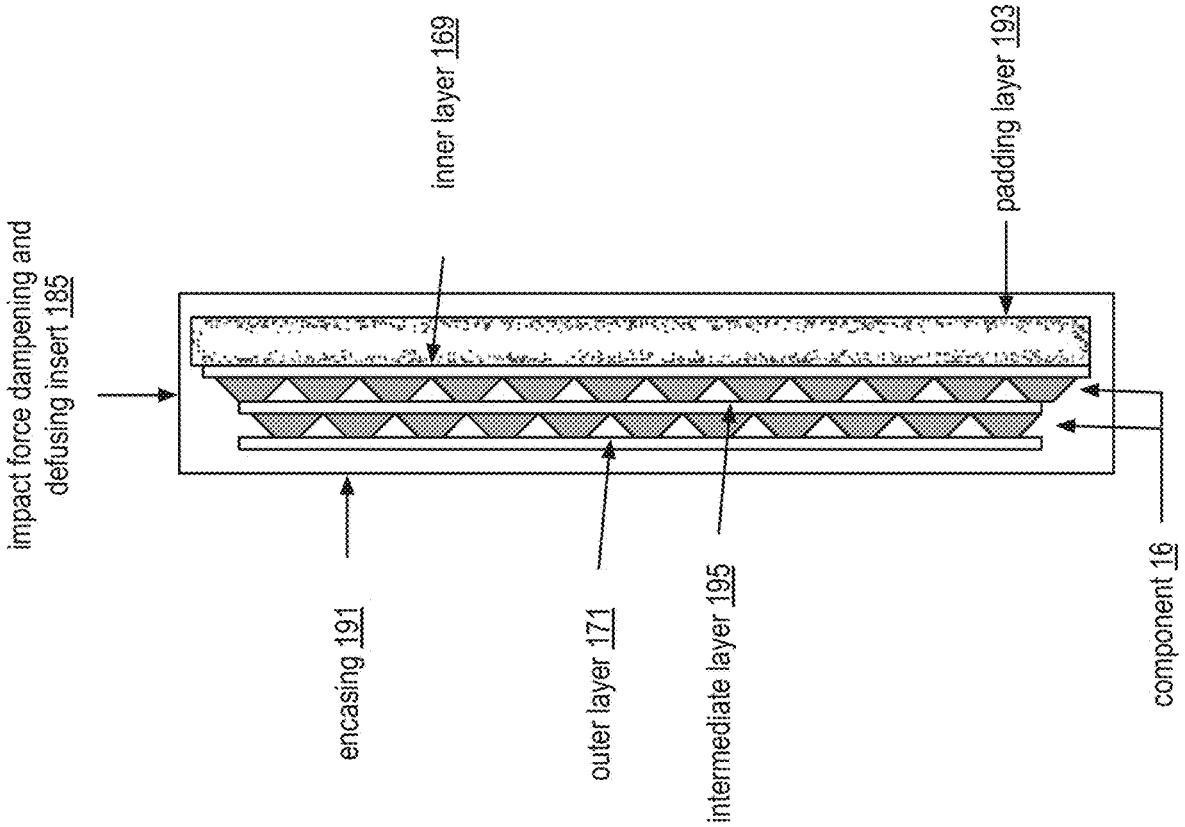

impact force dampening and defusing insert 185
encasing 191
inner layer 169
outer layer 171
intermediate layer 195
padding layer 193
component 16

FIG. 31

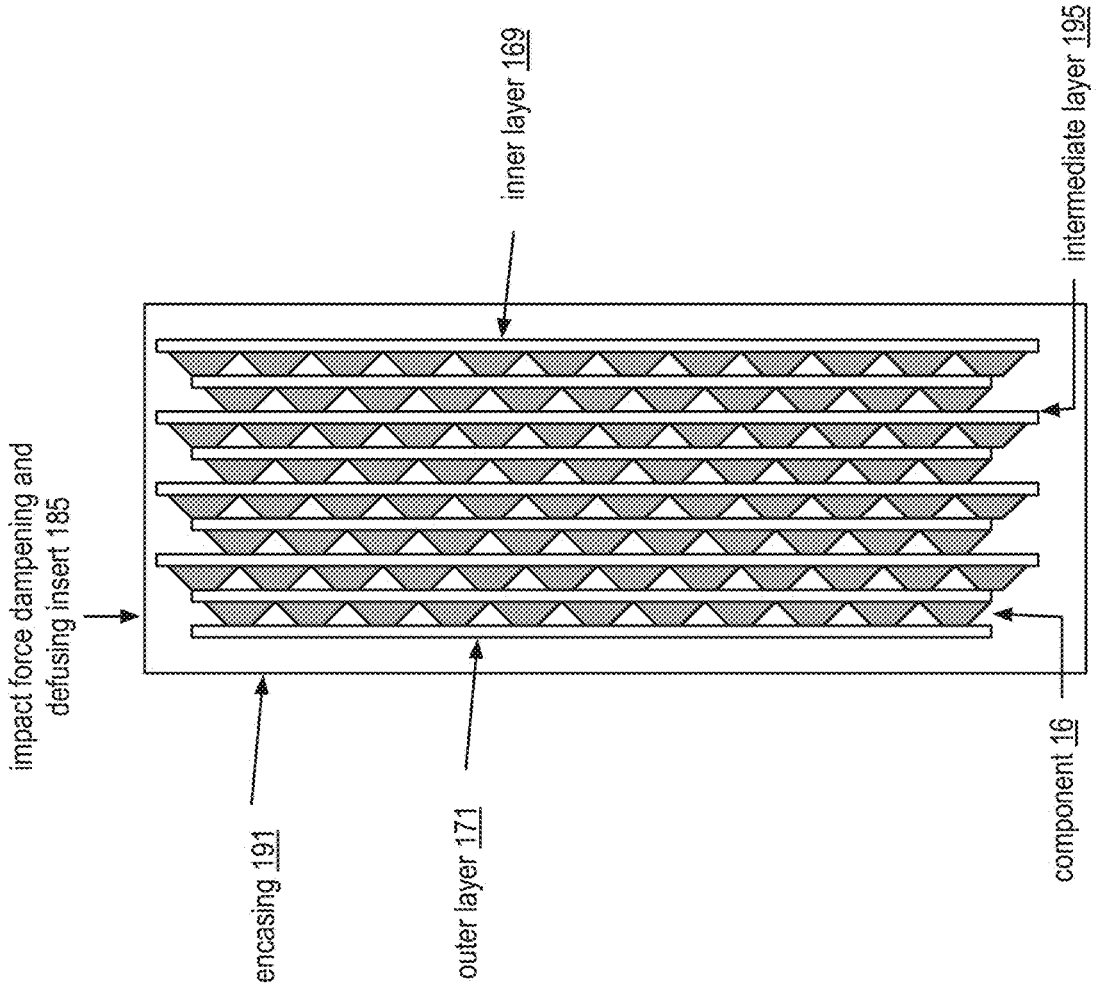

impact force dampening and defusing insert 185
encasing 191
outer layer 171
inner layer 169
component 16
intermediate layer 195

FIG. 32

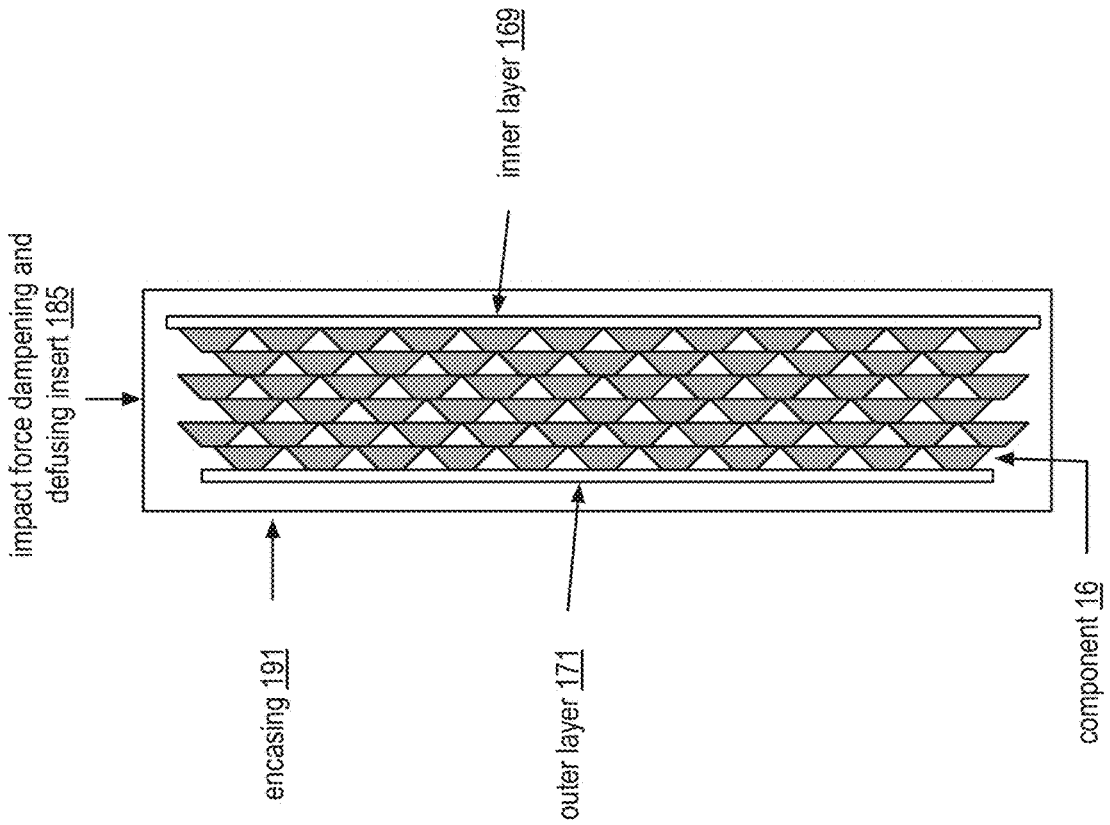

impact force dampening and defusing insert 185
encasing 191
inner layer 169
outer layer 171
component 16

FIG. 33

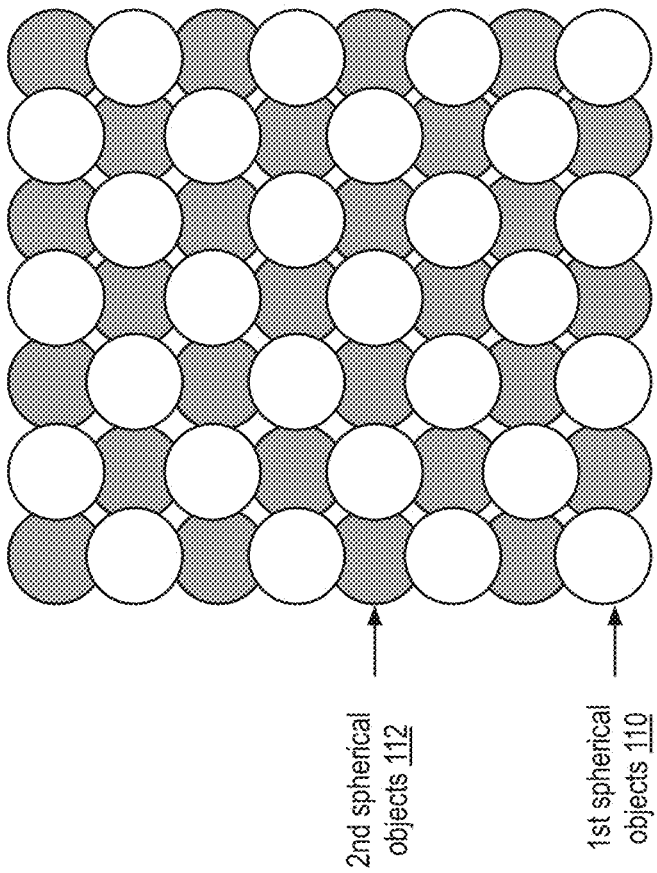

2nd spherical objects 112
1st spherical objects 110

FIG. 35

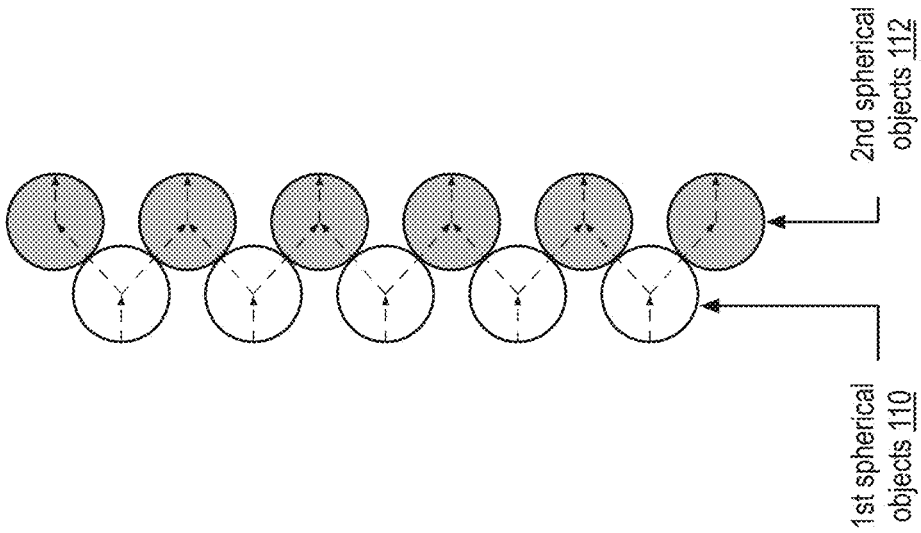

2nd spherical objects 112
1st spherical objects 110

FIG. 34

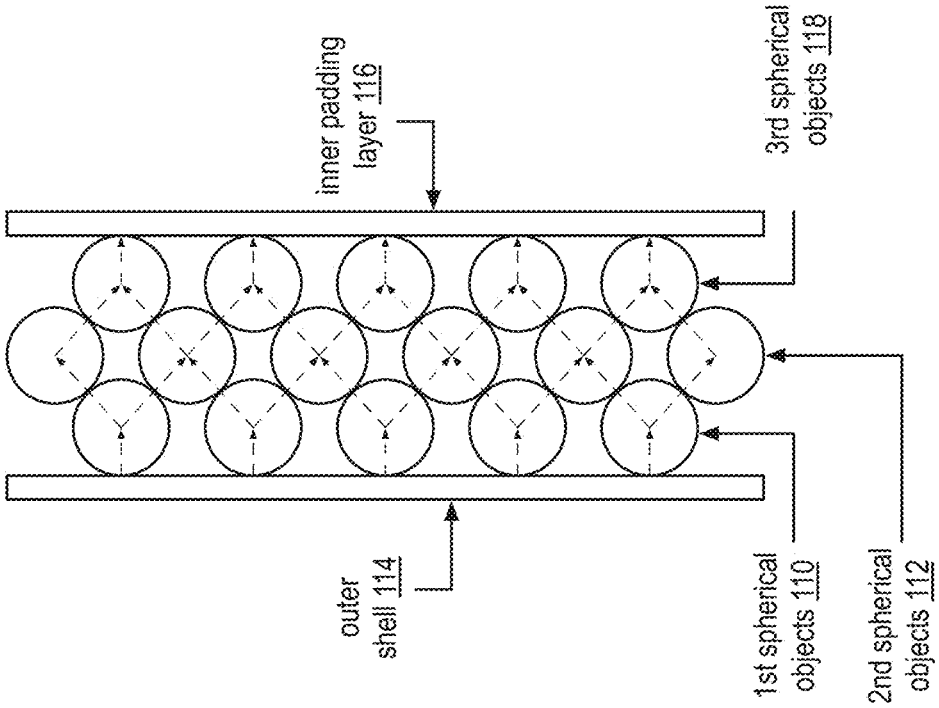

inner padding layer 116
3rd spherical objects 118
outer shell 114
1st spherical objects 110
2nd spherical objects 112

