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(54) **CLAMPING DEVICE**

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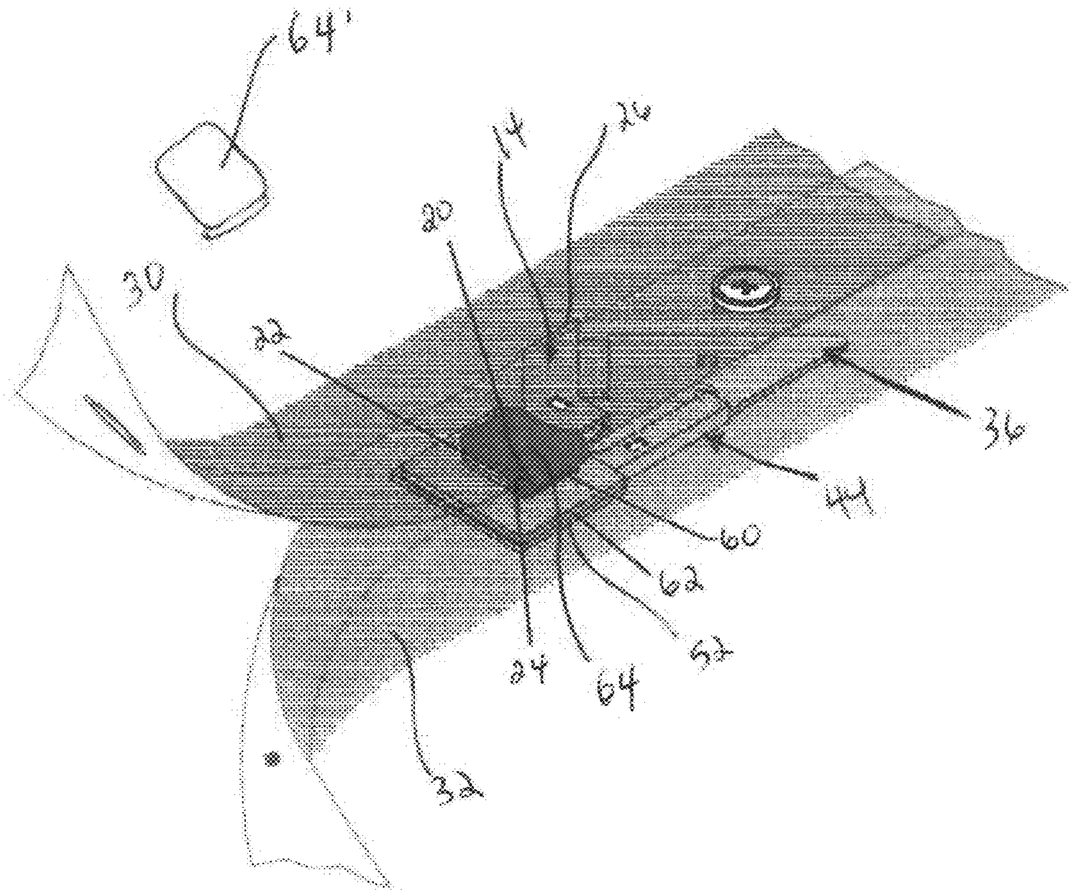
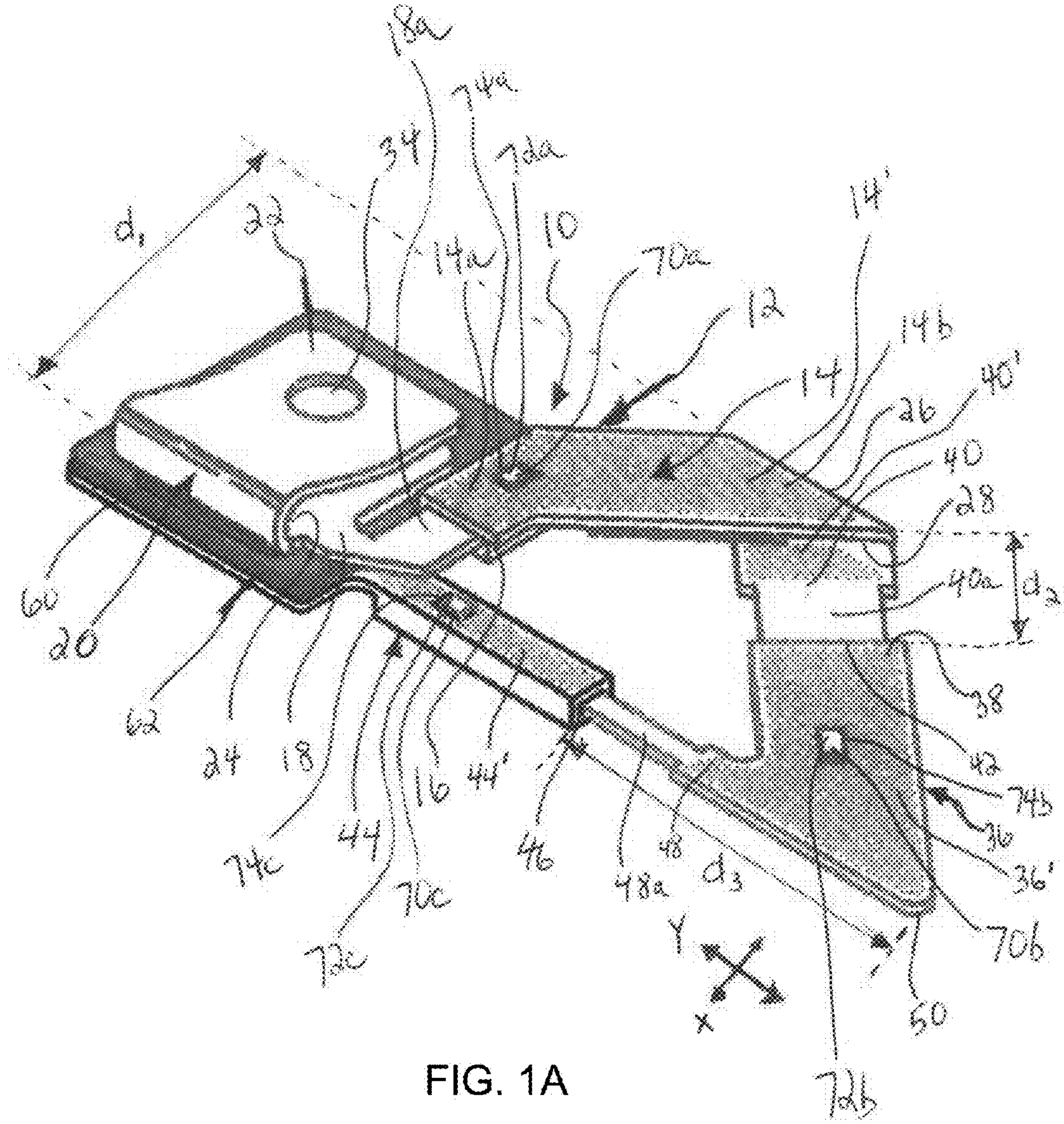
CPC *A41F 1/002* (2013.01); *A44B 99/00* (2013.01)

(57) **ABSTRACT**

A clamping device including a first and second magnet is provided. The first magnet includes predetermined first and second side surface areas, and a first friction element on least one of the first and second side surface areas. The second magnet includes predetermined third and fourth side surface areas, and a second friction element on at least one of the third and fourth side surface areas. The first and second friction elements of the first and second magnets are arranged opposite to each other and define a clamping area between the first and second magnets.




18a
74a
72a
34
d1
22
14a
10
70a
12
14'
14b
14
26
40'
40
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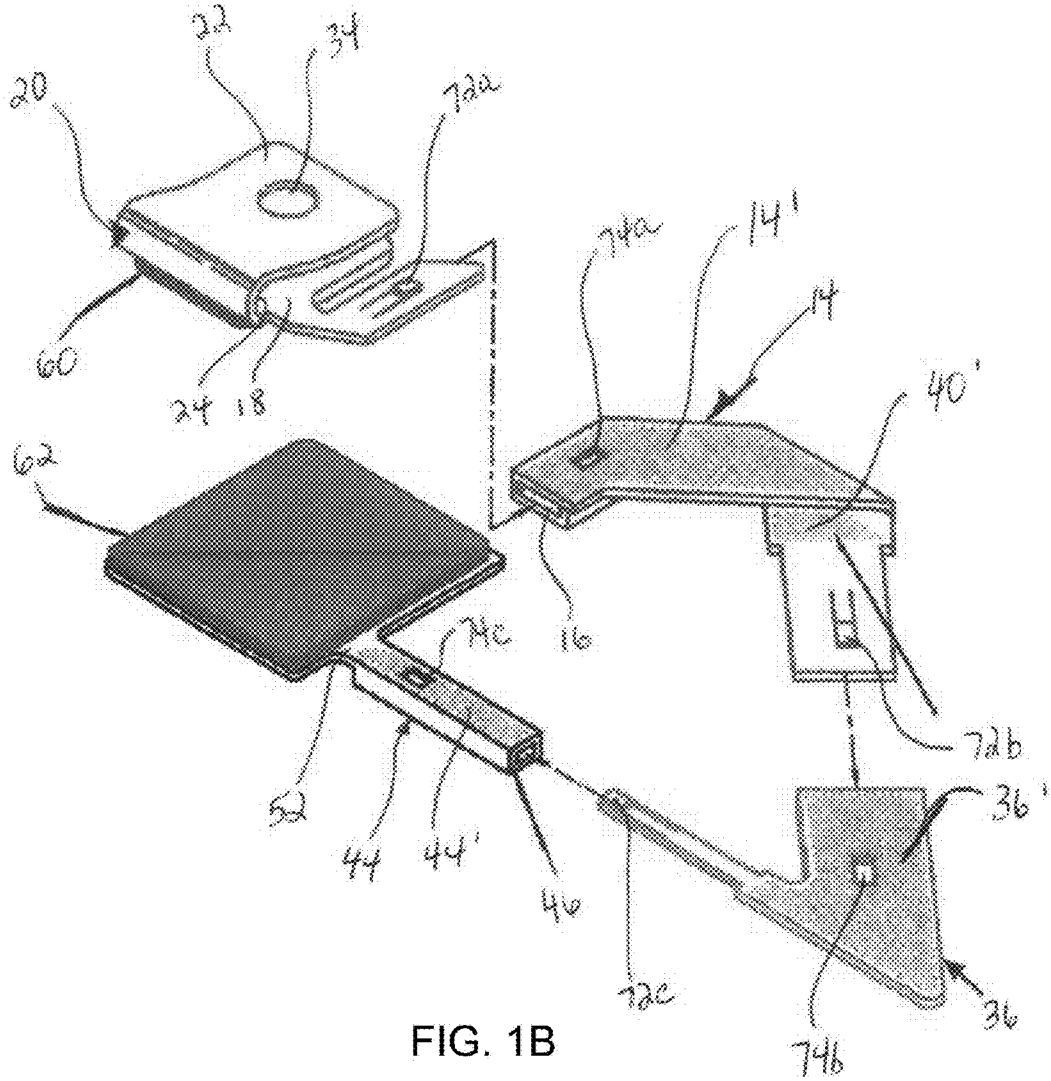
40a
d2
60
20
62
24
18
74c
44
16
44'
46
48a
48
d3
38
42
74b
36
36'
70b
72c
70c
Y
X
50
72b

FIG. 1A


22
34
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72a
14'
74a
14
40'
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24 18
62
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74c
72b
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44
44'
46
36'
72c
74b
36

FIG. 1B

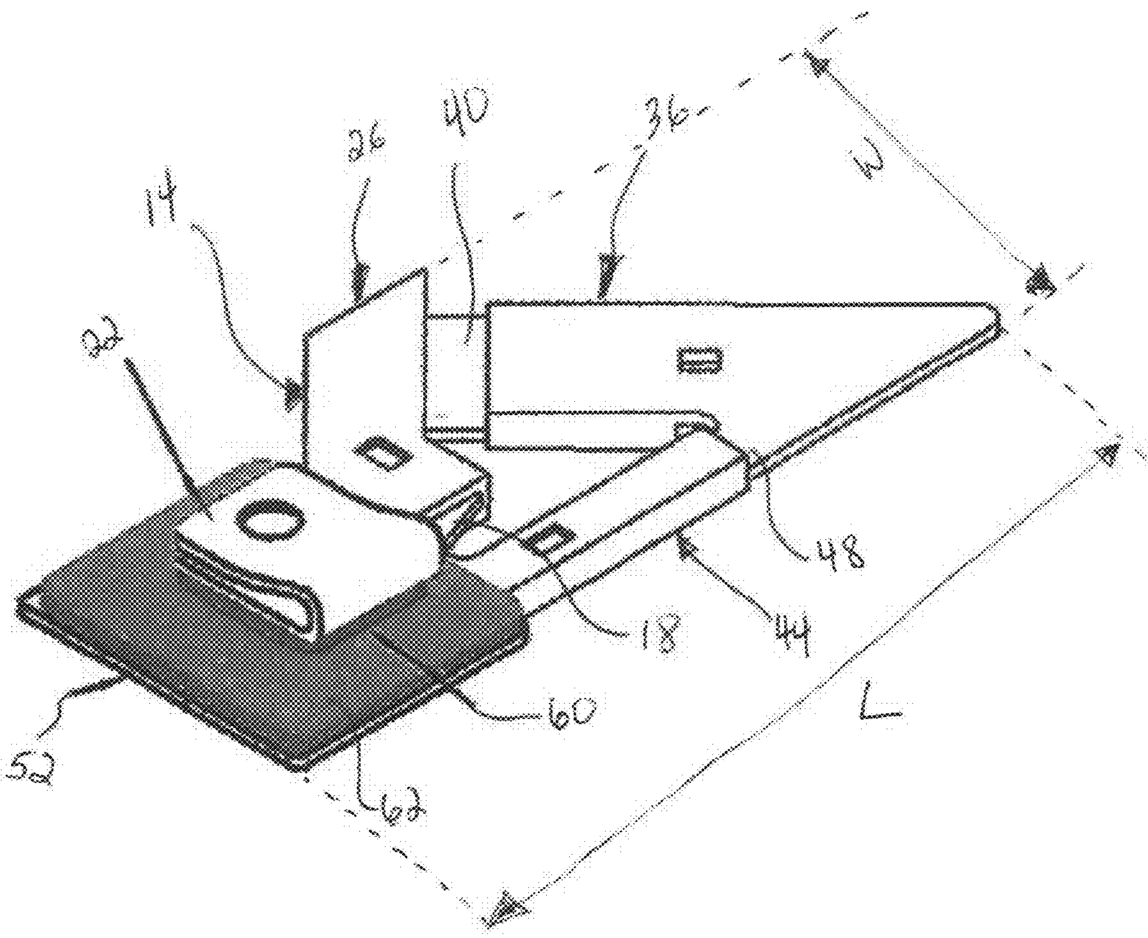

FIG. 1C

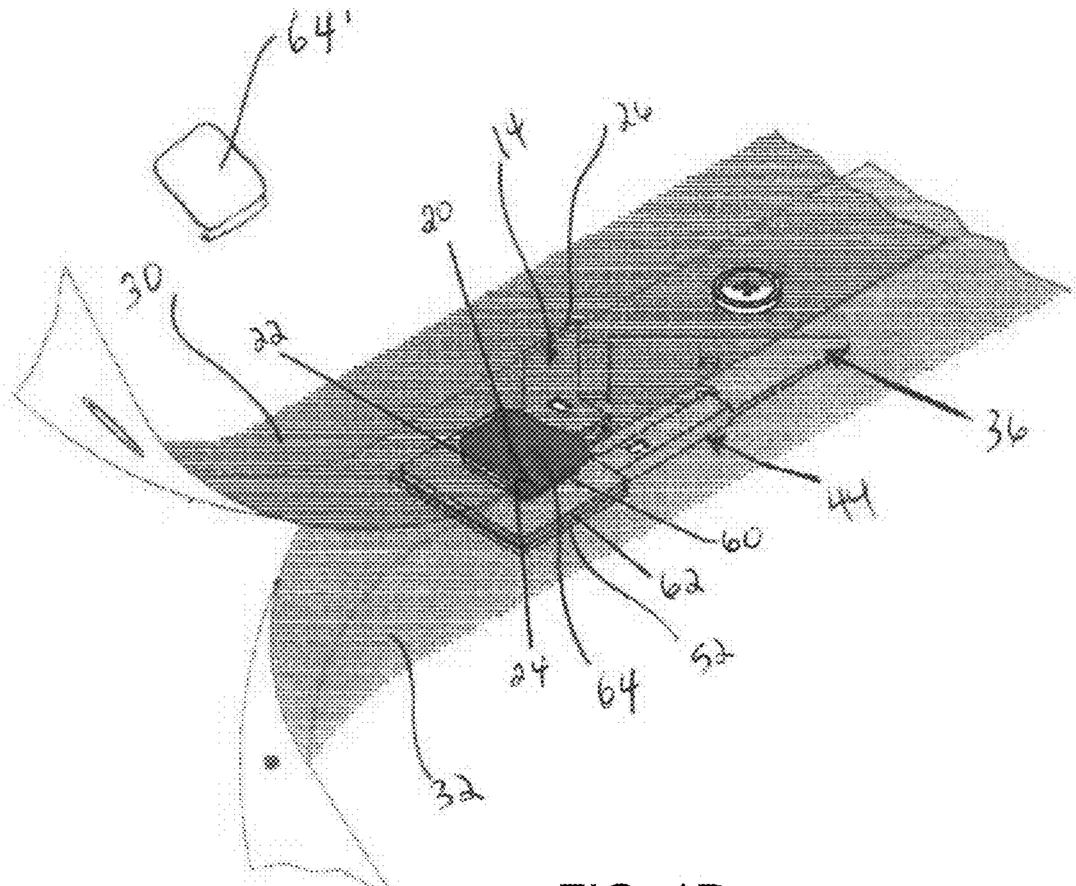

FIG. 1D

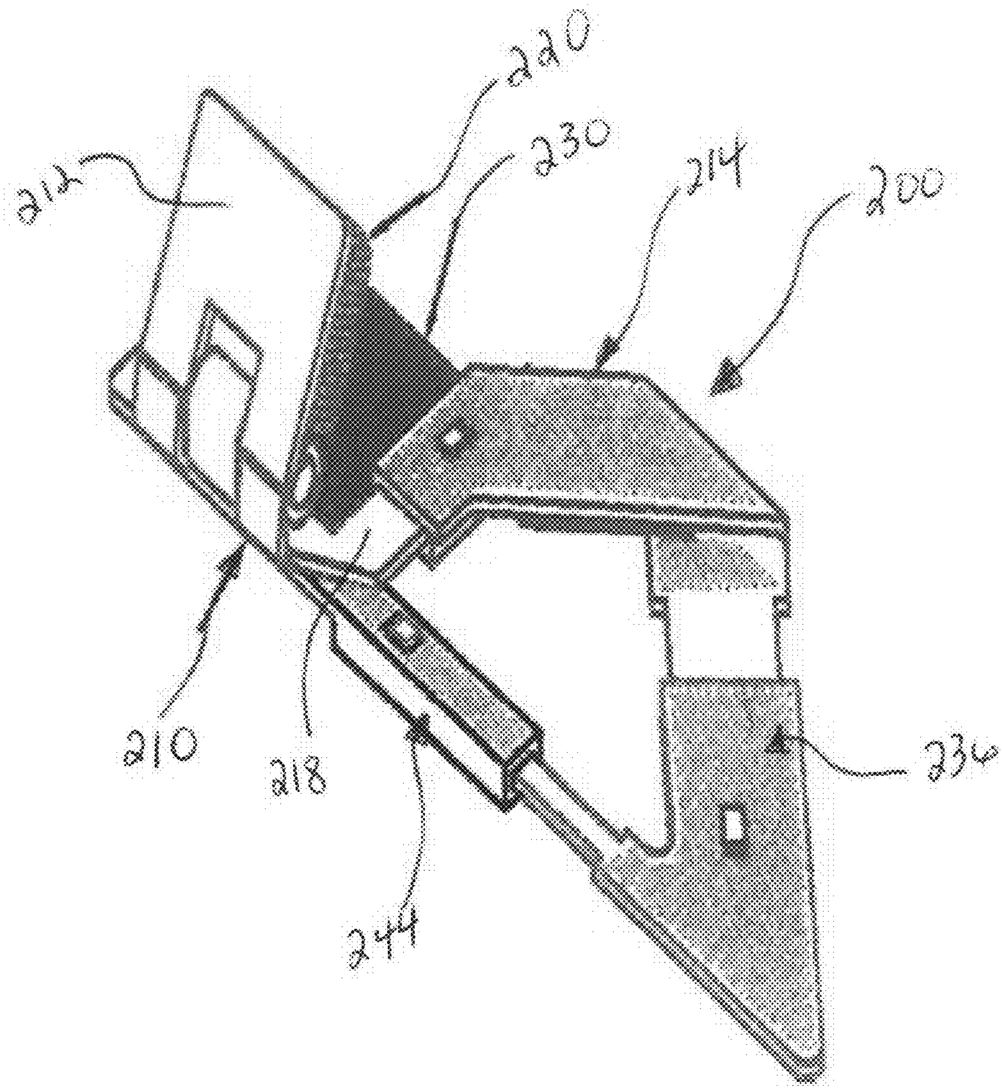

FIG. 2A

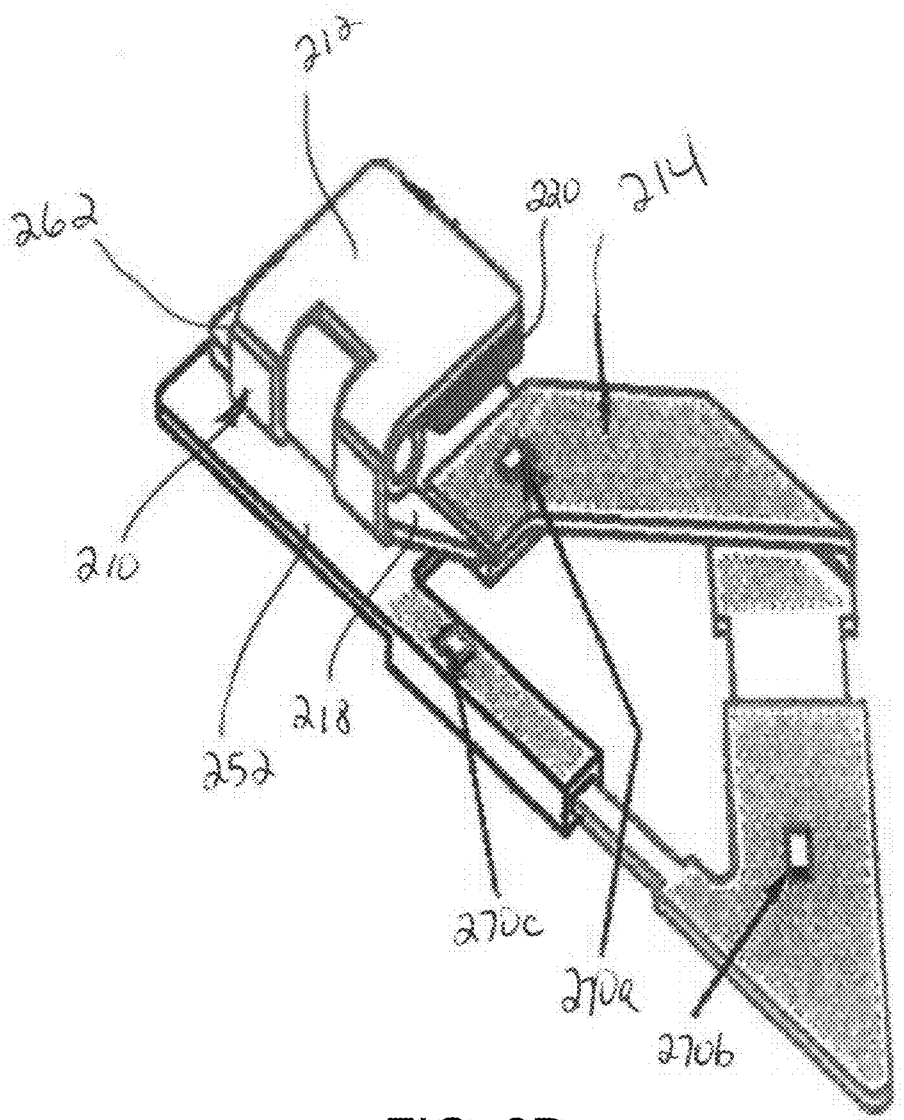

FIG. 2B

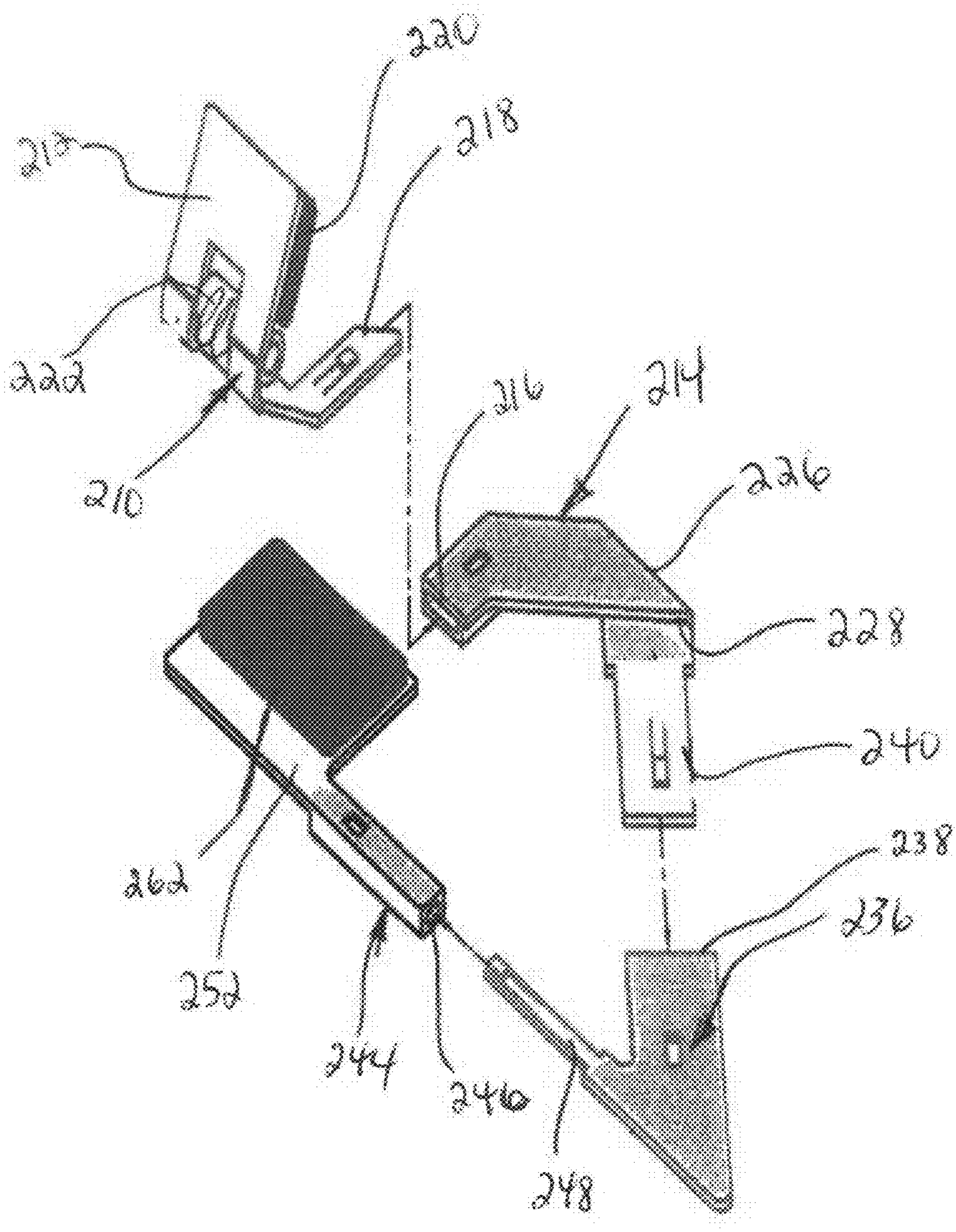
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FIG. 2C