FIG. 37

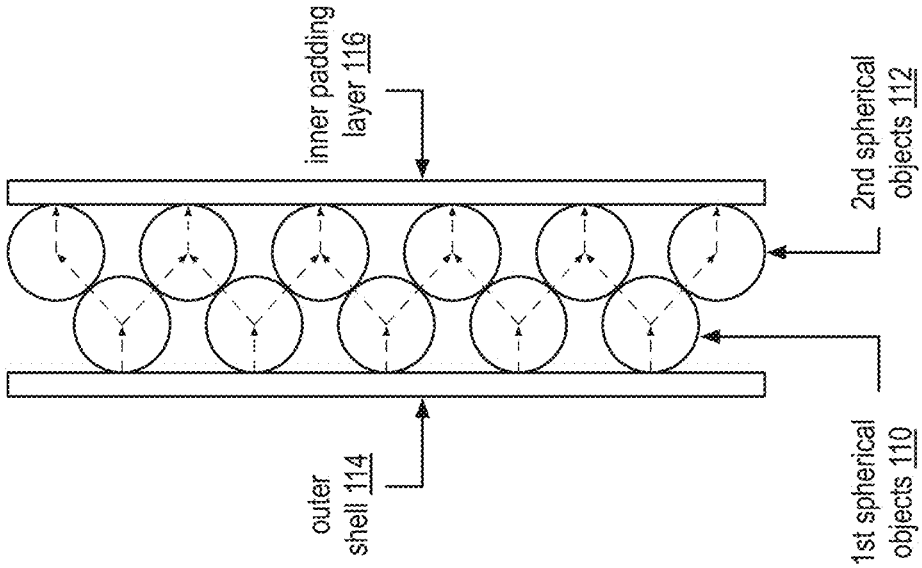

inner padding layer 116
2nd spherical objects 112
outer shell 114
1st spherical objects 110

FIG. 36

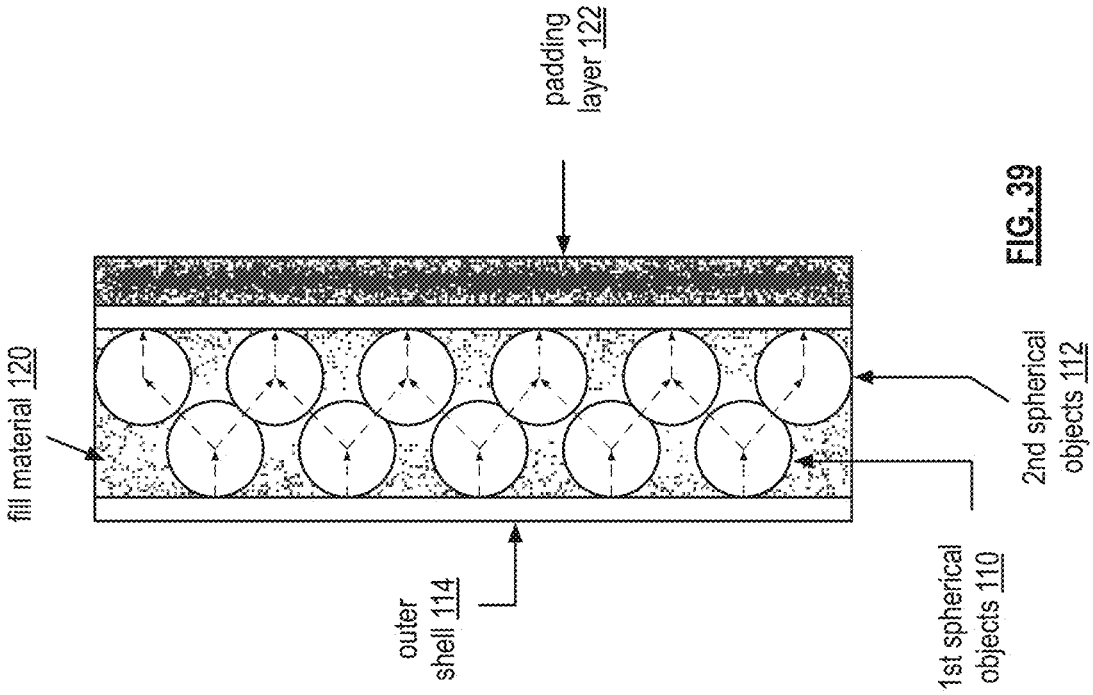

padding layer 122
fill material 120
2nd spherical objects 112
outer shell 114
1st spherical objects 110

FIG. 39

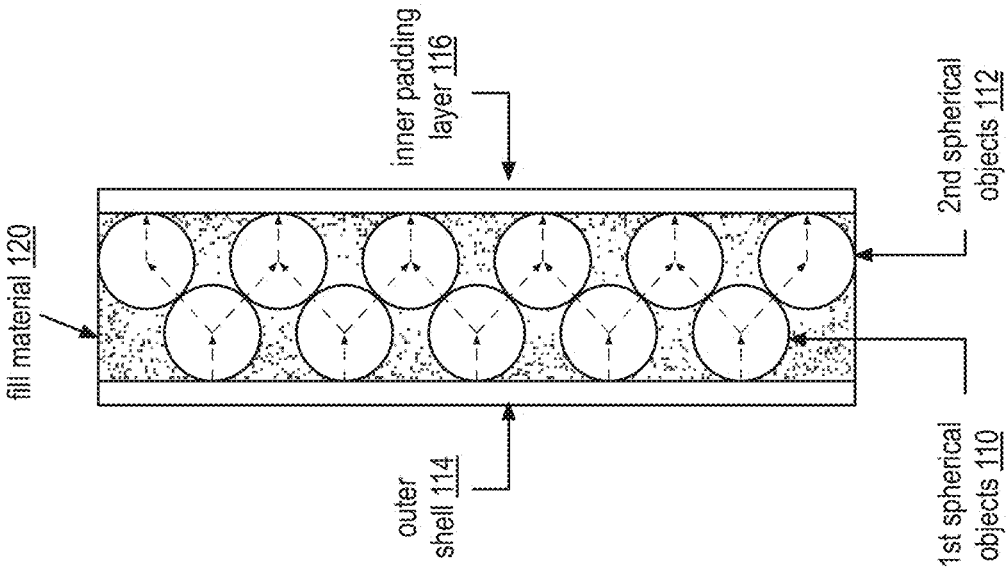

inner padding layer 116
fill material 120
2nd spherical objects 112
outer shell 114
1st spherical objects 110

FIG. 38

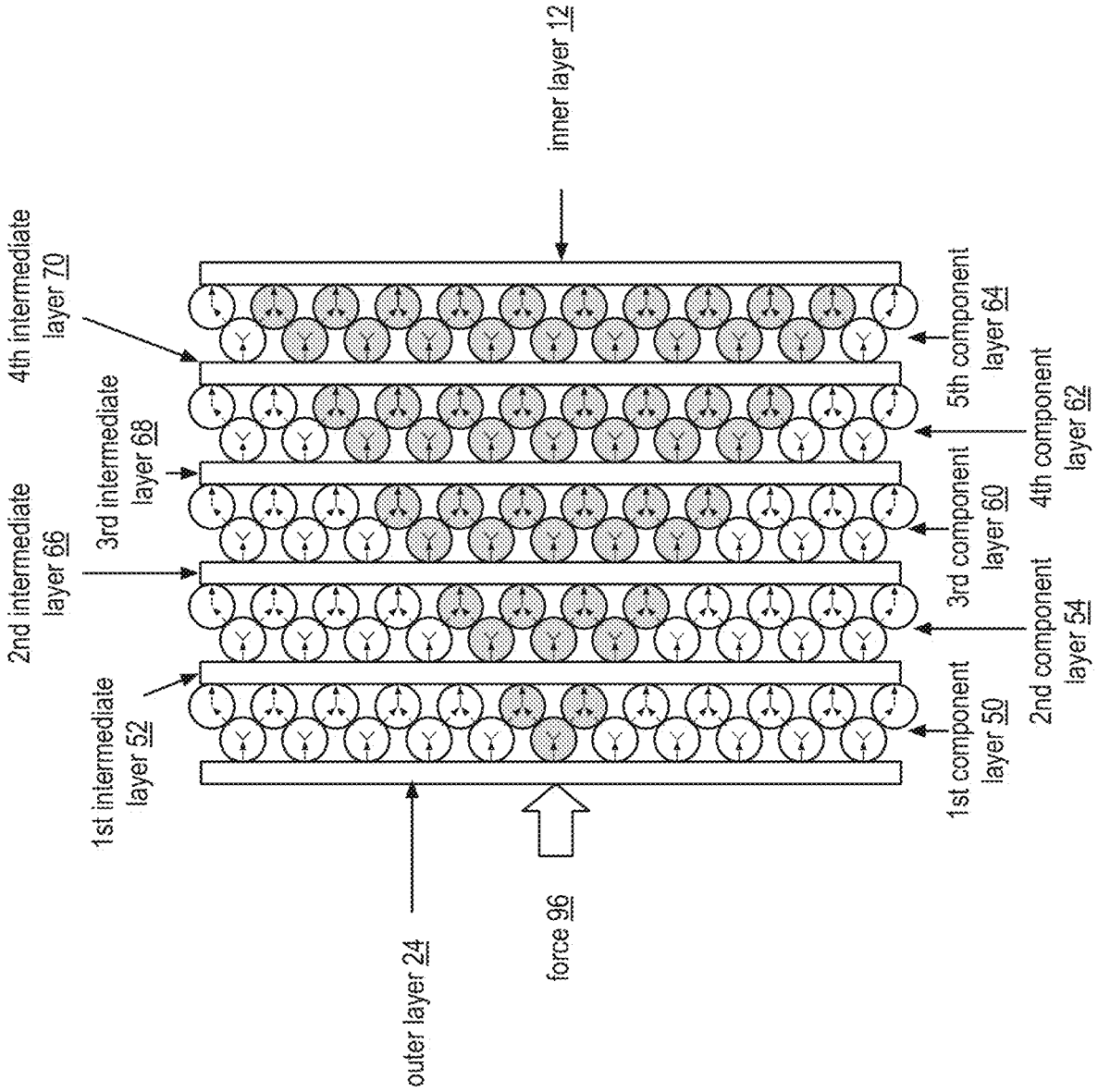

inner layer 12
4th intermediate layer 70
3rd intermediate layer 68
2nd intermediate layer 66
1st intermediate layer 52
5th component layer 64
4th component layer 62
3rd component layer 60
2nd component layer 54
1st component layer 50
outer layer 24
force 96

FIG. 40

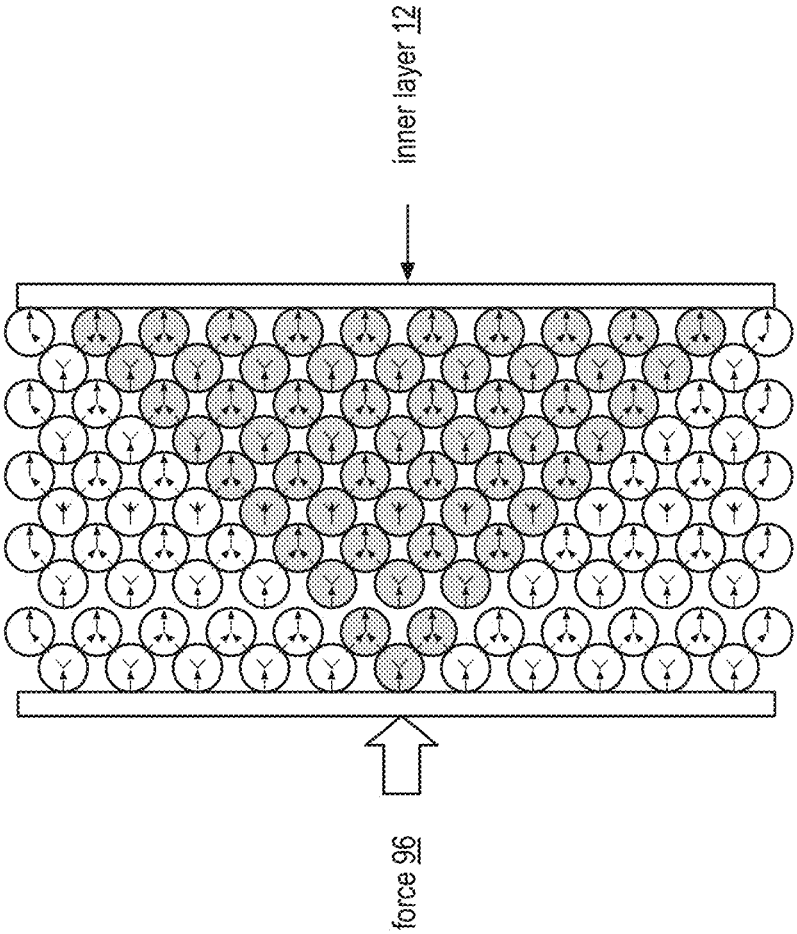


FIG. 41

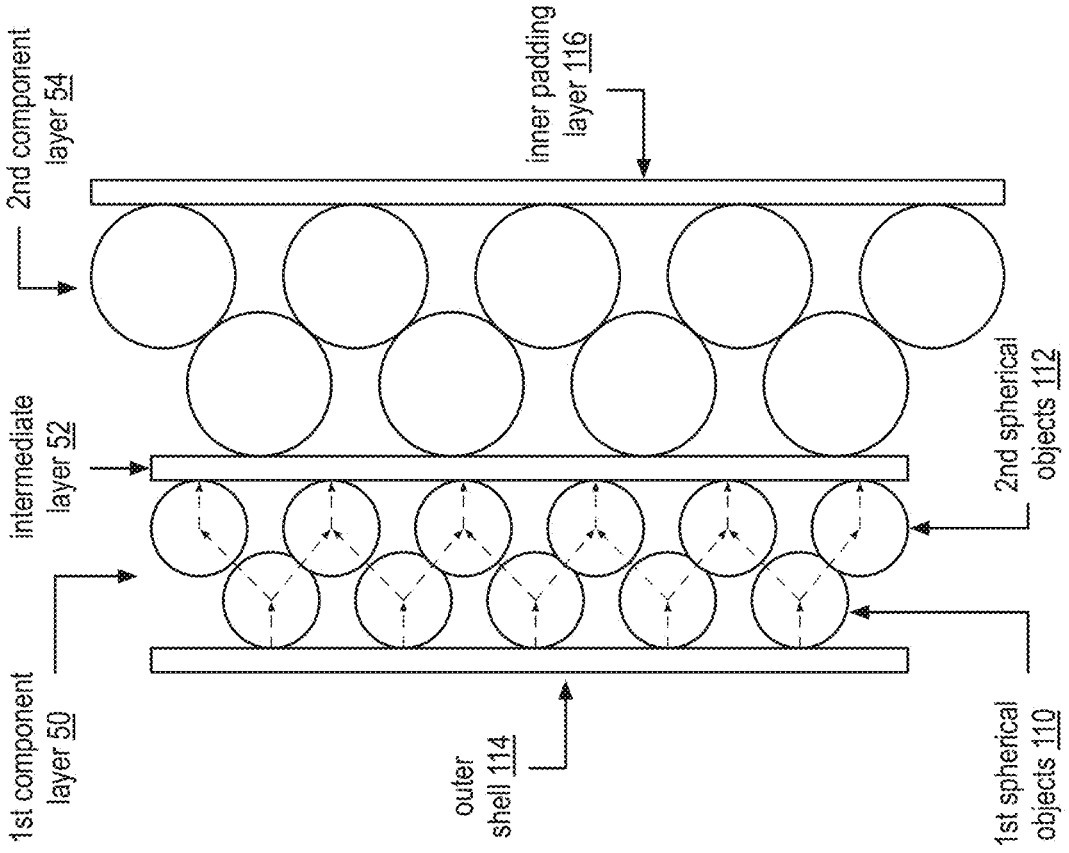
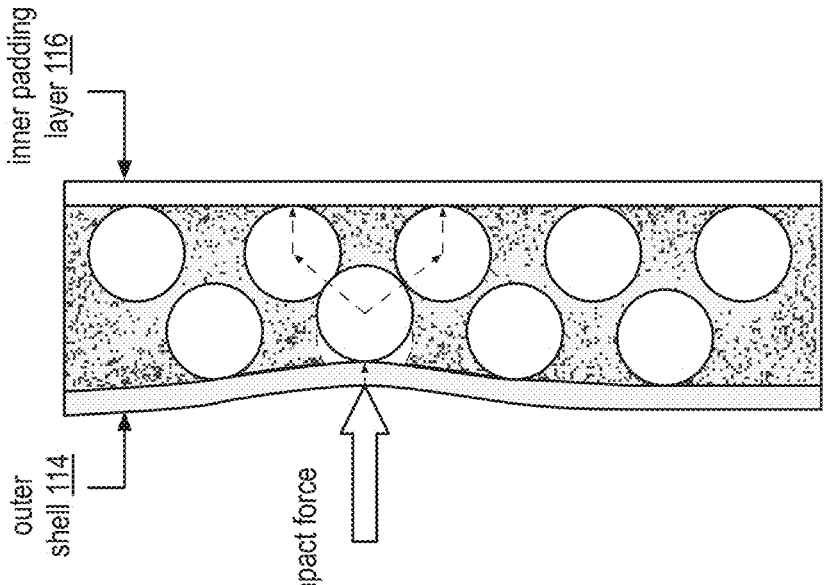