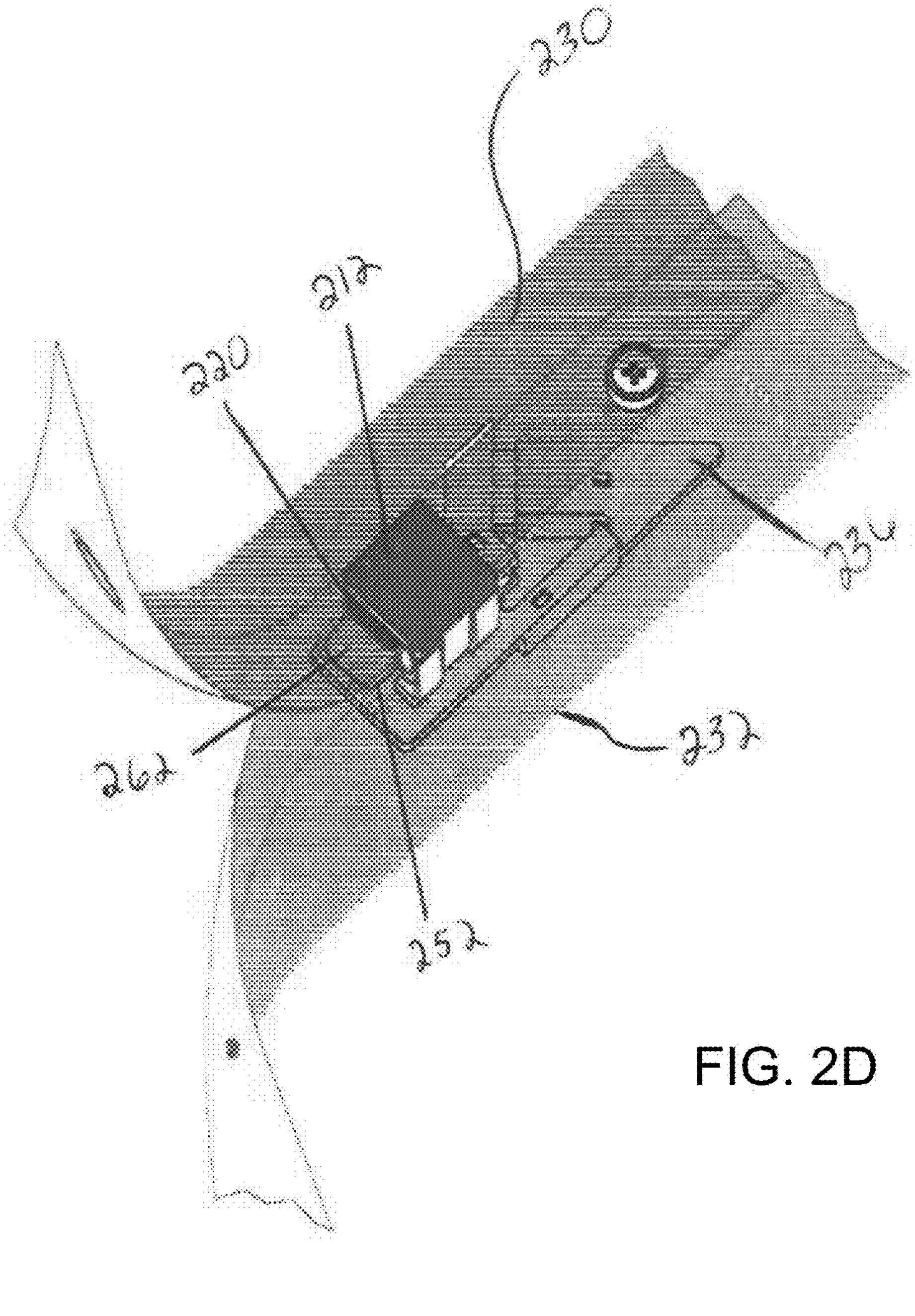


FIG. 2D

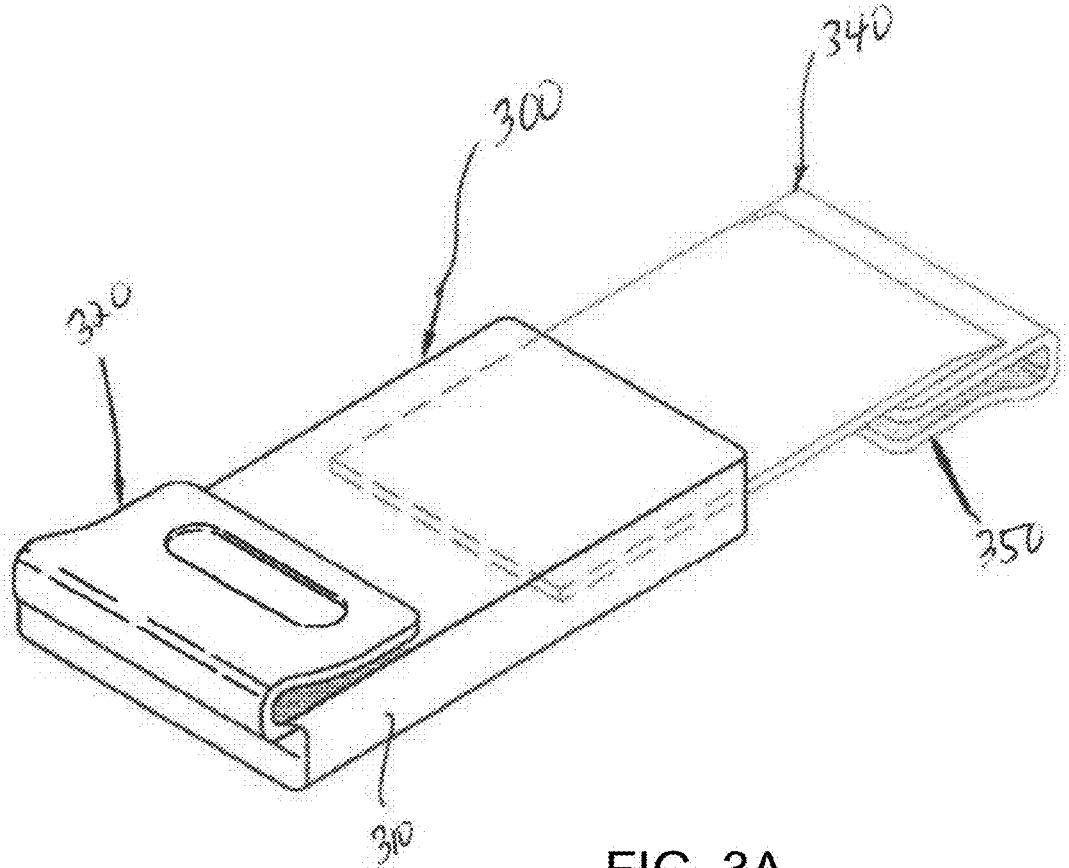


FIG. 3A

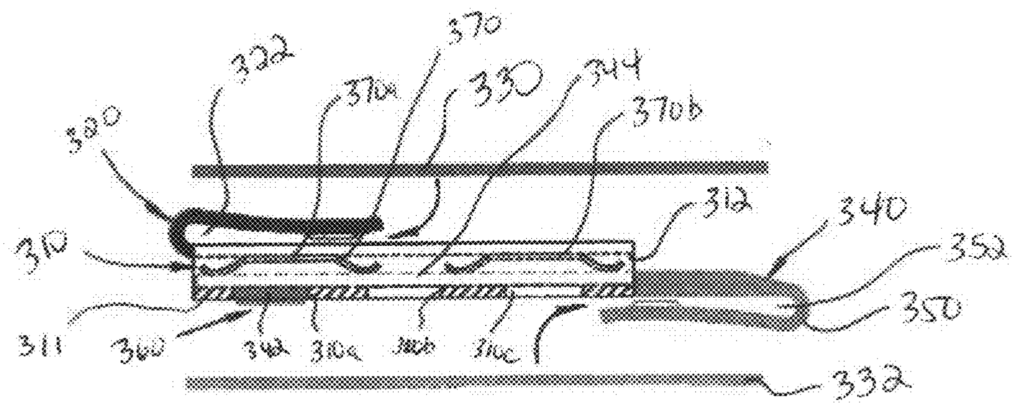


FIG. 3B

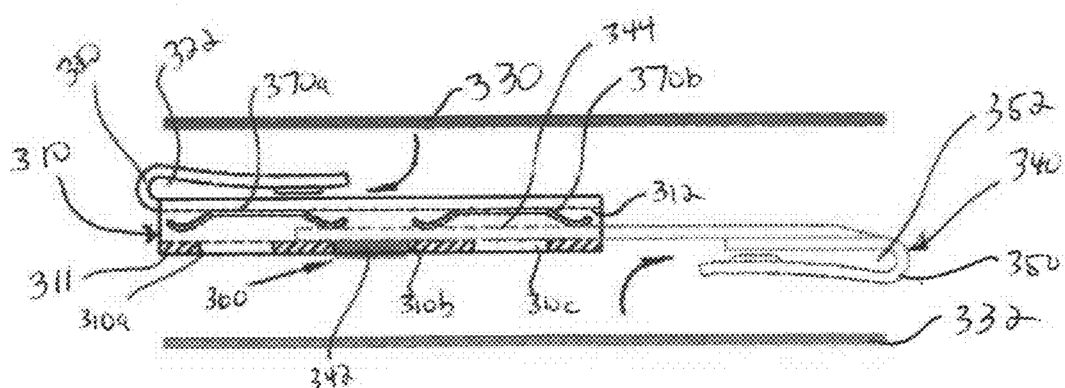


FIG. 3C

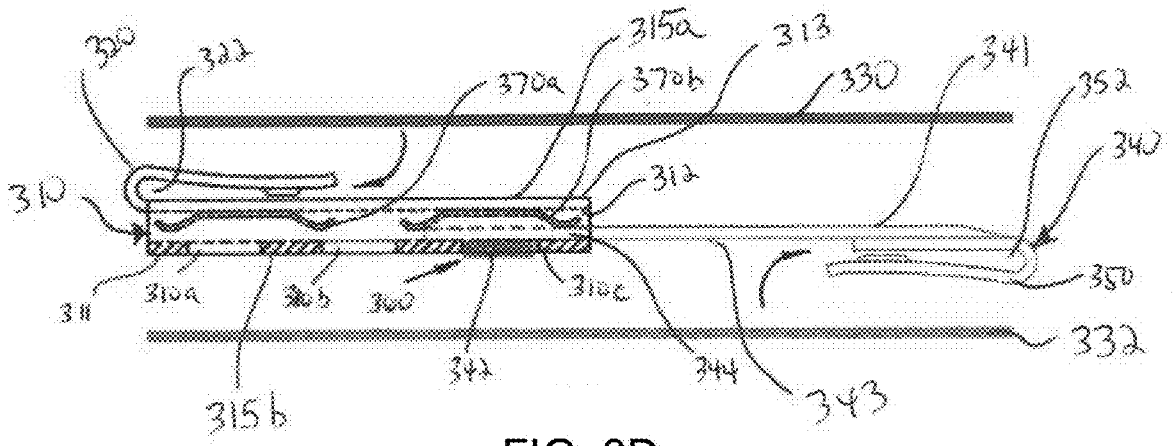
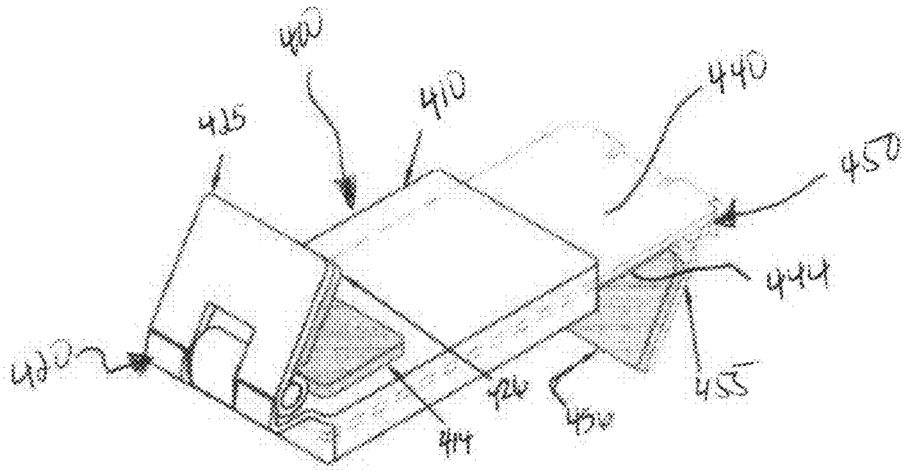


FIG. 3D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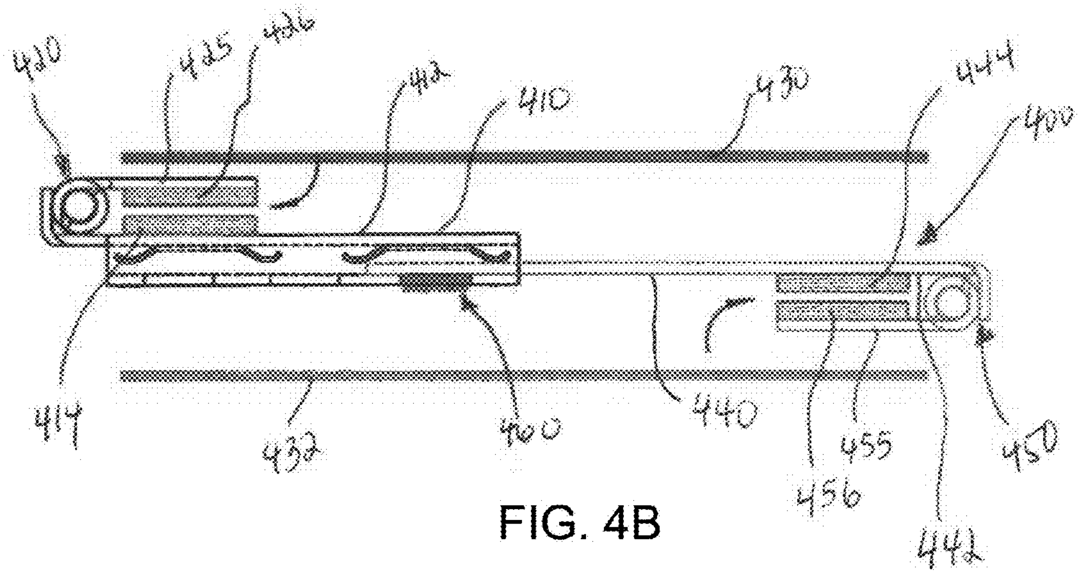
444
420
426
455
430
414

FIG. 4A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450
442

FIG. 4B

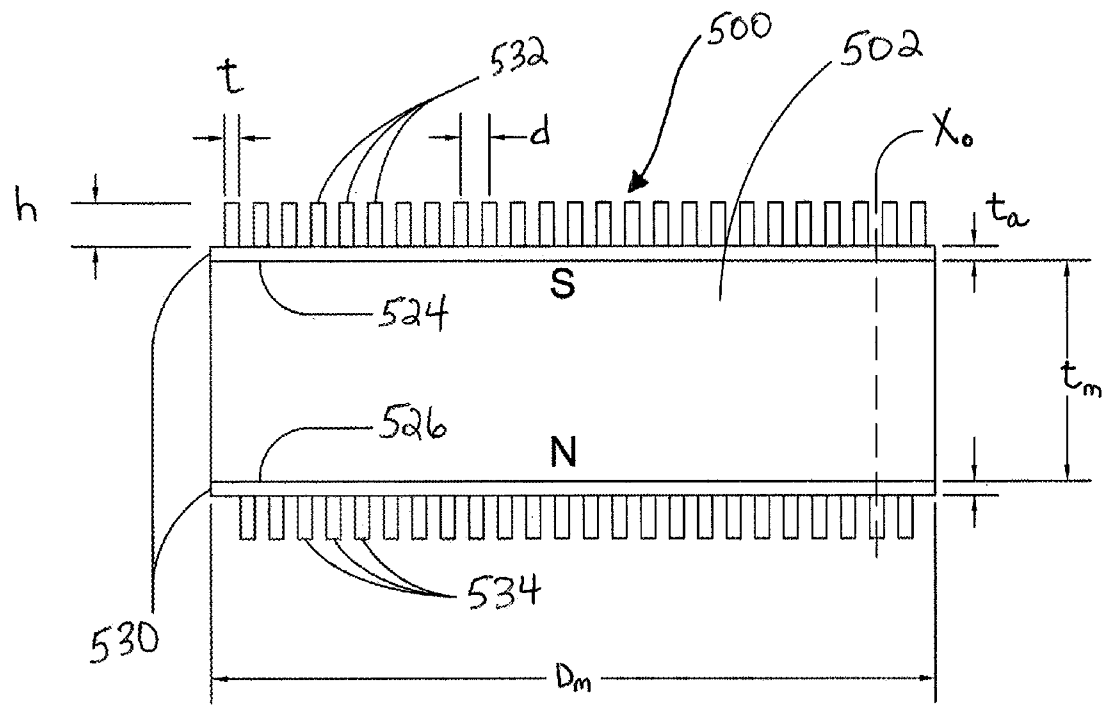

FIG. 5A

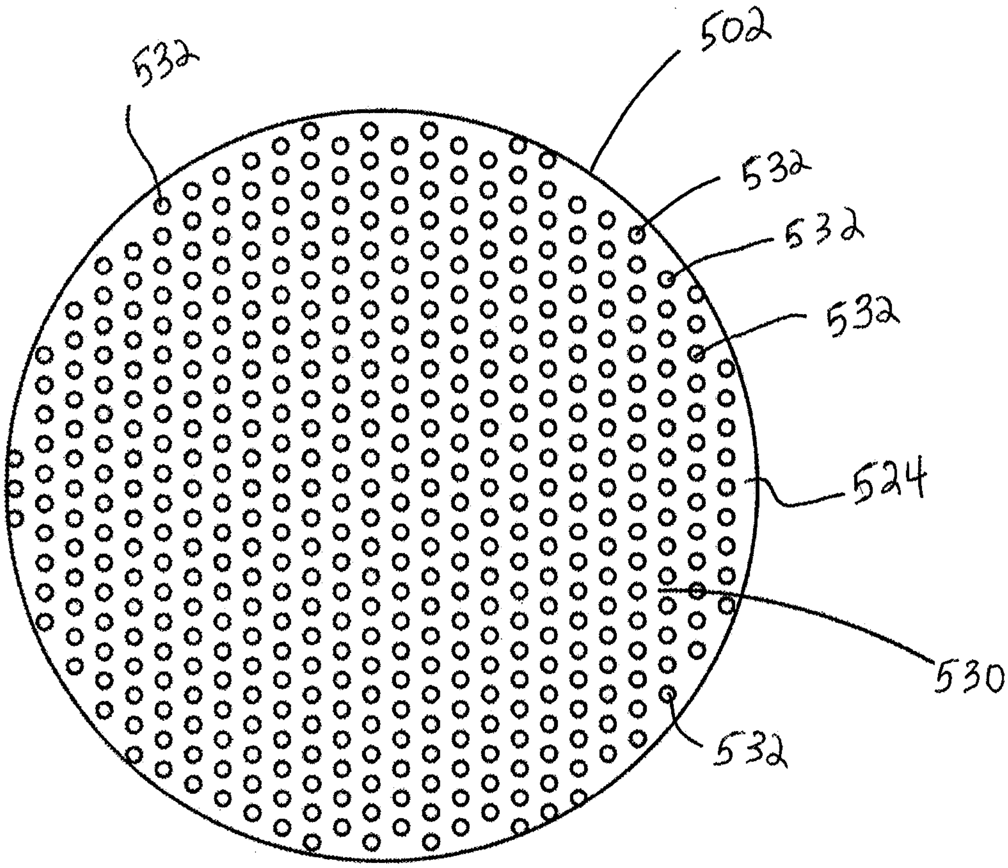

FIG. 5B

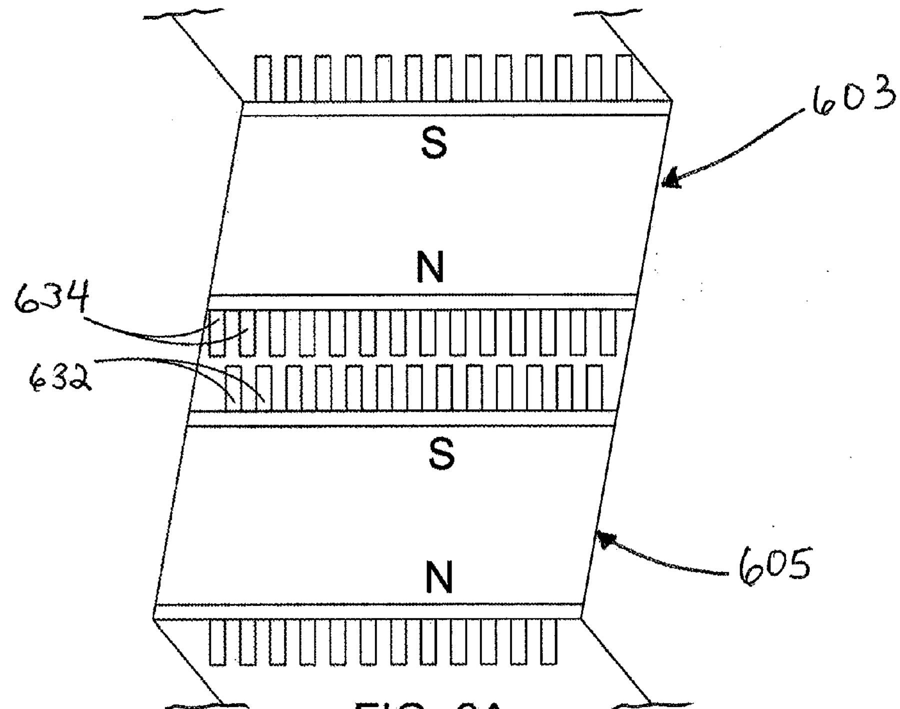

FIG. 6A

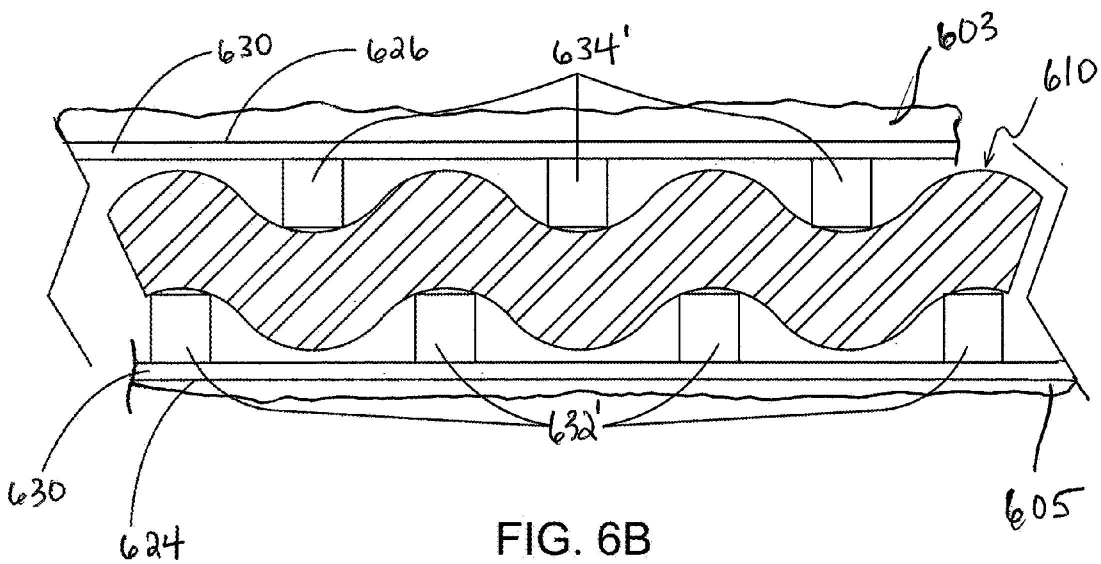

FIG. 6B

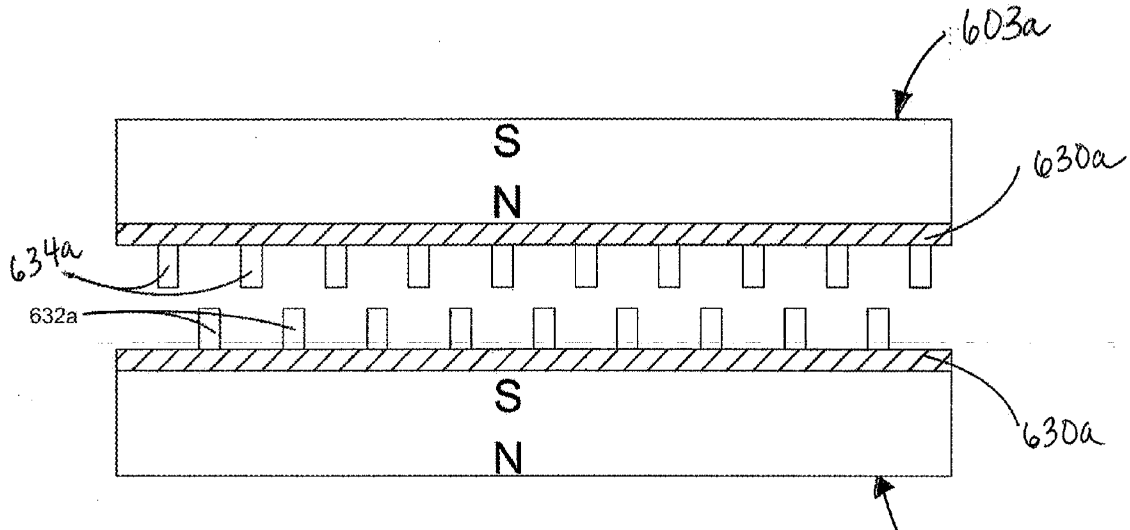
603a
S
N
630a
634a
632a
S
N
630a
605a

FIG. 6C

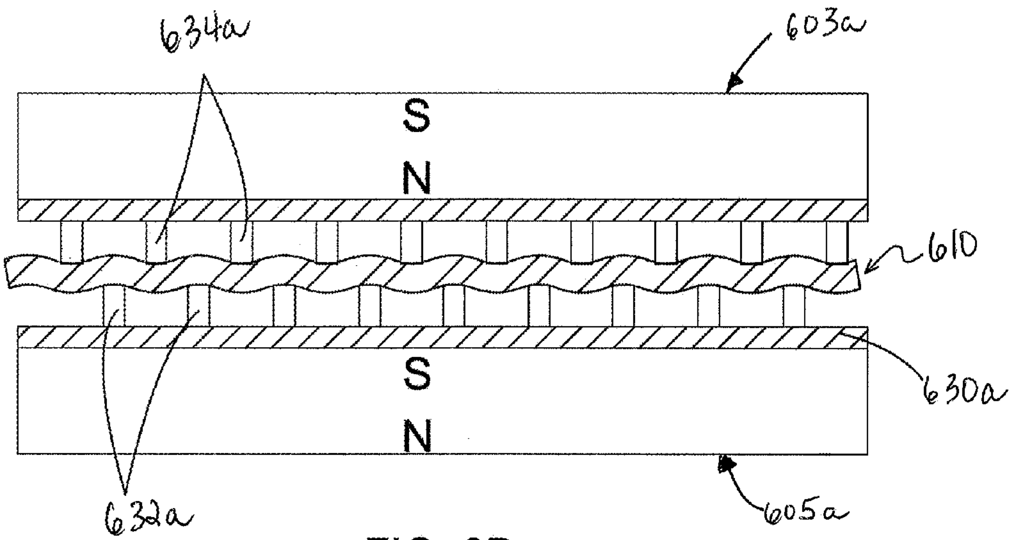
634a
603a
S
N
610
S
N
630a
632a
605a

FIG. 6D

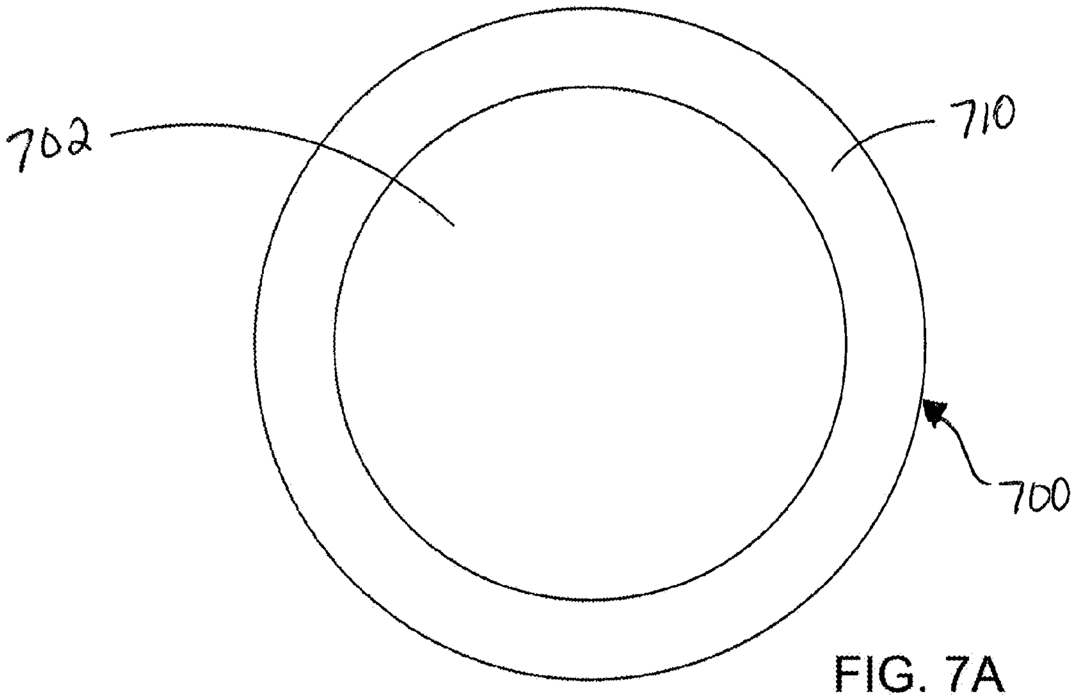

FIG. 7A

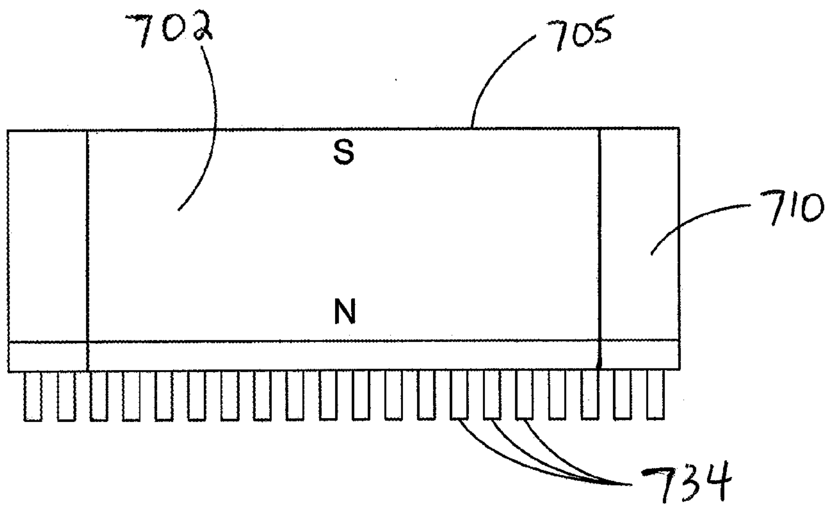

FIG. 7B

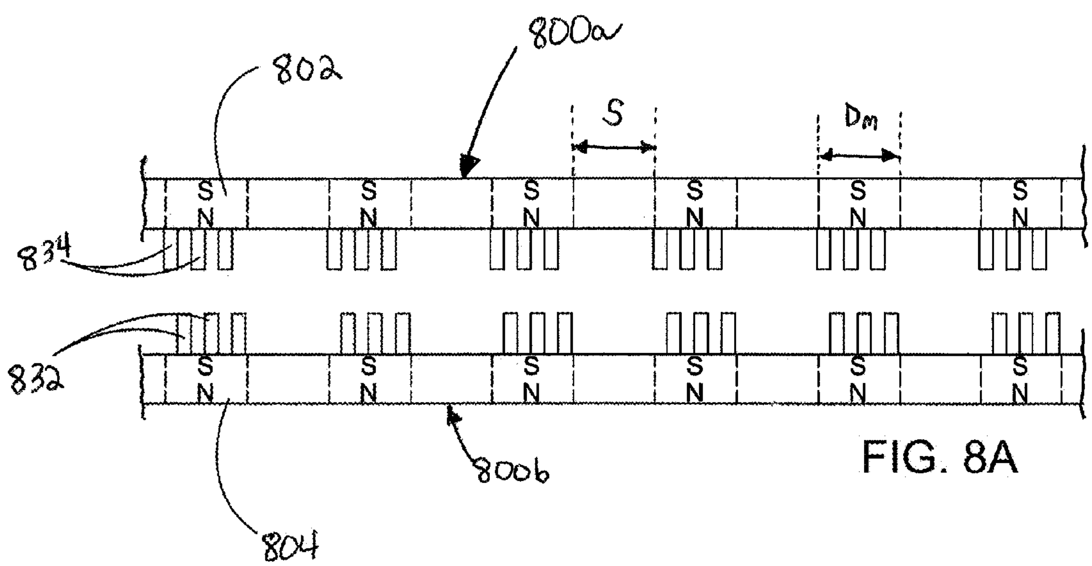

FIG. 8A

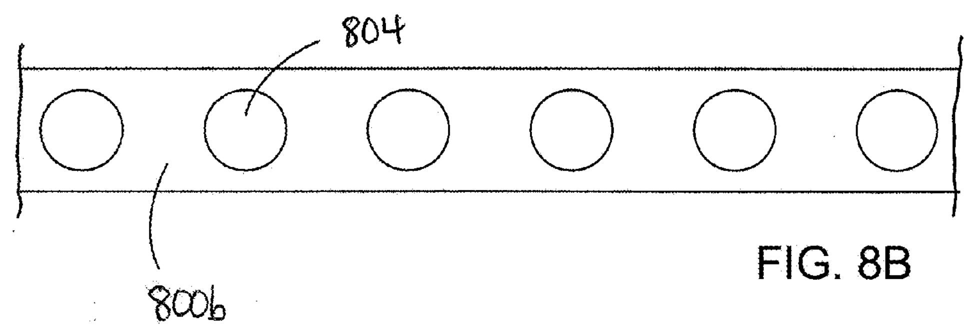

FIG. 8B

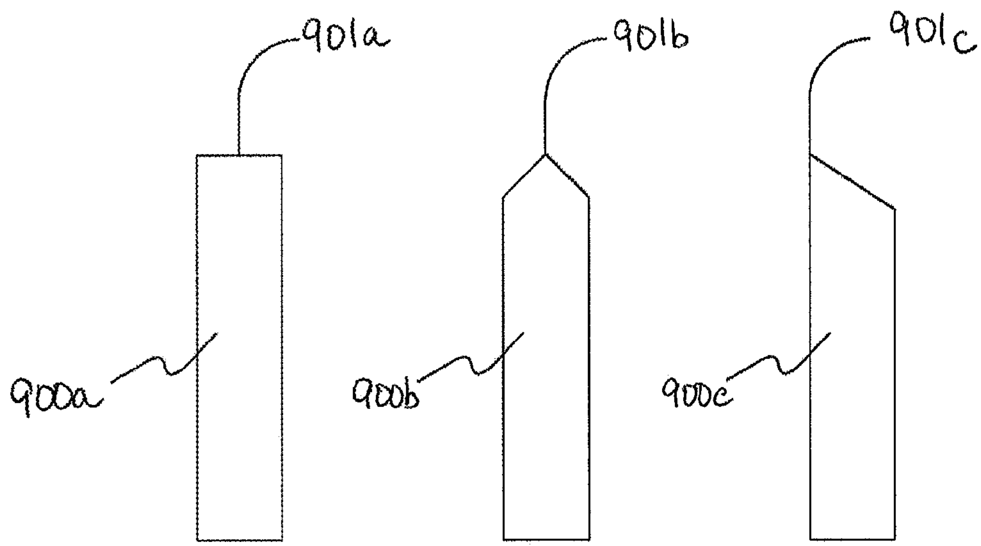

FIG. 9A FIG. 9B FIG. 9C

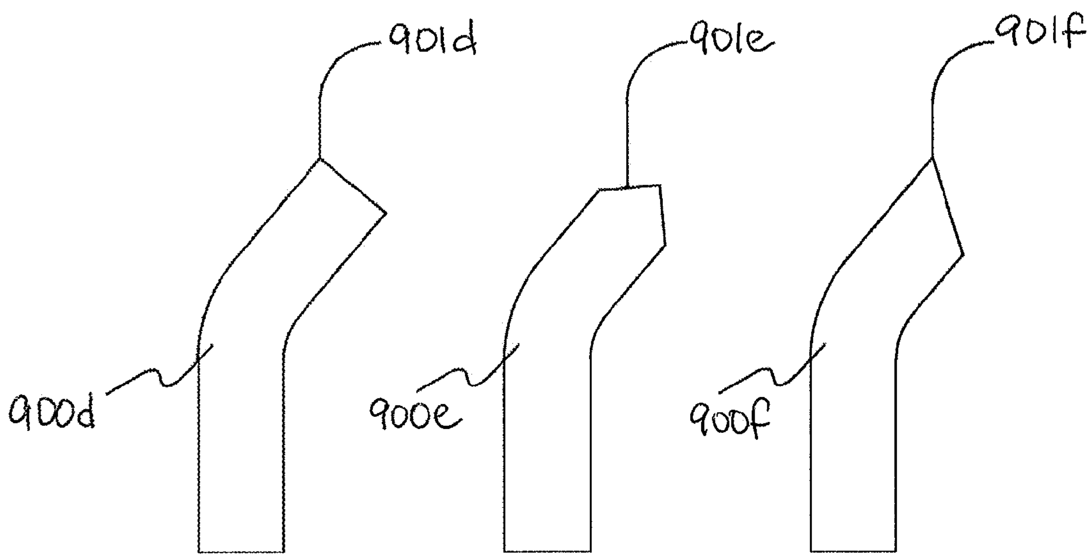

FIG. 9D FIG. 9E FIG. 9F

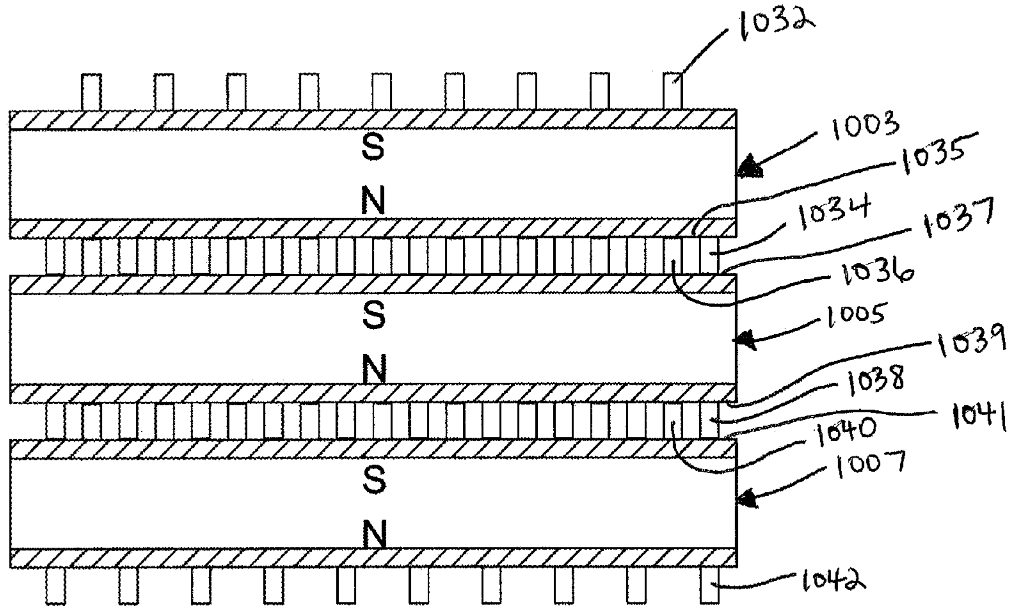

FIG. 10A

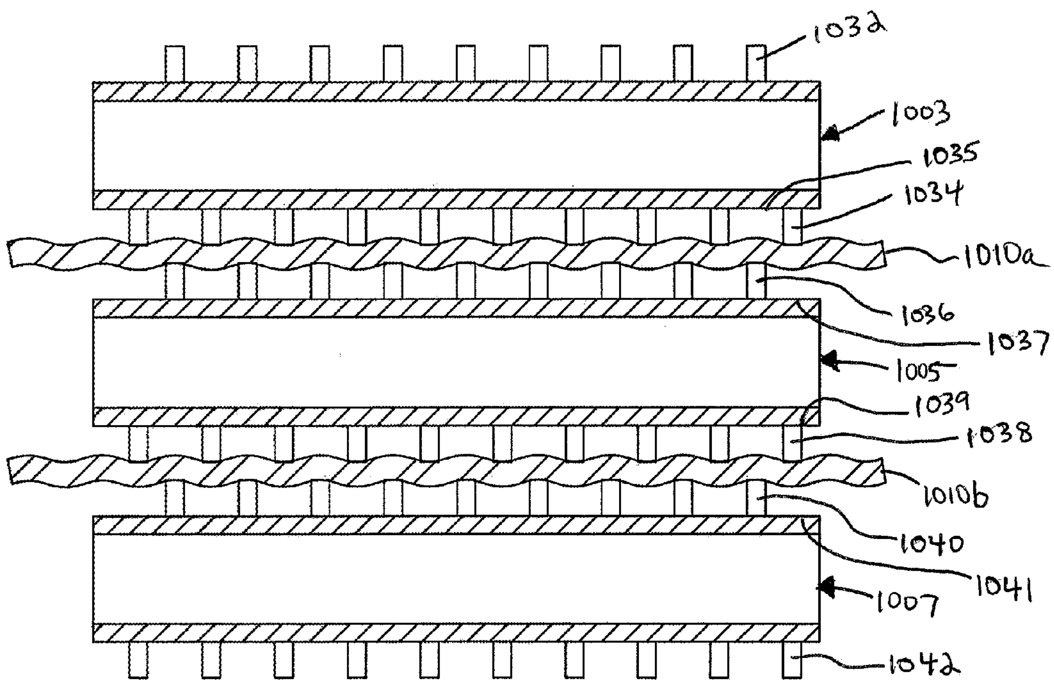

FIG. 10B

CLAMPING DEVICE

INCORPORATION BY REFERENCE

[0001] This application claims the benefit of U.S. Provisional Application 62/310,246 filed on Mar. 18, 2016, which is incorporated by reference as if fully set forth.

FIELD OF INVENTION

[0002] This application is generally related to a clamping device and is more particularly related to a magnetic clamping device.

BACKGROUND

[0003] Clamping devices are generally known. Known clamping devices can provide permanent fixing of a clamped element in a desired position. Other clamping devices can provide movable clamping elements that can be easily positioned and removed by a user. These clamping devices generally cause deformation of the clamped material to achieve clamping, or do not provide sufficient strength to reliably hold a clamped element in a desired position.