2nd component layer 54
inner padding layer 116
intermediate layer 52
2nd spherical objects 112
1st component layer 50
outer shell 114
1st spherical objects 110

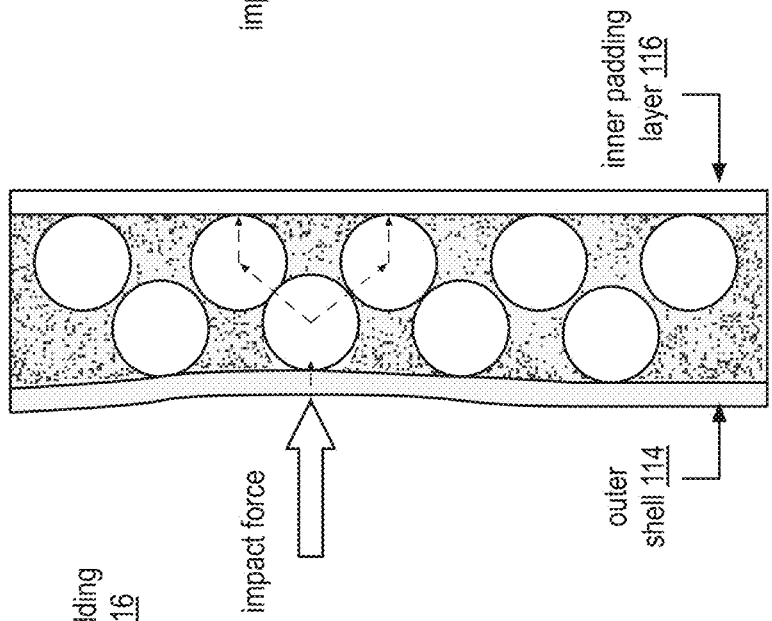
FIG. 42



at impact

FIG. 43C

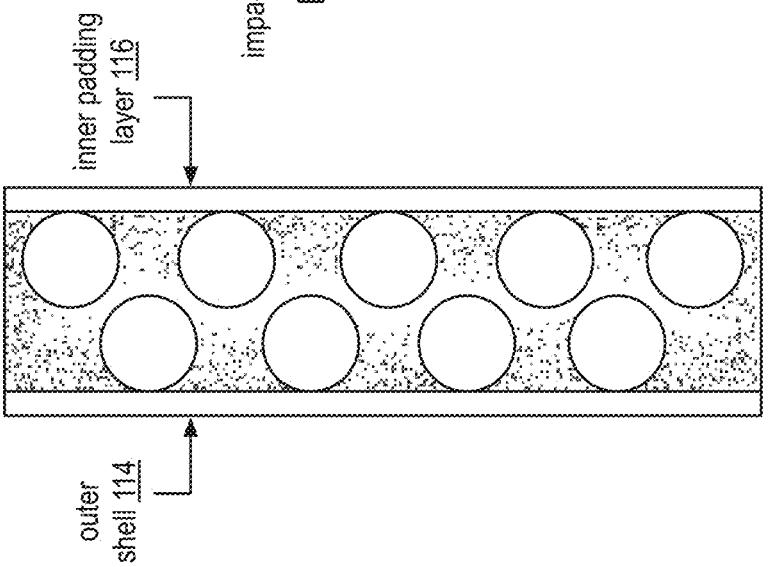
flexible layer receiving the force



at impact

FIG. 43B

rigid layer receiving the force



prior to impact

FIG. 43A

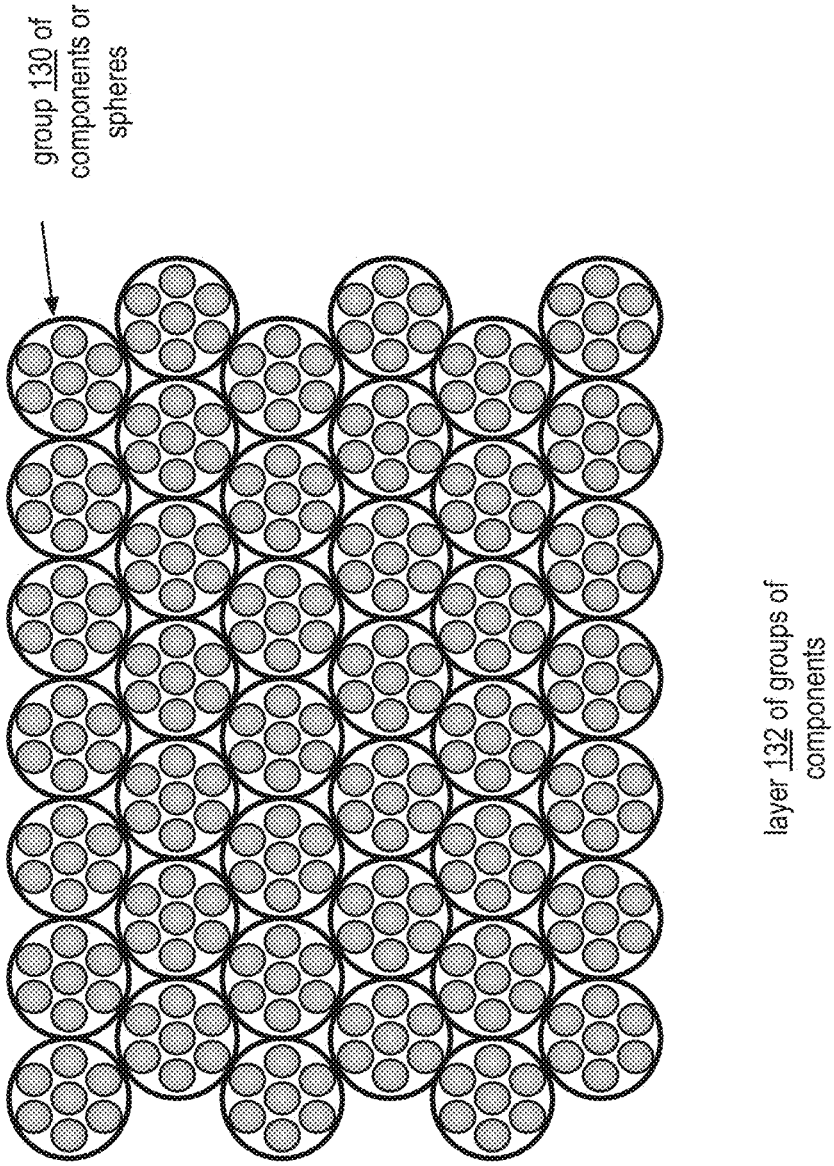

group 130 of components or spheres
layer 132 of groups of components

FIG. 44

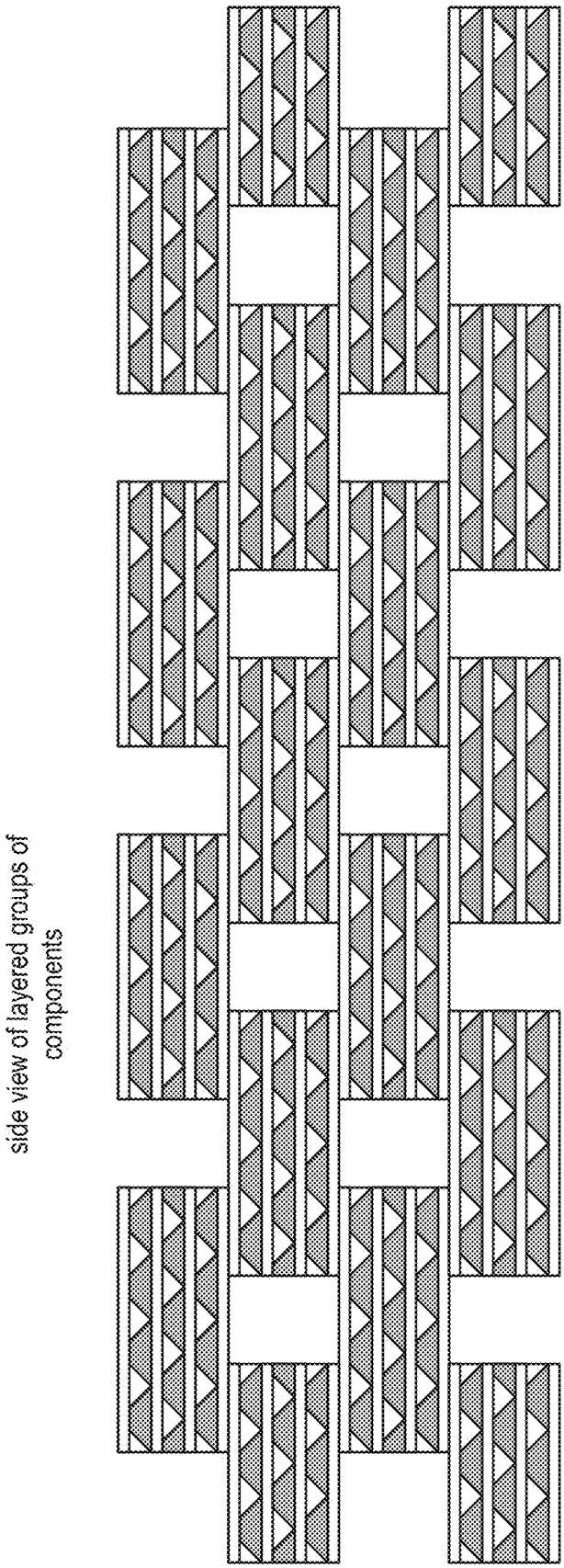


FIG. 45

BODY IMPACT PROTECTION SYSTEM

CROSS REFERENCE TO RELATED PATENTS

The present U.S. Utility Patent Application claims priority pursuant to 35 U.S.C. § 119(e) to U.S. Provisional Application No. 62/375,767, entitled "BODY IMPACT PROTECTION SYSTEM", filed Aug. 16, 2016, which is hereby incorporated herein by reference in its entirety and made part of the present U.S. Utility Patent Application for all purposes.

CROSS REFERENCE TO RELATED PATENTS

NOT APPLICABLE

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

NOT APPLICABLE

INCORPORATION-BY-REFERENCE OF MATERIAL SUBMITTED ON A COMPACT DISC

NOT APPLICABLE

BACKGROUND OF THE INVENTION

Technical Field of the Invention

This invention relates generally to impact protection and more particularly to a protection system that reduces impact pressure resulting from an impact force.

Description of Related Art

Impact protection devices are known to reduce injury to a body part as a result of an impact. Most impact protecting devices include an outer shell and padding to protect the body part, which may be a limb, a joint, a portion of a limb, the back, ribs, the chest, the abdomen, the neck, and/or the head. For example, the impact protecting device is a helmet when the body part is a head.

For most helmets, the outer shell is a rigid material such as plastic, polycarbonate, etc. and the padding includes foam, air bladders, or a combination thereof. Vicis™ makes a football helmet that includes a softer outer shell, a 1½ inch thick core layer, and a foam based form liner.

As is generally accepted in the medical community, a concussion results from a sudden acceleration or deceleration of the head. Such rapid acceleration and declaration of the head can result from a car cash or violent shaking. This medical premise forms the basis for which helmets are tested. The testing of football helmets and other helmets involves dropping a headform wearing the helmet from various heights on to a platform and measuring g-forces from the impact. Thus, helmets are designed to pass g-force based testing.

G-force, however, is not a measure of force. It is a measure of acceleration or deceleration with respect to earth's gravitational field. Thus, for an impact, G-force is a measure of how fast the object decelerations with respect to the earth's gravity. In equation for, G-Force=a/g, where "g" is gravitational force of 32.2 ft/s^2 and "a" is the deceleration of the object from impact, where $a=v^2/2*d$, where "v" is the velocity at impact and "d" is the impact distance. With

G-force being the unit of measure for testing helmets, the only variable in reducing G-Force is impact distance "d". Thus, increasing impact distance is the only way to improve G-force based testing result of helmets. Accordingly, helmets are designed to increase impact distance.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

FIG. **1** is a schematic diagram of an example of a conventional impact protection device receiving an impact force;

FIG. **2** is a diagram of an example graph of the impact protection device of FIG. **1** that plots impact force versus impact area;

FIG. **3** is a schematic block diagram, in a side view, of an embodiment of a body impact protection system in accordance with the present invention;

FIG. **4** is a schematic block diagram, in a side view, of an embodiment of a defusing cell (i.e., component) of a layer of a body impact protection system in accordance with the present invention;

FIG. **5** is a schematic block diagram, in a side view, of an example of force dampening and diffusion by a defusing cell (i.e., component) of a layer of a body impact protection system in accordance with the present invention;

FIG. **6** is a schematic block diagram, in a top view, of an embodiment of a body impact protection system in accordance with the present invention;

FIG. **7** is a schematic block diagram, in a side view, of another embodiment of a body impact protection system in accordance with the present invention;

FIG. **8** is a schematic block diagram, in a side view, of an example of force components within a body impact protection system in accordance with the present invention;

FIG. **9** is a schematic block diagram, in a side view, of another example of force components within a body impact protection system in accordance with the present invention;

FIG. **10** is a graph of an example of impact force components v. body impact area of a body impact protection system in accordance with the present invention;

FIG. **11** is a schematic block diagram, in a side view, of another embodiment of a body impact protection system in accordance with the present invention;

FIG. **12** is a schematic block diagram, in a top view, of another embodiment of a body impact protection system in accordance with the present invention;

FIG. **13** is a schematic block diagram, in a side view, of another example of force components within a body impact protection system in accordance with the present invention;

FIGS. **14**A-**14**B are a schematic block diagram of an example of force defusing and distribution layer by layer within a body impact protection system in accordance with the present invention;

FIG. **15** is a schematic block diagram, in a side view, of another embodiment of a body impact protection system in accordance with the present invention;

FIG. **16**A is a graph of an example of an impact force pulse v. time;

FIG. **16**B is a graph of an examples of frequency responses of different layers of a body impact protection system having different resonant frequencies in accordance with the present invention;

FIGS. **17**A-**17**E are a schematic block diagram of an example of force defusing and distribution layer by layer within a body impact protection system in accordance with the present invention;

FIG. **18** is a schematic block diagram, in a side view, of another embodiment of a body impact protection system in accordance with the present invention;

FIG. **19** is a schematic block diagram, in a side view, of another embodiment of a defusing cell of a layer of a body impact protection system in accordance with the present invention;

FIG. **20** is a schematic block diagram, in a side view, of another embodiment of a defusing cell of a layer of a body impact protection system in accordance with the present invention;

FIGS. **21**A-**21**F are a schematic block diagrams, in a top view, of other embodiments of a defusing cell of a layer of a body impact protection system in accordance with the present invention;

FIGS. **21**G-**21**J-**2** are diagrams of another defusing cell or component in accordance with the present invention;

FIGS. **21**K-**21**N are diagrams of another defusing cell or component in accordance with the present invention;

FIGS. **21**O and **21**Q-**21**S-**2** are diagrams of another defusing cell or component in accordance with the present invention;

FIG. **21**T is a top and side view of a layer of components in accordance with the present invention;

FIGS. **21**U-**21**V are diagrams of another defusing cell or component in accordance with the present invention;

FIGS. **21**W-**21**X are diagrams of another defusing cell or component in accordance with the present invention;

FIG. **21**Y is a side view of a layer of components in accordance with the present invention;

FIGS. **21**Z-**21**AB are diagrams of another defusing cell or component in accordance with the present invention;

FIG. **21**AC is a top view of a layer of components in accordance with the present invention;

FIG. **21**AD is a top view of a layer of components in accordance with the present invention;

FIG. **21**AE is a top view of a layer of components in accordance with the present invention;

FIG. **21**AF is a top view of two overlapping layers of components in accordance with the present invention;

FIG. **22** is a schematic block diagram, in a side view, of another embodiment of a layer of a body impact protection system in accordance with the present invention;

FIG. **23**A is a schematic block diagram, in a cross section front view, of an embodiment of a helmet at the instant of an impact.