[0004] Clamping devices can be used with garments and clothing accessories. For example, button-up shirts typically do not have a uniform spacing pattern between different brands, designers, sizes, etc. A v-shaped neckline for a shirt is set by the buttoning or unbuttoning of the buttons of the shirt. Typically, an adjustment of the v-shaped neckline of a shirt may occur depending on a social situation, wearer's mood, or other factors. The arbitrary placement of buttons on a shirt generally makes it difficult to achieve a desired v-shaped neckline. It is desirable to provide a clamping device that allows a user to set and maintain the location of a clamped material.

[0005] It would be desirable to provide a clamping device that is freely positionable, does not mar or damage a clamped material, and provides reliable clamping force to retain the clamped material in a desired position.

SUMMARY

[0006] A clamping device including a first magnet and a second magnet is provided. The first magnet has predetermined first and second side surface areas and a first friction element on least one of the first and second side surface areas. The second magnet has predetermined third and fourth side surface areas, and a second friction element on at least one of the third and fourth side surface areas. The first friction element of the first magnet and the second friction element of the second magnet are arranged opposite to each other and define a clamping area between the first magnet and the second magnet.

[0007] In one embodiment, the friction elements are tines. The tines permit compression of a clamped material to grip the clamped material, which provides increased strength and reduces the chances of the clamping device becoming unclamped. The tines increase the requisite lateral force necessary to unclamp the clamping device.

[0008] In another embodiment, the clamping device includes a plurality of magnets. The plurality of magnets preferably includes more than two magnets. Stacking the magnets increases the strength of the clamping device, while the tines ensure that the additional stacked magnets cannot slide away from each other. In this embodiment, the clamping device is infinitely stackable, i.e. it is possible to continuously add magnets until the requisite strength of the clamping device is achieved. Stacking magnets on both sides of a clamped material increases the magnetically attractive force between the two stacks of magnets, thereby increasing the overall clamping force of the clamping device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The following Detailed Description will be understood when read in conjunction with the appended drawings wherein:

[0010] FIG. **1**A shows a perspective view of a garment device according to a first embodiment in an extended state.

[0011] FIG. **1**B shows an exploded perspective view of the garment device of FIG. **1**A.

[0012] FIG. **1**C shows a perspective view of the garment device of FIGS. **1**A and **1**B in a contracted state.

[0013] FIG. **1**D shows a perspective view of the garment device of FIGS. **1**A-**1**C in an installed state on a garment.

[0014] FIG. **2**A shows a perspective view of a garment device according to a second embodiment with a hinged plate in an open configuration.

[0015] FIG. **2**B shows a perspective view of the garment device of FIG. **2**A with the hinged plate in a closed configuration.