FIG. **23**B is a schematic block diagram, in a cross section front view, of an embodiment of a helmet at compression of the padding as result of an impact.

FIG. **23**C is a schematic block diagram, in a cross section front view, of an embodiment of a helmet at movement of the brain within the skull as result of an impact.

FIG. **23**D is a schematic block diagram, in a side view, of an embodiment of a helmet that includes a body impact protection system in accordance with the present invention;

FIG. **23**E is a schematic block diagram, in a side view, of a portion of an embodiment of a helmet that includes a body impact protection system in accordance with the present invention;

FIG. **23**F is a schematic block diagram, in a side view, of a portion of an embodiment of a helmet that includes a body impact protection system receiving an angular impact force in accordance with the present invention;

FIG. **23**G is a schematic block diagram, in a side view, of a portion of an embodiment of a helmet that includes a body impact protection system dampening and defusing an angular impact force in accordance with the present invention;

FIG. **24**A is a schematic block diagram, in a side view, of an embodiment of a chest protector that includes a body impact protection system in accordance with the present invention;

FIG. **24**B is a schematic block diagram, in a side view, of an embodiment of a chest protector that includes a body impact protection system in accordance with the present invention;

FIG. **25** is a schematic block diagram, in a side view, of an embodiment of a knee protection apparatus that includes a body impact protection system in accordance with the present invention;

FIG. **26** is a schematic block diagram, in a side view, of another embodiment of a knee protection apparatus that includes a body impact protection system in accordance with the present invention;

FIG. **27** is a schematic block diagram, in a side view, of an embodiment of a body impact protection system for use in a knee protection apparatus in accordance with the present invention;

FIG. **28** is a schematic block diagram, in a side view, of an embodiment of a body limb protection apparatus that includes a body impact protection system in accordance with the present invention;

FIG. **29**A is a schematic block diagram, in a side view, of another embodiment of a body impact protection system in accordance with the present invention;

FIG. **29**B is a schematic block diagram, in a top view, of another embodiment of a body impact protection system in accordance with the present invention;

FIG. **30** is a schematic block diagram, in a side view, of an embodiment of a force defusing inert for use in an impact protection system in accordance with the present invention;

FIG. **31** is a schematic block diagram, in a side view, of another embodiment of a force defusing inert for use in an impact protection system in accordance with the present invention;

FIG. **32** is a schematic block diagram, in a side view, of another embodiment of a force defusing inert for use in an impact protection system in accordance with the present invention;

FIG. **33** is a schematic block diagram, in a side view, of another embodiment of a force defusing inert for use in an impact protection system in accordance with the present invention;

FIG. **34** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention;

FIG. **35** is a schematic block diagram, in a top view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention;

FIG. **36** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention;

FIG. **37** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention;

FIG. **38** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention;

FIG. **39** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention;

FIG. **40** is a schematic block diagram, in a side view, of an example of force diffusion via force defusing layers for use in an impact protection system in accordance with the present invention;

FIG. **41** is a schematic block diagram, in a side view, of another example of force diffusion via force defusing layers for use in an impact protection system in accordance with the present invention;

FIG. **42** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention;

FIGS. **43**A-**43**C are schematic block diagrams, in a side view, of examples of impact force dampening and diffusion via force defusing layers of an impact protection system in accordance with the present invention;

FIG. **44** is a schematic block diagram, in a top view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention; and

FIG. **45** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a schematic diagram of an example of a conventional impact protection device **5**, which may be a helmet, receiving an impact force **11**. The impact protection device **5** includes an outer surface **7** (e.g., a hard-plastic shell) and padding **9** (e.g., a foam, air bladders, or a combination thereof). For this example, assume that the impact protection device **5** is a conventional football helmet and the impact force **11** is causes by a collision with another football helmet.

Given the spherical nature of football helmets, a helmet to helmet collision creates a small impact area (e.g., about the size of a dime). At impact, the impact force **11** creates a surface shock wave response **15** and a normal impact force component **17**. The surface shock response **15** is a surface wave at the resonant frequency of the outer surface **7**. As a practical example, the impact force **11** creates a wave pattern similar to waves created from a rock being dropped still water.

The normal impact force **17** has a magnitude that is similar to that of the impact force **11** and follows a path that corresponds to the outer surface impacted area **13** towards the head (i.e., body part **21**). As the normal impact force **17** is traversing this path, it is dampened by the padding. A concentration of the dampened normal impact force is asserted against the head in a primary body part impact area **19**. Through conventional padding, the primary body part impact area **19** is approximately the same size as the outer surface impacted area **13**.

With conventional football helmets being tested on G-Force measurements, the effectiveness of the padding dictates the tested effectiveness of the helmet. G-force testing, however, is an incomplete testing metric for determining concussion safety of helmets. To illustrate the incompleteness of G-Force measurements, consider a nine-inch hunting knife with a five-inch blade dropped forty-two inches into modeling clay with the blade down and then with the handle down. The following table shows that the blade down has a G-Force that is about 5 times less than the G-Force with the handle down. Using the G-Force measurements of helmet testing protocols as an indication of injury prevention, the handle down presents significantly more risk and severity of injury than the blade down.

Measurement	Blade Down	Handle Down
weight	0.3 lbs	0.3 lbs
drop height	42 inches	42 inches
impact distance	0.89 inches	0.18 inches
velocity	15.01 ft/sec	15.01 ft/sec
deceleration	1,519 ft/sec2	7,513 ft/sec2
G-Force	47 G's	221 G's
average impact force (lbs)	14 lbs	66 lbs
average impact area	0.032 in2	0.866 in2
average impact pressure	442.4 lbs/in2	76.6 lbs/in2

Yet, when mass, impact force, impact area, and impact pressure are taken into account, a much clearer picture of the risk and severity of injury is revealed. From the above table, the blade has a significantly smaller area than the handle. Even though the blade down has a smaller impact force, the blade down has a significantly greater impact pressure (almost 6 to 1)! Note that the impact area of the blade is an average and is significantly smaller at the tip; making the initial impact pressure of the blade even greater (e.g., over 1,000 pounds per square inch).

Due to the spherical nature of the head, protective headgear is also spherical. As such, in a helmet-to-helmet impact or helmet-to-ground impact, the helmet surface impact area **13** is about the size of dime to about the size of a silver dollar. Preliminary testing indicates that conventional football helmets do little to expand the impact area from the surface of the helmet to the head. Thus, even if a helmet dampens the impact force by about 97.5%, the impact pressure to the head may still be substantial.

For example, assume a 200-pound player traveling at 16 miles per hours collides head first and comes to a complete stop in 1.25 inches. This creates a G-force of 82 g's (which is at the low end of possible concussion range of 100 g's+/−30 g's). Continuing the analysis, this impact creates an external impact force **11** of about 16,400 force-pounds. Assume the padding reduces the impact force by 96% such that the normal impact force reaching the head is about 650 force-pounds. If the primary body impact area **19** is also about the size of a dime (e.g., 0.375 square inches), then the pressure (e.g., force/area) applied to the head is about 1,750 pounds per square inch (PSI)! This creates a very large localized force being applied to a small area of the head that is likely to cause a head injury.

FIG. **2** is a diagram of an example graph of the impact protection device of FIG. **1** that plots impact force versus primary body part impact area. In this example, the vertical axis corresponds to impact force that reaches the body part and the horizontal axis represents the surface area of a body part (e.g., head). The dampened normal impact force **17** that reaches the body includes a plurality of impact force components dispersed over an area of the body part creating a force gradient. The force components with the largest magnitudes are concentrated in the primary body part impact area. As the distance from the primary body part impact area increases, the magnitude of the force components rapidly decrease. From this illustration, the impact pressure (i.e., impact force/impacted area) is large.

To illustrate further illustrate that G-force is an incomplete measure of concussion safety and that impact pressure is a much more accurate measure, consider that a standing person turns at a velocity of 2.2 feet/second and bumps her head on an edge of a pipe. Assume that the impact distance is 1/16 inch, the impact area of 1/16 in^2, and a mass of her head of 11 pounds. From these values the following metrics are obtained: G-Force of 14.4 g's, an average impact force of 158 pounds, and an average impact pressure of 2,560 PSI. While the g-force was very low, the pressure was very large, which caused a severe concussion for which the person missed weeks of work. As such, when impact force components are in a small impact area, the pressure can be very significant, which can cause severe injury.

FIG. **3** is a schematic block diagram, in a side view, of an embodiment of a body impact protection system **10** that includes an impact force dampening and defusing structure **14** and an inner layer **12**. The inner layer **12** supports components **16** of the impact force dampening and defusing structure **14**. The components **16** may be of any size (i.e., height, width, circumference, radius, diameter, perimeter, and/or depth), any shape, and/or any material composition provided the side walls of the components are angled and the outer surface area (i.e., away from the body part **8**) is less than the inner surface area (towards the body part **8**).

With reference to FIG. **4**, a component **16**, from a side view, includes an angled side wall(s) **71** (e.g., a side structure), an impact receiving surface area **70** (e.g., a top that is away from the body part), a body impact surface area **72** (e.g., a base that is towards the body part), and a distance "d" **74**. The distance "d" **74** is the distance between the body impact surface area **72** and the impact receiving area **70** and ranges from 1/32 of an inch to multiple inches, depending on the application of the body impact protection system. The angled side wall(s) **71** that is/are at an angle of θ with respect to the horizontal axis, where the angle is in the range of 25 degrees to 89 degrees. Depending on the angle θ and the distance "d", the body impact surface area **72** is two or more times larger than the impact receiving surface area **70**, where the impact receiving surface area is 1/256 square inches (e.g., 1/16 by 1/16) to tens of square inches depending on the application of the body impact protection system. Various embodiments and examples of the components **16** are described in one or more subsequent figures.

The component **16** is constructed (e.g., molded, press-formed, printed, etc.) of a material composition that includes one or more of a rubber material, a foam material, a padding material, a plastic material, a gel material, a carbon fiber material, a cloth material; a polyester material, a moisture absorbing material, a moisture wicking material and a silicon material. A characteristic of the material composition is that the component retains the angle θ within +/−33% and retains the ratio of Ai to Ao to within +/−33%. Distance "d" may decrease while the impact force is being applied, but substantially returns to its pre-impact force value when the impact force is removed.

Returning to the discussion of FIG. **3**, the inner layer **12** provides a supporting structure for the components **16** and provides some dampening of the impact force **18**. The inner layer **12** is comprised of rubber, foam, air bladder, corrugated fiberboard pads, a plastic material, a gel material, a carbon fiber material, a cloth material, a polyester material, a moisture absorbing material, a moisture wicking material, an expanding polystyrene, a polypropylene, a polyethylene, a polyurethane, a rubber, a silicon, and/or a gel. In one example embodiment, the components **16** are adhered to the inner layer **12** by an adhesive, by molding, by three-dimensional printing, and/or other means. In another example embodiment, the inner layer **12** includes receptacles in which the inner surface area of the components is placed with or without an adhesive. In both examples, the components **16** on the same layer move independently from each other as a result of an impact force **18**.

In an example, the body impact protection system **10** is protecting a body part **8** (e.g., head, a limb, the core, etc.) from an impact force **18** created by an impacting object (e.g., another person's head, elbow, shoulder, etc., from the ground, from a ball, from a projectile, etc.). The impacting object strikes the outer surface area (or portion thereof) of one or more components creating an average impact force **18** over a system impact area **20**. The average impact force **18** includes a plurality of impact force components distributed across the system impact area **20**.

Based on the nature of impact, some of the impact force components will have a magnitude that is greater than the magnitude of the average impact force. For example, in a sphere to sphere impact, the impact force components in the middle of the impact area will have greater magnitudes than impact force components are at the perimeter of the impact area. As another example, in a flat surface to flat surface impact, the impact force components across impact area will have about the same magnitudes.

The component(s) **16** receiving the average impact force **18** dampens and defuses it. A component dampens the average impact force **18** based on the angle of the side walls and defuses it based on the difference between the outside surface area and the inside surface area. With reference to FIG. **5**, the component dampens the average impact force **18** (F**1**) based on the sine of the angle θ. For example, of the angle θ is 45 degrees, then the impact force is dampened by sin θ=0.707. As such, the resulting average impact force (F**2**)=F**1***sin θ, which, in the present example, is F**2**=0.707*F**1**.

Impact pressure is "impact force" divided by impact area. For the outer surface, the impact pressure is F**1**/Ao, where Ao is the outer surface area and, for the inner surface, the impact pressure is F**2**/Ai, where Ai is the inner surface area. Continuing with the example, if Ai is 9 times Ao, then the inner impact pressure is 0.707/9 (7.8%) of the outer impact pressure via just one cell or component.

FIG. **6** is a schematic block diagram, in a top view, of an embodiment of a body impact protection system **10** that includes the inner layer **12** supporting a plurality of components **16** forming an impact force dampening and defusing structure **14**. The components **16** are shown to have a conical shape and are all of the same size and shape. In other embodiments, the components have a shape other than conical and/or are of different sized and/or of different shapes. In another embodiment, a fill material is injected, sprayed, placed, etc. between the components **16**. The fill material is softer that the material of the component (i.e., the fill material will compress more from an impact force than the component), which includes one or more of a gel, foam, etc.

In an example, the impact force impacts three components **16** having a system impact area **20**. Each of the three components dampens their respective portion based on the side wall angle θ, the material composition of the component, and/or the distance "d". Each component further diffuses the dampened impact by spreading it over a larger area. In this example, the body part impact area **22** is significantly larger than the system impact area **20**. As such, the pressure applied to the body part is significantly less that the pressure exerted in the system impact area **20**.

FIG. **7** is a schematic block diagram, in a side view, of another embodiment of a body impact protection system **10** that is similar to the body impact protection system **10** of FIG. **3** with the addition of an outer layer **24**. The outer layer **24** may be comprised on the same material as the inner layer **12** or a different material. Each of the inner and outer layers **12** and **24** are 1/16 inch to 3/4 inch thick depending on the application of the body impact protection system **10**.

FIG. **8** is a schematic block diagram, in a side view, of an example of force components within a body impact protection system **10**. In this example, the body impact protection system **10** includes an inner layer **12**, an impact force dampening and defusing structure **14**, and an outer layer **24**. The impact force dampening and defusing structure includes one or more layers of components **16** and the inner layer **12** is positioned proximal to a body part **8**.

When on object (e.g., another person, a ball, the ground, etc.) collides with the body impact protection system **10**, it creates an average impact force **18** over a system impact area **20**. The average impact force **18** is calculated as $F=KE/d$, where KE is the kinetic energy at impact and d is the impact distance (i.e., the distance the object travels at the moment of the collision until it stops or the collision is over). The kinetic energy (KE) is calculated as $KE=0.5*m*v^2$, where m is the mass of the object and v is the velocity of the impact at the instant of collision. For a falling object, velocity (v) is calculated as $v=(2*g*h)^{1/2}$, where g is the gravitational field of earth and his the height the object has fallen. Deceleration of the object is calculated as $a=v^2/2*d$ and the G-Force of the object is calculated as $G=a/g$.

The components of the impact force dampening and defusing structure **14** provide a collision angle **26** between the impact force **18** and the body part **8**. The impact force **18** is divided into a normal force component **28** and a tangential force component **30** based on the collision angle **26** (e.g., θ). For example, and on a layer by layer basis, the normal force component **28** is equal to the impact force times the sine of the collision angle and the tangential force component **30** is equal to the impact force times the cosine of the collision angle.

In addition to dampening the impact force on a layer by layer basis, the collision angle **26** increases the impacted area. Thus, when the normal force component(s) **28** is applied to the body part **8** through the inner layer **12**, its magnitude is substantially less than the magnitude of the impact force **18** and it is spread out over a much larger area (i.e., the body part impact area **22** is much larger than the system impact area **20**). Since pressure is force over area, decreasing the force and increasing the area substantially reduces the impact pressure on the body. In an analogy, the body impact protection system **10** takes a hard punch and turns it into a mild slap. As another analogy and from the example of the knife being dropped into molding clay, the body impact protection system **10** takes the blade down scenario and converts it into the handle down scenario.

FIG. **9** is a schematic block diagram, in a side view, of another example of force components within a body impact protection system **10**. In this example, the body impact protection system **10** includes an inner layer **12**, an impact force dampening and defusing structure **14**, and an outer layer **24**. The impact force dampening and defusing structure includes one layer of components **16** and the inner layer **12** is positioned proximal to a body part **8**.

When on object **21** (e.g., a ball) collides with the body impact protection system **10**, it creates an average impact force **18** over a system impact area **20**. As a result of the impact force **18**, an outer surface shock response or wave **23** is created within the outer layer **24**. The magnitude and energy of the outer surface shock response is dependent on the material of the outer layer **24** and the impact force **18**. A majority of the energy of the impact force **18**, however, will be concentrated in the system impact area **20** and directed toward the body part. As an analogy, consider a rock dropped into a still pond. The rock creates a rippling wave on the surface of the pond (i.e., an impact shock response or wave), but the rock continues to fall to the bottom of the pond. In this analogy, the rock is the impact force and the surface of the pond is the outer layer.

In this example, the system impact area **20** corresponds to the outer or top area of a component or cell of the impact force dampening and defusing structure **14**. As such, a majority of the impact force **18** is applied to one cell. The cell functions to convert the impact force **18** into an angular force **25**. When the angular force **25** reaches the inner layer **12**, it creates a normal force component **28** and a tangential force component **30**. Depending on the material of the inner layer **12**, the angular force **25** may also create a shock wave **27** in the inner layer **12**. For example, if the inner layer includes a combination of padding and a non-malleable to semi-malleable plastic or the like, then a surface wave would be created in the plastic portion.

In addition, the cell creates a body part impact area **22** that is larger (e.g., 2× or more) than the system impact area **20** via the angular force **25**. Note that the body part impact area **22** would be even larger if the impacting object **21** impacted the system **10** between cells. In this instance, two or more cells would share the impact force **18** and respective create angular forces and collectively form a larger body part impact area **22**.

FIG. **10** is a graph of an example of impact force components v. body impact area of a body impact protection system. In this example, the vertical axis corresponds to force in force-pounds and the horizontal axis corresponds to a body part surface area. The thicker darker lines correspond to the body impact protection system **10** and the thinner lighter lines corresponds to conventional protective gear.

For the body impact protection system **10**, the impact force reaching the body is spread out over a larger area of the body and has lower magnitudes in comparison to the conventional protective gear. As such, the pressure applied to the body is less with the body impact protection system **10** than conventional protective gear.

FIGS. **11** and **12** are schematic block diagrams, in a side view and a top view, of another embodiment of a body impact protection system **10** that includes two component layers **50** and **54**, an intermediate layer **52**, and an inner layer **12**. The components of the first layer **50** are positioned to overlap (from the top view) two or more components of the second layer **54**. The components **16** of both layers **50** and **54** may be of the same size, shape, and material composition, of different size, of different shape, and/or of different material composition, or a combination thereof. The intermediate layer **52** and the inner layer **12** may be of the same size, shape, and material composition, of different size, of different shape, and/or of different material composition, or a combination thereof.

For example, the first component layer **50** will be subjected to a greater impact force than the second component layer **54**. As such, the components **16** of the first layer have a more rigid material composition (i.e., able to withstand a large impact force) than the components of the second layer. As an optional addition, the components of the first layer have a larger side wall angle θ (i.e., larger sine value) than the components of the second layer such that the compo-

nents of the second layer provide more dampening of the impact force than the components of the first layer.

When an impact force **18** is applied to the first component layer **50**, one or more components **16** are impacted. The component(s) **16** of the first layer (e.g., the darker component of the first layer) dampen and defuse the impact force **18**, which is then applied to the intermediate layer **52**. Depending on the material composition of the intermediate layer **52**, the dampened and defused impact force is applied to a group of components of the second layer **54**.

As an example, the intermediate layer **52** is composed of a foam material that has a high dampening ratio and a low rigidity factor (i.e., the intermediate layer further dampens the impact force but does little to distribute it over a larger area than the receiving area). In this example, the group of components of the second layer **54** would be the ones having a direct overlap with the impacted component(s) of the first layer **50**, which are shown as darkened cells.

As another example, the intermediate layer **52** is composed of a rigid material (e.g., plastic, carbon fiber, etc.) that has a low dampening ratio and a high rigidity factor (i.e., the intermediate layer does little to further dampen the impact force but does distribute it over a larger area than the receiving area). In this example, the group of components of the second layer **54** would be the ones having a direct overlap with the impacted component(s) of the first layer **50** and another circle of components surrounding them having indirect overlap, which are shown as darker cells. In another example, the intermediate layer **52** includes a combination of foam material and rigid material.

In another example, each component layer includes components arranged in a grid array (e.g., arranged in rows and columns, arranged in a repeating pattern, randomly arranged, etc. provide that, from layer to layer, the components of an outer layer overlap multiple components of an inner layer). Each of the components has a three-dimensional geometric shape that includes an impact receiving surface area and an impact defusing surface area that are separated by a distance "d". Each of the components further includes a material composition that is the same or different from component to component or layer to layer. This example or other examples, further include an impact surface layer (e.g., an outer layer) juxtaposed to the impact receiving surface area of the components and an impact defusing surface layer (e.g., an intermediate and/or inner layer) juxtaposed to the impact defusing surface area of the components.

FIG. **13** is a schematic block diagram, in a side view, of another example of force components within a body impact protection system **10** that is similar to FIG. **9** but with the addition of the intermediate layer **52** and the first component layer **50**. In this example, when on object **21** (e.g., a ball) collides with the body impact protection system **10**, it creates an average impact force **18** over a system impact area **20**. As a result of the impact force **18**, an outer surface shock response or wave **23** is created within the outer layer **24**. The magnitude and energy of the outer surface shock response is dependent on the material of the outer layer **24** and the impact force **18**. A majority of the energy of the impact force **18**, however, will be concentrated in the system impact area **20** and directed toward the body part.

In this example, the impact force is applied the outer or top area of a component or cell of the first layer **50**. As such, a majority of the impact force **18** is applied to one cell. The cell functions to convert the impact force **18** into an angular force **25-1**. When the angular force **25-1** reaches the intermediate layer **52**, it creates a normal force component **28-1** and a tangential force component **30-1**. Depending on the material of the intermediate layer **52**, the angular force **25-1** may also create a shock wave (or response) **33** in the intermediate layer **52**.

The normal force components **28-1** are applied to two cells of the second layer **54**. As such, each cell receives about one-half of the normal impact force component produced by the first layer **50**. Each of the cell functions to convert the normal impact force component **28-1** into a second angular force **25-2**. When the second angular force **25-2** reaches the inner layer **12**, it creates second normal force components **28-2** and second tangential force components **30-2**. Depending on the material of the inner layer **12**, the second angular force **25-2** may also create a second shock wave (or response) **27** in the inner layer **12**.

In addition, the cells of the second layer **54** creates a body part impact area **22** that is significantly larger (e.g., 10× or more) than the system impact area **20** via the angular forces **25-1** and **25-2**. Note that the body part impact area **22** would be even larger if the impacting object **21** impacted the system **10** between cells. In this instance, two or more cells of the first layer **50** would share the impact force **18** and respective create angular forces and collectively form a larger impact area being exerted on the intermediate layer **52** and engage more components of the second layer **54**.

FIGS. **14**A-**14**B are a schematic block diagram of an example of an impact force being defused and distributed layer by layer within a body impact protection system **10**. From a top view perspective and as shown in FIG. **14**A, the outer (or top) surfaces of four components **16** of the first layer **50** receive the impact force in the system impact area **20**. The components of the first layer are arranged in a pattern **56**.

The second layer **54** of components includes a second pattern of components **58** that is complimentary to the first pattern of components **56**. In particular, a component of the first layer overlaps multiple components of the second layer such that, from layer to layer, more and more components are dampening and defusing the impact force. In FIG. **14**B, eight components or cells of the second layer are receiving a portion of the normalized impact force created by the four components or cells of the first layer. The base of the eight cells of the second layer form the body part impact area **22**, which is significantly larger than the system impact area **20**.

FIG. **15** is a schematic block diagram, in a side view, of another embodiment of a body impact protection system **10** that includes an inner layer **12**, an outer layer **24**, a plurality of component layers **50**, **54**, **60-64** (five in this example, but could be more or less than five); and a plurality of intermediate layers **52**, **66-70** (four in this example, but could be more or less). The first component layer **50** includes a plurality of components arranged in a first pattern; the second component layer **54** includes a plurality of components arranged in a second pattern; the third component layer **60** includes a plurality of components arranged in a third pattern; the fourth component layer **62** includes a plurality of components arranged in a fourth pattern; and the fifth component layer **64** includes a plurality of components arranged in a fifth pattern. From layer to layer, the pattern of components is at least partially complimentary such that one component of an outer layer overlaps, or overlays, multiple components of an inner layer.

From layer to layer, the size, shape, side wall angle θ, and/or material composition of the components may be different. For example, first layer **50**, which is the outer most layer of components, has components that are comprised of a material that can withstand impact force pulses up to

50,000 force-pounds of force for 20-100 milliseconds (mSec). Continuing with the example, the side wall angle of the components of the first layer is 45 degrees, such that the normal force produced by the first layer of components is 0.0707 of the external impact force. As such, the impact force being exerted by the first layer of components on the first intermediate layer **52** will be 0.707*50,000 pounds, which equals 35,350 force-pounds.

Continuing with the example, the first intermediate layer **52** has a low dampening ratio and a high rigidity factor such that a majority of the impact force received from the first layer of components is provided to components of the second layer. In this example, the side wall angle of the components of the second layer is 42.5 degrees, such that the normal force produced by the second layer of components is 0.676 of the impact force it receives. As such, the impact being exerted by the second layer of components in the second intermediate layer **66** is 0.676*35,350, which equals 23,880 force-pounds.

Continuing with the example, the second intermediate layer **66** has a low dampening ratio and a high rigidity factor such that a majority of the impact force received from the second layer of components is provided to components of the third layer. In this example, the side wall angle of the components of the third layer is 40 degrees, such that the normal force produced by the third layer of components is 0.643 of the impact force it receives. As such, the impact being exerted by the third layer of components in the third intermediate layer **68** is 0.643*23,880, which equals 15,350 force-pounds.

Continuing with the example, the third intermediate layer **68** has a low dampening ratio and a high rigidity factor such that a majority of the impact force received from the third layer of components is provided to components of the fourth layer. In this example, the side wall angle of the components of the fourth layer is 35 degrees, such that the normal force produced by the third layer of components is 0.536 of the impact force it receives.

As such, the impact being exerted by the fourth layer of components in the fourth intermediate layer **68** is 0.574*15,350, which equals 8,804 force-pounds.

Continuing with the example, the third intermediate layer **68** has a low dampening ratio and a high rigidity factor such that a majority of the impact force received from the third layer of components is provided to components of the fourth layer. In this example, the side wall angle of the components of the fourth layer is 35 degrees, such that the normal force produced by the fourth layer of components is 0.536 of the impact force it receives. As such, the impact being exerted by the fourth layer of components in the fourth intermediate layer **68** is 0.574*15,350, which equals 8,804 force-pounds.

Continuing with the example, the fourth intermediate layer **68** has a low dampening ratio and a high rigidity factor such that a majority of the impact force received from the fourth layer of components is provided to components of the fifth layer. In this example, the side wall angle of the components of the fifth layer is 30 degrees, such that the normal force produced by the fifth layer of components is 0.500 of the impact force it receives. As such, the impact being exerted by the fifth layer of components in the inner layer **12** is 0.500*8,804, which equals 4,402 force-pounds.

Continuing with the example, the inner layer **12** has a high dampening ratio (e.g., 0.55) and a low rigidity factor. As such, 0.55 of the impact force exerted on the inner layer is passed to the body part. In this example, the body part would receive an average impact force of 0.55*4,402, which equals 2,421 force pounds. The resulting impact force is spread out over the body impact area to produce an impact pressure. For instance, a body impact area of 5.5 square inches yields a pressure of 440 PSI (pounds per square inch).

In this example, the components of the first layer will need to withstand impact forces of up to 50,000 force pounds; the components of the second layer will need to withstand an impact force of 35,350 force-pounds; the components of the third layer will need to withstand an impact force of 23,880 force-pounds; the components of the fourth layer will need to withstand an impact force of 15,350 force-pounds; and the components of the fifth layer will need to withstand an impact force of 8,804 force-pounds.

To reduce the impact force and impact pressure being exerted on the body of the above example, additional layers can be added. For example, by adding three more layers, each having components with side wall angles of 30 degrees, then the body impact force is further reduced by 0.5^3, which equals 0.125. With the additional three layers, the resulting impact force being applied to the inner layer **12** is 0.125*4,402, which equals 550 force pounds. With the inner layer **12** having a dampening factor of 0.55, the body impact force is 302.5 force-pounds. With a body impact area of 5.5 square inches, the resulting body impact pressure is 55 PSI.

Another way to reduce the impact force and impact pressure being exerted on the body of the above example is to have the intermediate layers have a high dampening ratio (e.g., 0.67). With four intermediate layers, the cumulative dampening is 0.67^4, which equals 0.2. Thus, the impact force being applied to the inner layer is 0.2*4,402, which equals 887 force-pounds. With the inner layer **12** having a dampening factor of 0.55, the body impact force is 487 force-pounds. With a body impact area of 5.5 square inches, the resulting body impact pressure is 89 PSI.

FIG. **16**A is a graph of an example of an impact force pulse v. time. In this example, the vertical axis is acceleration in G-forces (G), where G-Force is a measure of acceleration with respect to earth's gravitational field. For instance, G=a/g, where a is acceleration and g is the earth's gravitational field. The horizontal axis is time scaled in mSec. The example further includes an impact pulse that has a magnitude of about −50 G and has a pulse duration of about 10 mSec.

FIG. **16**B is a graph of an examples of frequency responses of different layers (e.g., layers of components, the intermediate layers, the outer layer, and/or the inner layer) of a body impact protection system having different resonant frequencies. In this example, the vertical axis is acceleration in G-forces (G) and the horizontal axis is time scaled in mSec.

By varying the material composition of the layers, various resonant frequencies are obtained. With different resonant frequencies, different shock responses are produced. With proper selection of the resonant (or natural) frequencies, the resulting different shock responses destructively interfere with each other to further reduce the impact force being exerted on the body. In this example, a first layer has a first shock response, a second layer has a second shock response, and a third layer has a third shock response.

In addition to selecting the resonant or natural frequency of the various layers, the quality factor (Q) can be selected. With a higher quality factor, side bands dampen faster, but the main frequency passes substantially unattenuated. With a low-quality factor, the side bands dampen slower, but the main frequency is somewhat attenuated (e.g., reduced by 10% or more).

FIGS. **17**A-**17**E are a schematic block diagram of an example of force defusing and distribution layer by layer

within a body impact protection system **10** of FIG. **15**. With reference to FIG. **17**A, the 1st component layer **50** receives the impact force via one component or cell. As such, the system impact area **20** corresponds to the area of the top or outer surface area of the component. The component functions to dampen and defuse the received impact force based on the side wall angle θ and the distance "d" of the component (e.g., the distance between the top surface area and the bottom surface area of the component).

With the patterns between the layers being complimentary, the impacted component on the first layer **50** overlaps three components of the second layer as shown in FIG. **17**B. Ideally, the force exerted by the component of the first layer **50** is equally distributed among the three components of the second layer **54**. Each of the components of the second layer function to dampen and defuse the received impact force based on the side wall angle θ and the distance "d" of the component.

FIG. **17**C illustrates seven components of the third layer **60** receiving an impact force component from the three components of the second layer **54**. Each of the seven components of the third layer function to dampen and defuse the received impact force based on the side wall angle θ and the distance "d" of the component.

FIG. **17**D illustrates twelve components of the fourth layer **62** receiving an impact force component from the seven components of the third layer **60**. Each of the twelve components of the fourth layer function to dampen and defuse the received impact force based on the side wall angle θ and the distance "d" of the component.

FIG. **17**E illustrates nineteen components of the fifth layer **64** receiving an impact force component from the twelve components of the fourth layer **62**. Each of the nineteen components of the fifth layer function to dampen and defuse the received impact force based on the side wall angle θ and the distance "d" of the component. The body impact area **24** is the sum of the area of the base of the nineteen components. As an example, the base of a component has an area that is nine times the area of the top of the component. For this example, the body part impact area **24** is 9*19 times larger than the system impact area **20** (as shown in FIG. **17**A), which is 171 times larger. As such, the resulting impact pressure applied to the body is up to 171 times less than in conventional protection gear, assuming comparable force dampening ratios.

FIG. **18** is a schematic block diagram, in a side view, of another embodiment of a body impact protection system that includes a plurality of component layers, a plurality of rigid layers, and a plurality of padding layers. This example includes three groupings of two component layers, three rigid layers, and one padding layers. In a grouping, the two component layers are sandwiched between the three rigid layers. The padding layer is on the dampening and defusing side of the component layers.

The number of each layer type can vary from the numbers shown in this example and may be in different layering configurations. For example, the body impact protection system could include two or four groupings. In another example, the body impact protection system includes three component layers and four rigid layers in a grouping. In yet another example, the body impact protection system includes three component layers and two rigid layers in a grouping, where one rigid layer is on the impact receiving side of the three component layers and the other rigid layer is on the dampening and defusing side of the component layers. In yet a further example, the body impact protection system does not include rigid layers, it only includes component layers and padding layers. In a still further example, the body impact protection system includes only component layers and rigid layers. These are but a few examples of the almost endless combination of component layers, rigid layers, and/or padding layers.

FIG. **19** is a schematic block diagram, in a cross-section side view, of another embodiment of a defusing cell or component of a layer of a body impact protection system. The cell includes a top surface **70-1**, a base surface **72-1**, a side structure **76**, and a distance "d" **74** that is the distance between the top surface and the base surface. In this embodiment, the center of the cell is hollow and the top and base are open. The side structure **76** is angled from the base surface to the top surface at the side wall angle θ and has a thickness such that the component, or cell, includes an outer shell and an interior volume. The interior volume can be filled with air, a gel, an oil, rubber, silicon, and/or foam. The component or cell is comprised of a material composition (as previously described) that, when an impact force is applied, retains the angle θ within +/−33% and retains the ratio of Ai to Ao to within +/−33%.

FIG. **20** is a schematic block diagram, in a side view, of another embodiment of a defusing cell or component of a layer of a body impact protection system. The cell includes a top surface **70-1**, a base surface **72-1**, a side structure **76**, and a distance "d" **74** that is the distance between the top surface and the base surface. In this embodiment, the center of the cell is hollow. The side structure **76** is angled from the base surface to the top surface at the side wall angle θ. Each of the top surface **70-1**, the base surface **72-1**, and the side structure **76** has a thickness such that the component, or cell, includes an outer shell and an interior volume. The interior volume can be filled with air, a gel, an oil, rubber, silicon, and/or foam. The component or cell is comprised of a material composition (as previously described) that, when an impact force is applied, retains the angle θ within +/−33% and retains the ratio of Ai to Ao to within +/−33%.

FIGS. **21**A-**21**F are a schematic block diagrams, in a top view, of other embodiments of a defusing cell of a layer of a body impact protection system. Each of the defusing cells or components includes a top perimeter that outlines the top surface area and a base perimeter that outlines the base surface area. The top surface area is the impact force receiving surface and the base surface area is the dampening and defusing side.

FIG. **21**A illustrates the defusing cell or component having a circular shape from a top perspective. As such, the top perimeter **80** and the bottom perimeter **82** each have a circular shape. The radius of the bottom perimeter **82** is at least 1.414 times the radius of the top perimeter **80** such that the base surface area is at least 2 times the surface area of the top surface area. With a circular shape for the top and base perimeters, the cell or component has a conical shape.

FIG. **21**B illustrates the defusing cell or component having an elliptical or oval shape from a top perspective. As such, the top perimeter **80-1** and the bottom perimeter **82-1** each have an elliptical or oval shape. The dimensions of the bottom perimeter **82-1** and of the top perimeter **80-1** are selected such that the base surface area is at least 2 times the surface area of the top surface area. With an elliptical or oval shape for the top and base perimeters, the cell or component has an elliptical or oval conical shape.

FIG. **21**C illustrates the defusing cell or component having a square shape from a top perspective. As such, the top perimeter **80-2** and the bottom perimeter **82-2** each have a square shape. The dimensions of the bottom perimeter **82-2** and of the top perimeter **80-2** are selected such that the base

surface area is at least twice the surface area of the top surface area. With a square shape for the top and base perimeters, the cell or component has a pyramid shape.

FIG. **21**D illustrates the defusing cell or component having a rectangular shape from a top perspective. As such, the top perimeter **80-3** and the bottom perimeter **82-3** each have a rectangular shape. The dimensions of the bottom perimeter **82-3** and of the top perimeter **80-3** are selected such that the base surface area is at least twice the surface area of the top surface area. With a rectangular shape for the top and base perimeters, the cell or component has an elongated pyramid shape.

FIG. **21**E illustrates the defusing cell or component having a triangular shape from a top perspective. As such, the top perimeter **80-4** and the bottom perimeter **82-4** each have a triangular shape. The dimensions of the bottom perimeter **82-4** and of the top perimeter **80-4** are selected such that the base surface area is at least twice the surface area of the top surface area. With a triangular shape for the top and base perimeters, the cell or component has a three-dimensional triangular shape.

FIG. **21**F illustrates the defusing cell or component having an octagon shape from a top perspective. As such, the top perimeter **80-5** and the bottom perimeter **82-5** each have an octagon shape. The dimensions of the bottom perimeter **82-5** and of the top perimeter **80-5** are selected such that the base surface area is at least twice the surface area of the top surface area. With an octagon shape for the top and base perimeters, the cell or component has a three-dimensional octagon shape.

FIGS. **21**A-**21**F are a few examples of the possible shapes of the components or defusing cell. Other examples include a pentagon shape, a hexagon shape, and/or other polygon shape. As another example, the top perimeter could be one shape and the base perimeter could be another shape.

FIGS. **21**G-**21**J-**2** are diagrams of another defusing cell or component. The defusing cell or component has a substantially square or rectangular shaped top perimeter **80-6** and base perimeter **82-6** with a hole running the distance "d" through the middle. The base perimeter **82-6** has angular cut corners (e.g., at θ_2), has a width of "w", and a height of "h". The top perimeter **80-6** has a width of "w**1**" and a height of "h**1**". The top surface area outlined by the top perimeter **80-6** is the distance "d" from the base surface area outlined by the base perimeter **82-6**. The side walls of the cell are angled at the side wall angle of θ_1, where θ_1 is readily calculable from w, h, w**1**, h**1**, and d, or d is readily calculable from w, h, w**1**, h**1**, and θ_1.

The hole at the top surface has a width of "w**2**" and a height of "h**2**". In an example, the hole runs straight through the cell as shown in the cross-sectional side view of FIG. **21**J-**1**. In another example, the hole increases in sizes as it traverses from the top surface to the base surface of the cell as shown in the cross-sectional side view of FIG. **21**J-**2**. The combination of the hole and the angled corners of the base surface allow air flow from layer to layer.

FIGS. **21**K-**21**N are diagrams of another defusing cell or component that is similar to the cell of FIGS. **21**G-**21**J-**2** with the addition of perforation holes or vents to improve air flow and/or reduce weight of the cell. The perforation holes or vents may be circular, rectangular, square, or other polygon shape and pass through the cell from the top surface to the bottom surface. Alternatively, some or all of the perforation holes do not pass fully from the top surface to the base surface. These holes may only pass 50%-90% of the way through the cell to reduce weight.

FIGS. **21**O and **21**Q-**21**S-**2** are diagrams of another defusing cell or component. The defusing cell or component has, from a top perspective, a substantially square or rectangular shaped top perimeter **80-6** and base perimeter **82-6** with a hole running the distance "d" through the middle. From the side view and/or the front view, the defusing cell or component has an arch shape, which allows for a layer of such cells to be fitted to a curved and/or spherical shaped body part. Note that the cell may only have on arched perspective from the side or front view.

The base perimeter **82-7** has angular cut corners (e.g., at θ_2), has a width of "w", and a height of "h". The top perimeter **80-7** has a width of "w**1**" and a height of "h**1**". The top surface area outlined by the top perimeter **80-7** is the distance "d" from the base surface area outlined by the base perimeter **82-7**. The side walls of the cell are angled at the side wall angle of θ_1, where θ_1 is readily calculable from w, h, w**1**, h**1**, and d, or d is readily calculable from w, h, w**1**, h**1**, and θ_1.

The hole at the top surface has a width of "w**2**" and a height of "h**2**". In an example, the hole runs straight through the cell as shown in the cross-sectional side view of FIG. **21**S-**1**. In another example, the hole increases in sizes as it traverses from the top surface to the base surface of the cell as shown in the cross-sectional side view of FIG. **21**S-**2**. The combination of the hole and the angled corners of the base surface allow air flow from layer to layer.

As shown in FIGS. **21**S-**1** and **21**S-**2**, the arced perspective includes an inner radius r_1 and an outer radius r_2. The inner radius r_1 is dependent on the radius of the body part it is protecting, the inner layer thickness, the layer in which the cell lies, the distance "d" between the top and base surface areas, and the thickness of any intermediate layers. The outer radius r_2 is dependent on the inner radius r_1 and the distance "d" between the top and base surface areas. For example, assume that the body part being protected is the head with a radius of 3 inches, the inner layer is 0.25 inches thick, the cell is in the second layer, the intermediate layer is 0.125 inches thick, and "d" is 0.125 inches. Based on these parameters, the inner radius r_1 is (3+0.25+0.125+0.125)=3.5 inches and the outer radius r_2 is 3.625 inches.

FIG. **21**T is a top and side view of a layer of components or cells as shown in FIGS. **21**G-**21**J-**2**. The layer includes a plurality of components and a component layer support. The component layer support functions to align the components and may further function to provide some dampening of the impact force. For example, the component layer support is comprised of a rubber material that includes locating holes, slots, and/or other aligning mechanisms for positioning the cells, or components. With the use of a rubber material, the component layer support has a degree of flexibility to allow for custom fitting of the layers and further provides dampening of the impact force. In an embodiment, the component layer support is an intermediate layer as previously described.

FIGS. **21**U-**21**V are diagrams of another defusing cell or component **16** that includes a plurality of spherical elements **85**, a suspension material **87**, and a housing **89**. The housing **89** has an overall size and shape corresponding to one of the components previously described. The spherical elements **85** are comprised of a material composition that will substantially maintain a spherical shape (e.g., up to 25% compression) when an impact force is exerted on the cell. For example, the spherical elements are comprised of a rubber material, a plastic material, stainless steel, aluminum, and/or a carbon fiber material. The spherical elements **85** may be solid or hollow.

The suspension material **87** may be a liquid and/or a solid that, when no force is applied to the cell, keeps the spherical elements **85** in a distributed pattern. When a force is applied to the cell, the suspension material **87** allows the spherical elements **85** to come in contact with each other and propagate the impact force through the colliding spheres and provide a fairly even distribution of the resulting dampened and defused impact force across the base surface area. When the force is removed, the suspension material **87** causes the spherical elements **85** to return to the distributed pattern.

FIGS. **21**W-**21**X are side view diagrams of another defusing cell or component that include a flexible shell **99** and a cell platform **101**. Each of the flexible shell **99** and cell platform **101** is comprised of a material composition that includes a rubber material, a plastic material, stainless steel, aluminum, and/or a carbon fiber material. The base of the flexible shell **99** fits within the cell platform **101** and is held within the cell platform via the encircling lip **103**.

When no force is exerted on the cell, as shown in FIG. **21**W, the flexible shell **99** is uncompressed and is not pushing on the encircling lip **103** of the cell platform **101**. When an impact force is exerted on the cell, as shown in FIG. **21**X, the flexible shell **99** is compressed and its edges are contained with the cell platform **101** via the encircling lip **103**. The material composition of the flexible shell **99** is such that it can withstand the impact force, be compressed as shown in FIG. **21**X, retained its shape (e.g., maintains a side wall angle), and substantially returns to the uncompressed state as shown in FIG. **21**W when the force is removed.

In an example, the flexible shell **99** has a side wall angle of θu when it in the uncompressed state and has a side wall angle of θc when in the compress state. For instance, θu is 45 degrees and θc is 35 degrees.

FIG. **21**Y is a side view of layers **103** of flexible cells or components. The cells are compressible cells as discussed with reference to FIGS. **21**W and **21**X. Intermediate layers **105** are between one or more flexible cell layers **103**. In this example, intermediate layers **105** are between the second and third flexible cell layers **103** and between the fourth and fifth flexible cell layers **103**.

FIGS. **21**Z-**21**AB are top, front, and side view diagrams of another defusing cell or component that has a triangular shape. The cell may be of any size (i.e., height, width, perimeter, and/or distance between the top and base surfaces) and/or of any material composition provided the side walls of the components are angled and the top surface area is less than the base surface area.

The distance "d" between the top surface area and the base surface area ranges from 1/32 of an inch to multiple inches, depending on the application of the body impact protection system. The angled side wall(s) are at an angle of θ with respect to the horizontal axis, where the angle is in the range of 25 degrees to 89 degrees. Depending on the angle θ and the distance "d", the base surface area is two or more times larger than the top surface area, where the top surface area is 1/256 square inches to tens of square inches depending on the application of the body impact protection system.

The cell is constructed (e.g., molded, press-formed, printed, etc.) of a material composition that includes one or more of a rubber material, a foam material, a padding material, a plastic material, a gel material, a carbon fiber material, a cloth material; a polyester material, a moisture absorbing material, a moisture wicking material and a silicon material. A characteristic of the material composition is that the cell retains the angle θ within +/−33% and retains the ratio of Ai (i.e., the base surface area) to Ao (i.e., the top surface area) to within +/−33%. Distance "d" may decrease while the impact force is being applied, but substantially returns to its pre-impact force value when the impact force is removed.

FIG. **21**AC is a top view of a layer of the triangular components of FIGS. **21**Z-**21**AB. With the triangular shape of the cells, the layer can be formed around complex surfaces (e.g., a head, an arm, an elbow, etc.).

FIG. **21**AD is a top view of another layer of the triangular components of FIGS. **21**Z-**21**AB. In this example, the layer would be used for any layer but the one closes to the body part. For the inner most component layer, there should be as few gaps between cells and possible, and each impacted cell should, as evenly as possible, distribute the force across its base surface area.

FIG. **21**AE is a top view of another layer of the triangular components of FIGS. **21**Z-**21**AB. In this example, the layer would be used for any layer but the one closes to the body part and is a complimentary layer to the layer of FIG. **21**AD.

FIG. **21**AF is a top view of two overlapping layers of components of FIGS. **21**AD and **21**AE. The first layer **91** is that of FIG. **21**AD and the second layer **93** is that of FIG. **21** AE. When a cell of the second layer **93** receives an impact force, it spreads the dampened and defused impact force to three cells of the first layer **91**.

FIG. **22** is a schematic block diagram, in a side view, of a portion of another embodiment of a layer of a body impact protection system **10**. The portion includes a 1st spherical component **90** of a first layer of the system **10** and two spherical components **92** and **94** of a second layer of the system **10**. Each of the spherical components **90-94** is comprised of a material composition that will substantially maintain a spherical shape (e.g., up to 25% compression) when an impact force **96** is exerted on the components. For example, the spherical components are comprised of a rubber material, a plastic material, stainless steel, aluminum, and/or a carbon fiber material. Further, the spherical components **90-94** may be solid or hollow.

In an example, the first component **90** receives an impact force **96** and collides with the second and third components **92** and **94** at first and second collision angles **98** and **100**, respectively. As a result of the collision between the first and second components, the second component **92** creates a 1st normal force component **28-1** and a 1st tangential force component **30-1**. As a result of the collision between the first and third components, the third component **94** creates a 2nd normal force component **28-2** and a 2nd tangential force component **30-2**.

If each of the first and second collision angles **98** and **100** is 45 degrees and the 1st component **90** impacts the 2nd and 3nd components equally, then each of the second and third components receives ½ of the impact force at an angle of 45 degrees. Accordingly, the normal force components produced by each of the second and third components is $0.5*F*\sin\theta$, where F is the impact force **96** and θ is the collision angle. As such, when the first spherical shaped object collides with the two or more second spherical shaped objects, a multi-dimensional collision is created that dampens and defuses the impact force **96**.

Protective headgear (e.g., a helmet) was originally created to reduce the risk of skull fractures, but was not designed to reduce the incidence of concussion. Since the turn of the 21st century, a helmet's ability to mitigate the incidence of concussions has been studied and, as a result, improvements have been made in helmets. It is generally accepted in the medical field that a concussion occurs as a result of a rapid acceleration and deceleration of the brain against the skull.

When object (e.g., another person's body part, another helmet, the ground, a ball, etc.) collides with protective headgear (e.g., a helmet) it produces an impact force that results in three collisions. The first collision is between the object and the helmet as shown in FIG. **23**A, the second collision is between the helmet and the skull as shown in FIG. **23**B, and third collision is between the skull and the brain as shown in FIG. **23**C. The helmet includes an outer shell **77** and padding **79** and the head is shown generically to include a brain **75**.

FIG. **23**A illustrates, in a cross section front view, of an embodiment of a helmet at the instant it collides with an object. The average impact force created by the object colliding with the helmet is F_1. The reactive force of the helmet, which includes the force dampening of the padding **79** and the surface wave dissipation of the outer shell **77**, which is designated F_3. The resulting force applied to the skull is F_2.

The average impact force F_1 of the object is calculated as m*a, where "m" is the mass of the object and "a" is the deceleration of the object as a result of the collision. Note that if the object is the ground, then mass and deceleration are of the person wearing the helmet. The deceleration is calculated as $v^2/2*d$, where "d" is impact distance (i.e., the distance the object travels from the start of the collision until the collision is over), and "v" is velocity at the instant of collision.

FIG. **23**B illustrates, in a cross section front view, the helmet to skull collision. In this collision, the padding **79** of the helmet is compressed as a result of the impact force F_1. The force exerted on the skull F_2 is equal to the negative of the impact force F_1 minus the reactive force F_3 of the helmet. In equation form, $F_2=-(F_1-F_3)$. As such, the greater F_3, the less force F_2 that exerted on the skull.

FIG. **23**C illustrates, in a cross section front view, the skull to brain collision. In this collision, the brain has a force F_5 exerted on it, which is the force exerted on the skull F_2 less the reactive force of the cerebrospinal fluid F_4. In equation form, $F_5=-(F_2-F_4)$. Via substitution, $-F_5=-(F_1-F_3)-F_4$. Thus, by reducing F_2 (i.e., the force on the skull), which is accomplished by increasing F_3 (i.e., the reactive force of the helmet), the force on the brain F_5 is reduced, which should reduce the risk of a concussion.

As previously discussed, however, current helmet testing protocols are based on G-Force measurements taken via a drop test and/or via a projectile test. As also previously discussed, G-Force is a ratio of deceleration versus earth's gravitational field. Many assumptions in the helmet testing are made to equate G-Force to reducing the impact force on the brain F_5. One assumption that is made in the testing is the mass of the object or the player. In testing, an 11 pound headform, which includes an accelerometer in its core, wears the helmet as the drop test and/or projectile test are performed.

Another assumption is that the impact force F**1** and the force exerted on the skull F**2** are average forces and evenly distributed across the entire surface of the helmet and head, respectively. In actuality and as discussed with reference to FIG. **1**, the impact force F**1** is received in a very small area of the helmet and a conventional helmet does little to expand the impact area as it reaches the skull. Thus, even if the G-Force measurements are in acceptable ranges and F**2** seems relatively mild, a concussion can still result of the skull impact area is small (e.g., less than a few square inches) and the risk for concussion increases as the skull impact area decreases.

FIG. **23**D is a schematic block diagram, in a side view, of an embodiment of a helmet **115** that includes a body impact protection system **10**. In general, the helmet **115** includes an outer layer, an inner layer, and an impact force dampening and defusing structure. The outer layer includes a first material composition and has a geometric shape to form an exterior surface of the helmet. The inner layer includes a second material composition and, when the helmet is worn, the inner layer is adjacent to a head. In an embodiment, the outer layer includes a rubber material and/or a plastic material and the inner layer includes a foam material and/or a gel material.

The impact force dampening and defusing structure is positioned between the inner layer and the outer layer. It includes a plurality of components arranged into more or more layers. The layer(s) of components function to reduce pressure on the head from a collision with an object. For example, the collision with the object creates an impact force on the outer layer of the helmet in a given area (e.g., a helmet impact area). Layer by layer, the components dampen the impact force and diffuse it over a larger and larger area. Thus, when the impact force reaches the head, it has been substantially reduced and spread out over a larger area creating a low impact pressure to substantially reducing the risk of concussion and the severity of a concussion if one did occur.

FIG. **23**E is a schematic block diagram, in a side view, of a portion of an embodiment of a helmet **115** that includes a force dampening and defusing outer shell **117**, force dampening and defusing layers **121**, dampening viscous layers **123**, and a padding layer **125**. The dampening and defusing layers **121** includes four layers of cells, or components **16**. The dampening viscous layers **123** include gel and/or padding that further dampens the impact force in both the linear direction and rotational direction as will be discussed in greater detail with reference to FIGS. **23**F and **23**G. The force dampening and defusing outer shell **117** includes a plurality of cells, or components **16**, that are laminated, encased, or impregnated with a rubber material, a plastic material, and/or other material to create a smooth, but compressible surface.

The cells of the outer shell **117** and the cells of the force dampening and defusing layers **121** convert the external impact force, which is exerted on the helmet in an outer surface impact area **119**, into a substantially reduced impact force spread out over a much larger area (i.e., the body impact area **127**). The impact force is further reduced by the dampening viscous layers **123**.

As an example, the side wall angle θ for the cells of each layer is 45 degrees, the mass of the player wearing the helmet is 200 pounds, is traveling at 16 miles per hour (mph), and collides head first with an object and has an impact distance of 1.25 inches. Further, the dampening factor of each layer of the viscous layers is 0.667 and the dampening factor of the padding layer is 0.5. From these parameters, $F_2 \simeq (0.707)^5 * F_1 * (0.667)^{(5-1)} * 0.5 = 0.017 * F_1$.

The 200-pound player creates a G-Force of 82 G's, which is borderline concussion level based on research that suggests a concussion in football can occur from an impact that produces a G-Force of 100 g's+/−30 g's. This equates to an external impact force F**1** of 16.4K force-pounds and, as result of the dampening of the helmet, creates a head impact force F**2** of about 290 force-pounds. With a conventional helmet that does not increase the impact area, an impact area of 0.375 square inches yields an impact pressure of 770 PSI. In contrast, the helmet with the dampening and defusing system **10**, produces an impact pressure of about 36 PSI. 36

PSI presents substantially less risk of an injury than 770 PSI, even though both have the same G-Force measurements and head impact force.

FIG. **23**F is a schematic block diagram, in a side view, of a portion of an embodiment of a helmet of FIGS. **23**D and **23**E. In this illustration, the helmet is receiving an angular impact force. In conventional helmets, this creates a rotational force that studies suggest increase the risk of injury.

FIG. **23**G is a schematic block diagram, in a side view, of the portion of the helmet of FIG. **23**F. In this illustration, the viscous layers **123** slide along the force dampening and defusing layers **121** to dampen the angular and rotational forces produced by the angular impact force.

FIG. **24**A is a schematic block diagram, in a side view, of an embodiment of a chest protector **135** that includes a body impact protection system **10**. The chest protector **135** may be used for baseball, football practice, hockey, motor-cross, mountain bicycling, riot gear, combat gear, and/or other applications where the chest needs to be protected from impacting objects. Further, the materials and implementation of the body impact protection system **10** create flexible chest protector **135** that allow for form fitting and movement with the person wearing the chest protector.

In general, the chest protector **135** includes an outer layer, an inner layer, and an impact force dampening and defusing structure. The outer layer includes a first material composition and has a geometric shape to conform to the shape of a human torso. The inner layer includes a second material composition and, when the chest protector is worn, the inner layer is adjacent to the chest. In an embodiment, each of the inner layer and the outer layer includes a rubber material, a foam material, a padding material, a plastic material, a gel material, a carbon fiber material, a cloth material, a polyester material, a moisture absorbing material, a moisture wicking material, and/or a silicon material. In an embodiment, the first and second material compositions are the same. In another embodiment, the first and second material compositions are different.

The impact force dampening and defusing structure **137** is positioned between the inner layer and the outer layer. It includes a plurality of components arranged into more or more layers. The layer(s) of components function to reduce pressure on the chest from a collision with an object. For example, the collision with the object creates an impact force on the outer layer of the chest protector in a given area (e.g., a system impact area). Layer by layer, the components dampen the impact force and diffuse it over a larger and larger area. Thus, when the impact force reaches the chest, it has been substantially reduced and spread out over a larger area creating a low impact pressure to substantially reducing the risk of injury and the severity of an injury if one did occur.

FIG. **24**B is a schematic block diagram, in a side view, of an embodiment of a chest protector **135** that includes a vest **141** and a plurality of dampening and defusing sheets **139**. A dampening and defusing sheet **139** includes one or more component layers and may further include the inner layer and/or the outer layer. Further, the sheet **139** may have a variety of top or front view perimeter shapes (a front view is the shown the present figure). Still further, each dampening and defusing sheet **139** has an overall width and an overall height, where the overall width is in the range of 1 inch to 10 inches or more and the overall height is in the range of 1 inch to 8 inches or more.

The vest **141** has a shape corresponding to the torso and is comprised of a foam material, a padding material, a cloth material, a polyester material, a moisture absorbing material, and/or a moisture wicking material. The vest **141** includes a plurality of receptacles for receiving the plurality of dampening and defusing sheets **139**. For example, the vest **141** includes a plurality of re-sealable pockets for receiving the sheets **139**. In another example, the vest **141** includes pockets that, once the sheets are inserted, are sealed.

The size and positioning of the sheets **139** are on the vest **141** may vary based on the application of the chest protector **135**. Further, the outer layer of the sheets may include a bullet-proof material when the chest protector is used in combat or as riot gear. Still further, the area around the heart may include a special sheet that includes more component layers than other sheets, may include a different outer layer than other sheets, and/or may include a different inner layer than other sheets to provide more protection for the heart than other parts of the torso.

FIG. **25** is a schematic block diagram, in a side view, of an embodiment of a knee protection apparatus **151** that includes an outer layer **153**, an inner layer **155**, and a force dampening and defusing structure **157**. The outer layer **153** includes a first material composition and has an exterior surface that includes a substantially planer area. The first material composition includes a rubber material, a foam material, a padding material, a plastic material, a gel material, a carbon fiber material, and/or a silicon material.

The inner layer **155** includes a second material composition and has a shape corresponding to the shape of a knee. The second material composition includes a rubber material, a foam material, a padding material, a plastic material, a gel material, a cloth material, a polyester material, a moisture absorbing material, a moisture wicking material, and/or a silicon material. Note that the inner layer is adjacent to the knee when the knee protection apparatus **151** is worn.

The force dampening and defusing structure **157** is positioned between the inner layer **155** and the outer layer **153**. From the front and side views, the force dampening and defusing structure **157** has a shape corresponding to a difference between the shapes of the inner and outer layers. In particular, the structure **157** includes components **16** that are arranged to reduce pressure on the knee when a force is applied to the outer layer. As shown, to achieve the desired shape of the structure **157**, some components are longer than others.

The substantially planar area of the outer layer **153** allows the knee protection apparatus to have a large impact area with the ground or other surface on which the knee protection apparatus will be used. As shown in FIG. **27**, the planar area **161** has, from a front view perspective, a rectangular shape, but could have a different polygonal shape. In the cross-section view the player area **161** provides a flat surface on which to kneel. As is further shown, the outer layer **153** also includes a concave area **163** that at least partially encompassing the substantially planer area.

FIG. **26** is a schematic block diagram, in a side view, of another embodiment of a knee protection apparatus **151** that includes an outer layer **153**, an inner layer **155**, a multi-layered force dampening and defusing structure **157**, and an intermediate layer **159**. The intermediate layer **159** includes a third material composition that includes a rubber material, a foam material, a padding material, a plastic material, a gel material, a carbon fiber material, and/or a silicon material.

The multi-layer force dampening and defusing structure **157** includes one layer of components between the inner layer **155** and the intermediate layer **159** and includes a second layer of components between the intermediate layer **159** and the outer layer **153**. From the front and side views, the first layer of components has a shape corresponding to a

difference between the shapes of the inner and intermediate layers. In particular, the first layer of components **157** includes components **16** that are arranged to reduce pressure and where some components are longer than others.

The second layer of components includes that are arranged to further reduce pressure and the components are of the same size. Note that the outer layer **153** may have a configuration as described with reference to FIG. **27**.

FIG. **28** is a schematic block diagram, in a side view, of an embodiment of a body limb protection apparatus **165** that includes an outer layer **171**, an inner layer **169**, and a force dampening and defusing structure **173** that includes one or more component layers. The outer layer **171** including a first material composition and has an exterior surface that includes a substantially planer area **167**.

The inner layer **169** includes a second material composition and has a shape corresponding to a body limb portion **175** (e.g., knee, shin, elbow, ankle, forearm, upper arm, thigh, calf, etc.). When the apparatus **165** is worn on the body limb portion, the inner layer **169** is adjacent to the body limb portion.

The force dampening and defusing structure **173** is positioned between the inner layer **169** and the outer layer **171** and includes a plurality of layers of components. For an example of multiple component layers, an inner layer, and an outer layer, refer to FIG. **15**. The apparatus **165** functions to reduce pressure on the body limb portion when a force is applied from an impacting object (e.g., a baseball, a helmet, the ground, etc.). On a layer by layer basis, the apparatus dampens and defuses the impact force such that, by the time it reaches the body part, the impact force is substantially attenuated and distributed over a large area.

FIGS. **29**A and **29**B are side and top views of a layer of components **16** arranged in a pattern **181** to produce a layer of an impact force dampening and defusing structure. In this embodiment, the components have a flat-top pyramid shape and are arranged in a pattern **181** of rows and columns. A component **16**, from the side view of FIG. **29**A, includes angled side walls, a top surface area (e.g., away from the body part), a base surface area (e.g., towards the body part), and a distance "d" **74**. The distance "d" is the distance between the top surface area and the base surface area and ranges from 1/32 of an inch to multiple inches depending on the application of the body impact protection system. The angled side walls are at an angle of θ with respect to the horizontal axis, where the angle is in the range of 25 degrees to 89 degrees. Depending on the angle θ and the distance "d", the base surface area is two or more times larger than the top surface area, where the top surface area is 1/256 square inches (e.g., 1/16 by 1/16) to tens of square inches depending on the application of the body impact protection system.

The components are placed on an inner or intermediate layer that is flexible and allows each cell to move independently. This allows sheets of layers to be flexible and form fitting to a particular body part. Such layers of components may be molded, casted, printed, etc. as individual pieces and then adhered to the supporting layer. Alternatively, a layer of components is produced via or molding, casting, printing, etc. as a single piece.

FIG. **30** is a schematic block diagram, in a side view, of an embodiment of a force defusing inert **185** for use in a variety of impact protection gear (e.g., as thigh pads, as shoulder padding, as rib padding, as shin padding, as elbow padding, etc.). The insert includes one or more layers of components **16**, an outer layer **171**, an inner layer **169**, and an encasing **191**. The one or more layers of components **16**, an outer layer **171**, an inner layer **169** are implemented in accordance with one or more embodiments previously discussed and/or as subsequently discussed. Note that the outer layer is on the impact receiving side **187** of the insert **185** and the inner layer **169** is on the impact defusing side **189**.

The encasing **191** houses the one or more layers of components **16**, an outer layer **171**, an inner layer **169** and is comprised of one or more materials that are flexible, provides additional padding, are moisture wicking, and/or are moisture absorbent. For example, the encasing **191** is comprised of a foam material, a padding material, a gel material, a cloth material, a polyester material, a moisture absorbing material, and/or a moisture wicking material.

FIG. **31** is a schematic block diagram, in a side view, of another embodiment of a force defusing inert **185** that is similar to the one of FIG. **30** with the addition of a second component layer, an intermediate layer **195**, and a padding layer **193**. The two layers of components **16**, the outer layer **171**, the inner layer **169**, the intermediate layer **195**, and the padding layer **193** are implemented in accordance with one or more embodiments previously discussed and/or as subsequently discussed.

FIG. **32** is a schematic block diagram, in a side view, of another embodiment of a force defusing inert **185** that includes eight layers of components **16**, seven intermediate layers **195**, the outer layer **171**, the inner layer **169**, and the encasing **191**. The various elements of this insert **185** are implemented in accordance with one or more embodiments previously discussed and/or as subsequently discussed.

FIG. **33** is a schematic block diagram, in a side view, of another embodiment of a force defusing inert **185** that includes a plurality of layers of components **16** (five in this example, but could be more or less), an inner layer **169**, an outer layer **171**, and an encasing **191**. In this embodiment, the layers of components are in direct contact with each other (i.e., no intermediate layers). The various elements of this insert **185** are implemented in accordance with one or more embodiments previously discussed and/or as subsequently discussed.

FIGS. **34** and **35** are side and front views of another embodiment of two force defusing layers for use in an impact protection system. The first layer includes 1st spherical objects **110** and the second layer includes 2nd spherical objects **112**. Each layer is arranged in an array that, from layer to layer, is complimentary. Each of the spherical objects **110-112** is comprised of a material composition that will substantially maintain a spherical shape (e.g., up to 25% compression) when an impact force is exerted on the objects. For example, the spherical objects are comprised of a rubber material, a plastic material, stainless steel, aluminum, and/or a carbon fiber material. Further, the spherical objects **110-112** may be solid or hollow. Still further, the material composition is such that, as a result the collision, the magnitude of the impact force is reduced.

In an example, one or more objects of the first spherical objects **110** receives an impact force and collides with two or more objects of the second spherical objects **112** at collision angles, respectively. As a result of the collision between spherical objects of the first and second spherical objects **110** and **112**, each of the impact spherical objects of the second spherical objects **112 92** creates a normal force component and a tangential force component.

If each of the first and second collision angles is 45 degrees and the spherical object of the first spherical objects **110** impacts the two or more objects of the second spherical objects **112** equally, then each of the objects in the second spherical objects receives an equal portion of the impact force at an angle of 45 degrees. Accordingly, the normal

force components produced by each of the impacted spherical objects of the second spherical objects **112** is 1/x*F*sin θ, where F is the impact force, x is the number objects in the second layer of spherical objects that are impacted, and θ is the collision angle.

FIG. **36** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system that includes the first and second layers of spherical objects of FIGS. **34** and **35** and further includes an inner padding layer **116** and an outer layer **114**. Note that the first spherical objects **110** and the second spherical objects **112** are of substantially identical spherical shapes, where the spherical shapes include a sphere, an ellipsoid, and/or a spheroid.

The outer shell **114** is juxtaposed to the first layer of spherical objects **110** and is comprised of a material as used for other outer layers as described herein. The inner padding layer **116** is juxtaposed to the second layer of spherical objects **112** and is towards the body part being protected. The inner padding layer **116** is comprised on a material composition that includes a rubber material, a foam material, a padding material, a gel material, a cloth material, a polyester material, a moisture absorbing material, and/or a moisture wicking material.

FIG. **37** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system that is similar to one of FIG. **36** with the addition of a third layer of spherical objects **118**. A spherical object of the third layer **118** has a sphere shape, an ellipse shape, and/or a spheroid shape. The spherical object is comprised of a rubber material, a plastic material, stainless steel, aluminum, and/or a carbon fiber material. Further, the third spherical objects **118** may be solid or hollow. Still further, the material composition of the third spherical object is such that, as a result the collision, the magnitude of the impact force is reduced.

FIG. **38** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system that is similar to one of FIG. **36** with the addition of a fill material **120**. The fill material **120** at least partially encases at least some of the first spherical objects **110** and at least some of the second spherical shaped objects **112**. The fill material has a force dampening property (e.g., a force dampening ratio of 0.5 to 0.95) and is comprised of a rubber material, a foam material, a padding material, and/or a gel material.

FIG. **39** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system that is similar to one of FIG. **38** with the addition of a padding layer **122**. The padding layer **122** force dampening property (e.g., a force dampening ratio of 0.5 to 0.95) and is comprised of a rubber material, a foam material, a padding material, and/or a gel material.

FIG. **40** is a schematic block diagram, in a side view, of an example of an impact protection system that includes a plurality of component layers **50 54 60-64**, an outer layer **24**, an inner layer **12**, and a plurality of intermediate layers **52 66-70**. While the present example shows 5 component layers and 4 intermediate layers, the system could have more or less component layers and/or more or less intermediate layers.

Each component layer **50 54 60-64** includes a first layer of spherical objects **110** and a second layer of spherical objects **112** as described with reference to FIGS. **34** and **35**. When a force **96** impacts the outer layer, the component layers, on a layer by layer basis dampens and defuses the impact force **96**. The intermediate layers **52 66-70** may further reduce the impact force such that, by the time the impact reaches the body part, it is substantially attenuated and spread out over a large area. The gray shaded spheres depict the diffusing of the impact force over a large and larger area with each layer.

FIG. **41** is a schematic block diagram, in a side view, of another example of force diffusion via force defusing layers for use in an impact protection system, which is similar to the one of FIG. **40** with the subtraction of the intermediate layers. As, each layer of spherical objects are in direct contact with the next layer. The gray shaded spheres depict the diffusing of the impact force **96** over a large and larger area with each layer such that, by the time it reaches the inner layer **12**, it has been spread out over a large area.

FIG. **42** is a schematic block diagram, in a side view, of another embodiment of a force defusing layers for use in an impact protection system that includes a first component layer **50**, a second component layer **54**, an intermediate layer **52**, and an inner padding layer **116**. The first component layer **50** includes a first layer of spherical objects **110** and a second layer of spherical objects **112**. The second component layer **54** also includes a first layer of spherical objects and a second layer of spherical objects, but are larger than the first and second layer spherical objects **110** and **112**.

FIGS. **43**A-**43**C are schematic block diagrams, in a side view, of examples of impact force dampening and diffusion via force defusing layers of an impact protection system. FIG. **43**A depicts the embodiment of FIG. **38** just prior to impact. FIG. **43**B illustrates the embodiment of FIG. **38** having a rigid outer shell **114** that bows a little due to the impact force. Even though the outer shell does not bow much, a majority of the impact force is still applied to the spheres closest to the impact area. FIG. **43**C illustrates the embodiment of FIG. **38** having a softer outer shell **114** bows due to the impact force. With the bowing the outer shell **114**, the impact force is applied to the spheres within the impact area.

FIGS. **44** and **45** are top and side views of another embodiment of a force defusing layers for use in an impact protection system. In this embodiment, spherical objects or components are grouped to produce an individual component group. Each component group is a separate piece that can be individually places to create various patterns and/or configurations. The groups **130** can be configured into layers **132**, which can be stacked to create further patterns for the protection system.

The impact protection system described herein has been directed towards the use of protecting body parts from injury due to an impact with an object. The impact protection system works equally well to protect parts of animals from an impacting object. The impact protection system further works to inanimate things from impacting objects, from being dropped during shipping, etc.

It is noted that terminologies as may be used herein such as bit stream, stream, signal sequence, etc. (or their equivalents) have been used interchangeably to describe digital information whose content corresponds to any of a number of desired types (e.g., data, video, speech, audio, etc. any of which may generally be referred to as 'data').

As may be used herein, the terms "substantially" and "approximately" provides an industry-accepted tolerance for its corresponding term and/or relativity between items. Such an industry-accepted tolerance ranges from less than one percent to fifty percent and corresponds to, but is not limited to, component values, integrated circuit process variations, temperature variations, rise and fall times, and/or thermal noise. Such relativity between items ranges from a differ-

ence of a few percent to magnitude differences. As may also be used herein, the term(s) "configured to", "operably coupled to", "coupled to", and/or "coupling" includes direct coupling between items and/or indirect coupling between items via an intervening item (e.g., an item includes, but is not limited to, a component, an element, a circuit, and/or a module) where, for an example of indirect coupling, the intervening item does not modify the information of a signal but may adjust its current level, voltage level, and/or power level. As may further be used herein, inferred coupling (i.e., where one element is coupled to another element by inference) includes direct and indirect coupling between two items in the same manner as "coupled to". As may even further be used herein, the term "configured to", "operable to", "coupled to", or "operably coupled to" indicates that an item includes one or more of power connections, input(s), output(s), etc., to perform, when activated, one or more its corresponding functions and may further include inferred coupling to one or more other items. As may still further be used herein, the term "associated with", includes direct and/or indirect coupling of separate items and/or one item being embedded within another item.

As may be used herein, the term "compares favorably", indicates that a comparison between two or more items, signals, etc., provides a desired relationship. For example, when the desired relationship is that signal **1** has a greater magnitude than signal **2**, a favorable comparison may be achieved when the magnitude of signal **1** is greater than that of signal **2** or when the magnitude of signal **2** is less than that of signal **1**. As may be used herein, the term "compares unfavorably", indicates that a comparison between two or more items, signals, etc., fails to provide the desired relationship.

One or more embodiments have been described above with the aid of method steps illustrating the performance of specified functions and relationships thereof. The boundaries and sequence of these functional building blocks and method steps have been arbitrarily defined herein for convenience of description. Alternate boundaries and sequences can be defined so long as the specified functions and relationships are appropriately performed. Any such alternate boundaries or sequences are thus within the scope and spirit of the claims. Further, the boundaries of these functional building blocks have been arbitrarily defined for convenience of description. Alternate boundaries could be defined as long as the certain significant functions are appropriately performed. Similarly, flow diagram blocks may also have been arbitrarily defined herein to illustrate certain significant functionality.

The one or more embodiments are used herein to illustrate one or more aspects, one or more features, one or more concepts, and/or one or more examples. A physical embodiment of an apparatus, an article of manufacture, a machine, and/or of a process may include one or more of the aspects, features, concepts, examples, etc. described with reference to one or more of the embodiments discussed herein. Further, from figure to figure, the embodiments may incorporate the same or similarly named functions, steps, modules, etc. that may use the same or different reference numbers and, as such, the functions, steps, modules, etc. may be the same or similar functions, steps, modules, etc. or different ones.

While particular combinations of various functions and features of the one or more embodiments have been expressly described herein, other combinations of these features and functions are likewise possible. The present disclosure is not limited by the particular examples disclosed herein and expressly incorporates these other combinations.

What is claimed is:

1. A body impact protection system comprises:

an inner layer including a material composition, wherein the inner layer is adjacent to a body part when the body impact protection system is worn; and

an impact force dampening and defusing structure that is juxtaposed to the inner layer, wherein the impact force dampening and defusing structure includes a plurality of components arranged in a plurality of force dampening and defusing layers to reduce pressure on the body part when an impact force strikes the body impact protection system by reducing a body part impact force resulting from the impact force and by increasing a body part impact area with respect to an impact area of an exterior layer of the plurality of force dampening and defusing layers that is receiving the impact force, wherein the exterior layer includes a set of components of the plurality of components, and wherein the set of components is encased with a second material composition to form a smooth and compressible surface of the exterior layer.

2. The body impact protection system of claim **1** further comprises:

a dampening viscous layer positioned between two layers of the plurality of force dampening and defusing layers.

3. The body impact protection system of claim **2**, wherein the dampening viscous layer comprises:

one or more of a gel and a padding to further dampen the impact force.

4. The body impact protection system of claim **1**, wherein each of the material composition and the second material composition comprises one or more of:

a rubber material;
a foam material;
a padding material;
a plastic material;
a gel material;
a carbon fiber material;
a cloth material;
a polyester material;
a moisture absorbing material;
a moisture wicking material; and
a silicon material.

5. The body impact protection system of claim **1** further comprises:

the plurality of components of the impact force dampening and defusing structure is arranged to create a collision angle between the impact force and the body part thereby dividing the impact force into a normal force component and a tangential force component.

6. The body impact protection system of claim **1**, wherein the impact force dampening and defusing structure comprises:

a first layer of a first set of components of the plurality of components arranged in a first pattern;

a second layer of a second set of components of the plurality of components arranged in a second pattern that is complimentary to the first pattern with respect to reducing pressure on the body part; and

an intermediate layer between the first and second layers of the first and second sets of components, wherein the intermediate layer includes a second material composition.

7. The body impact protection system of claim **6**, wherein the impact force dampening and defusing structure further comprises:

a third layer of a third set of components of the plurality of components arranged in a third pattern that is complimentary to the second pattern with respect to reducing pressure on the body part; and

a second intermediate layer between the second and third layers of the second and third sets of components.

8. The body impact protection system of claim **1**, wherein a component of the plurality of components comprises:

a three-dimensional geometric shape including an impact receiving surface area and a body impact surface area, wherein the body impact surface area is larger than, and a distance "d" from, the impact receiving surface area to facilitate increasing the body part impact area with respect to the impact area of the exterior layer receiving the impact force.

9. The body impact protection system of claim **1** further comprises:

a first component of the plurality of components;

a second component of the plurality of components; and

a third component of the plurality of components, wherein the first component is positioned to receive at least a portion of the impact force, wherein the second and third components are positioned at an angle with respect to the first component such that, when the first component receives the at least the portion of the impact force, the first component collides with the second and third components to produce a plurality of multi-dimensional collisions.

10. A helmet comprises:

an inner layer including a first material composition, wherein the inner layer is adjacent to a head when the helmet is worn;

an impact force dampening and defusing structure juxtaposed to the inner layer, wherein the impact force dampening and defusing structure includes a plurality of components arranged to reduce pressure on the head when an impact force strikes the helmet by reducing a body part impact force resulting from the impact force and by increasing a body part impact area with respect to a helmet impact area receiving the impact force; and

a force dampening and defusing outer shell having a geometric shape to form an exterior surface of the helmet, wherein the force dampening and defusing outer shell is juxtaposed to the impact force dampening and defusing structure and includes a set of components arranged to reduce pressure on the impact force dampening and defusing structure when the impact force strikes the helmet by reducing an impact force dampening and defusing structure force resulting from the impact force and by increasing an impact force dampening and defusing structure impact area with respect to the helmet impact area receiving the impact force, and wherein the set of components are encased with a second material composition to form a smooth and compressible surface of the force dampening and defusing outer shell.

11. The helmet of claim **10** further comprises:

the second material composition being different than the first material composition.

12. The helmet of claim **10**, wherein each of the first and second material compositions comprises one or more of:

a rubber material;

a foam material;

a padding material;

a plastic material;

a gel material;

a carbon fiber material;

a cloth material;

a polyester material;

a moisture absorbing material;

a moisture wicking material; and

a silicon material.

13. The helmet of claim **10** further comprises:

the plurality of components of the impact force dampening and defusing structure is arranged to create a collision angle between the impact force and the head thereby dividing the impact force into a normal force component and a tangential force component.

14. The helmet of claim **10**, wherein the impact force dampening and defusing structure comprises:

a first layer of a first set of components of the plurality of components arranged in a first pattern;

a second layer of a second set of components of the plurality of components arranged in a second pattern that is complimentary to the first pattern with respect to reducing pressure on the head; and

an intermediate layer between the first and second layers of the first and second sets of components, wherein the intermediate layer includes a third material composition.

15. The helmet of claim **14**, wherein the impact force dampening and defusing structure further comprises:

a third layer of a third set of components of the plurality of components arranged in a third pattern that is complimentary to the second pattern with respect to reducing pressure on the head; and

a second intermediate layer between the second and third layers of the second and third sets of components.

16. The helmet of claim **10**, wherein a component of the plurality of components comprises:

a three-dimensional geometric shape including an impact receiving surface area and a body impact surface area, wherein the body impact surface area is larger than, and a distance "d" from, the impact receiving surface area to facilitate increasing the body part impact area with respect to the helmet impact area receiving the impact force.

17. The helmet of claim **10** further comprises:

a first component of the plurality of components;

a second component of the plurality of components; and

a third component of the plurality of components, wherein the first component is positioned to receive at least a portion of the impact force, wherein the second and third components are positioned at an angle with respect to the first component such that, when the first component receives the at least the portion of the impact force, the first component collides with the second and third components to produce a plurality of multi-dimensional collisions.

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