[0016] FIG. **2**C shows an exploded perspective view of the garment device of FIGS. **2**A and **2**B.

[0017] FIG. **2**D shows a perspective view of the garment device of FIGS. **2**A-**2**C in an installed state on a garment.

[0018] FIG. **3**A shows a perspective view of a garment device according to a third embodiment.

[0019] FIGS. **3**B-**3**D show cross sectional views of the garment device of FIG. **3**A with an adjustment mechanism is different positions.

[0020] FIG. **4**A shows a perspective view of a garment device according to a fourth embodiment.

[0021] FIG. **4**B shows a cross sectional view of the garment device of FIG. **4**A.

[0022] FIG. **5**A is a side view of a clamping device according to a fifth embodiment.

[0023] FIG. **5**B is a top plan view of the clamping device of FIG. **5**A.

[0024] FIG. **6**A is a side view of two clamping devices according to a sixth embodiment with flexible tines.

[0025] FIG. **6**B is a side view of two of the clamping devices of FIG. **6**A with a material layer between the clamping devices.

[0026] FIG. **6**C is a side view of two clamping devices according to a sixth embodiment with rigid tines.

[0027] FIG. **6**D is a side view of two of the clamping devices of FIG. **6**C with a material layer between the clamping devices.

[0028] FIG. **7**A is a top view of a clamping device according to a seventh embodiment.

[0029] FIG. **7**B is a side view of the clamping device of FIG. **7**A.

[0030] FIG. **8**A is a side view of two strips of clamping devices according to an eighth embodiment.

[0031] FIG. **8**B is a top view one of the two strips of FIG. **8**A.

[0032] FIGS. **9**A-**9**F illustrates multiple embodiments of tines.

[0033] FIG. **10**A is a side view of a stack of clamping devices.

[0034] FIG. **10**B is a side view of the stack of clamping devices of FIG. **10**A with clamped material layers.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] FIGS. **1**A-**1**D illustrate a first embodiment of a garment closing device **10**. The garment closing device **10** includes a body **12** having a first arm **14** and a first sleeve **16**. As shown in FIGS. **1**A-**1**D, the body **12** preferably has a generally triangular profile. The first arm **14** includes a first portion **18** that is slidably received within the first sleeve **16**. The first sleeve **16** is dimensioned to allow for slidably adjusting the first portion **18** with respect to the first sleeve **16**. The first portion **18** includes a first clip **20** having a first bend **22** that bends forwards with respect to the first arm **14** to define a first gap **24**. The first arm **14** includes a second bend **26** that bends backwards with respect to the first arm **14** to define a second gap **28**. The second bend **26** is preferably at an opposite end **14***b* of the first arm **14** from an end **14***a* of the first arm **14** including the first bend **22**. The first bend **22** is dimensioned to grip a first portion **30** of a garment and the second bend **26** is dimensioned to grip a second portion **32** of a garment. Once installed, the first portion **30** of the garment is sandwiched between the first bend **22** and the second portion **32** of the garment is sandwiched between the second bend **26**. The first portion **30** and the second portion **32** of the garment are preferably interfacing plackets of a single shirt. The first portion **30** of the garment can either be a button placket or a buttonhole placket of a shirt. The second portion **32** of the garment can either be a button placket or a buttonhole placket of a shirt.

[0036] In the embodiment shown in FIGS. **1**A-**1**D, the first clip **20** of the first portion **18** includes a dimpled portion **34**. The dimpled portion **34** provides an improved gripping configuration for the first portion **30** of the garment since the dimpled portion **34** contacts the first portion **30** of the garment once the garment closing device **10** is attached to the first and second portions of the garment **30**, **32**. The dimensions of the dimpled portion **34** can be varied to provide increased contact between the dimpled portion **34** and the first portion **30** of the garment. The first bend **22** and the second bend **26** each preferably define gaps **24**, **28** having a clearance of 1/32", which corresponds to a thickness of an average placket for a dress shirt. The dimensions of the bends **22**, **26** are selected to provide a reliable gripping configuration for an average-sized placket. The dimpled portion **34** can include some resiliency to provide a narrower gap to provide additional gripping ability of the first portion **30** of the garment.

[0037] As shown in FIGS. **1**A-**1**C, the first portion **18** of the first arm **14** is slidably received within the first sleeve **16** such that a first distance (d**1**) between the first bend **22** and the second bend **26** is adjustable. This adjustment of a length of the first arm **14** allows the overall lateral size of the device **10** to be adjustable, as shown in the lateral direction (X) in FIG. **1**A. FIG. **1**A shows the first portion **18** in an extended position, such that an extension **18***a* of the first portion **18** is visible and outside of the first sleeve **16**. FIG. **1**C shows the first portion **18** in a contracted position such that the extension **18***a* of the first portion **18** is slid within the first sleeve **16** and not visible.

[0038] As shown in FIGS. **1**A-**1**D, the body **12** of the device **10** includes a second arm **36** having a second sleeve **38**, which is similar to the first sleeve **16** of the first arm **14**. The first arm **14** includes a second portion **40** that is slidably received within the second sleeve **38** of the second arm **36**. A second distance (d**2**) between an end **42** of the second sleeve **38** and the second bend **26** is adjustable.

[0039] As shown in FIGS. **1**A-**1**D, the body **12** of the device **10** includes a third arm **44** with a third sleeve **46**. The second arm **36** includes a second portion **48** that is slidably received within the third sleeve **46** of the third arm **44**. A third distance (d**3**) is adjustable between a corner **50** of the second arm **36** and the third sleeve **46** of the third arm **44**.

[0040] The third arm **44** includes a third portion **52** facing the first bend **22** of the first arm **14**. In an assembled condition, the third portion **52** overlaps with the first bend **22** of the first arm **14**, as shown in FIGS. **1**A, **1**C, and **1**D. The first bend **22** of the first arm **14** includes a first magnet **60** and the third portion **52** of the third arm **44** includes a second magnet **62**. In an assembled state, the first magnet **60** and the second magnet **62** are aligned in the lateral direction (X) and longitudinal direction (Y) such that the first magnet **60** and the second magnet **62** overlap with each other and provide a magnetic attraction to each other. The magnetic attraction between the first magnet **60** and the second magnet **62** helps to retain the device **10** in a desired position with respect to the first portion **30** and the second portion **32** of the garment. As shown in FIGS. **1**A-**1**D, the second magnet **62** preferably has a larger surface area such that even when the arms **14**, **36**, **44** are in the extended position or the contracted position. The larger surface area of the second magnet **62** ensures overlap of the first magnet **60** and the second magnet **62** regardless of whether the arms are in the extended or contracted positions.

[0041] Adjustment mechanisms **70***a*, **70***b*, **70***c* are provided on each of the arms **14**, **36**, **44** and include biased locking pins **72***a*, **72***b*, **72***c* and openings **74***a*, **74***b*, **74***c* dimensioned to receive the biased first locking pin **72***a*, **72***b*, **72***c*. The locking pins **72***a*, **72***b*, **72***c* can be depressed by a user such that the locking pins **72***a*, **72***b*, **72***c* are recessed within the openings **74***a*, **74***b*, **74***c*, and the first portion **18** of the first arm **14** can be slid with respect to the first sleeve **16**, the second portion **40** of the first arm **14** can be slid with respect to the second sleeve **38** of the second arm **36**, and the second portion **48** of the second arm **36** can be slid with respect to the third sleeve **46** of the third arm **44**. The first adjustment mechanism **70***a* allows the first bend **22** to move outward in the lateral direction (X) with respect to the second bend **26** such that the device **10** can be arranged on a larger garment. The second adjustment mechanism **70***b* allows movement of the second arm **36** both in an outward lateral direction (X) and a downward longitudinal direction (Y). The third adjustment mechanism **70***c* allows movement of the second arm **36** in the downward longitudinal direction (Y). The extended position of each of the adjustment mechanisms **70***a*, **70***b*, and **70***c* is shown in FIG. **1**A. In FIG. **1**A, the extension **18***a* of the first portion **18** is visible and outside of the first sleeve **16** of the first arm **14**, an extension **40***a* of the second portion **40** of the first arm **14** is visible and outside of the second sleeve **38** of the second arm **36**, and an extension **48***a* of the second portion **48** of the second arm **36** is visible outside of the third sleeve **46** of the third arm **44**. In FIG. **1**C, the device **10** is in a contracted state and the extension **18***a* of the first portion **18** is slide into the first sleeve **16** of the first arm **14**, the extension **40***a* of the second portion **40** of the first arm **14** is slide into the second sleeve

38 of the second arm, and the extension 48*a* of the second portion 48 of the second arm 36 is slid within the third sleeve 46 of the third arm 44.

[0042] The adjustment mechanisms 70*a*, 70*b*, 70*c* allow the overall width (W) and overall length (L) of the device 10 to be modified as shown in FIG. 1C. FIG. 1C shows the contracted position in which the length (L) and width (W) of the device 10 is smallest. In the extended state shown in FIG. 1A, the length (L) and width (W) are greater than the length (L) and width (W) of FIG. 1C. One of ordinary skill in the art would recognize from the present application that alternative forms of adjustment mechanisms could be used, such as a telescoping arm, friction fitted sleeve and arm, or other type of spring loaded extension element.

[0043] As shown in FIG. 1D, a decorative plate 64 can be provided on a front face of the first bend 22. The decorative plate 64 can include any variety of colors to match the color of a garment, or can include ornamental designs, similar to a lapel pin. A secondary decorative plate 64' is also illustrated in FIG. 1D. The decorative plates 64, 64' are interchangeable and can be snapped or otherwise selectively fastened onto the first bend 22.

[0044] As shown in FIGS. 1A and 1B, friction surfaces 14', 36', 40', 44' are arranged on front surfaces of the first arm 14, second arm 36, third arm 44, and second portion 40 of the first arm 14. These friction surfaces 14', 36', 40', 44' provide increased friction for the garment compared to an adjacent surface, such as an adjacent smooth surface of the extensions 18*a*, 40*a*, 48*a*. The body 12 of the device 10 is generally formed from a plastic or sheet metal having a smooth surface except for the regions of the friction surfaces 14', 36', 40', 44'. The friction surfaces 14', 36', 40', 44' can include a non-abrasive friction element to provide an increased friction coefficient when rubbing against the first portion 30 and second portion 32 of the garment. Friction surfaces can also be arranged on an interior of the first bend 22 and second bend 26 to provide improved gripping ability. In other embodiments, friction surfaces or friction elements can include tines, which are described in more detail below with respect to FIGS. 5A-10B.

[0045] In another embodiment, the dimpled portion 34 of the first bend 22 can include a magnetic material such that the dimpled portion 34 of the first bend 22 is magnetically attracted to the first portion 18.

[0046] FIGS. 2A-2D show a second embodiment of a garment closing device 200 that is similar to the first embodiment of the garment closing device 10. The device 200 includes a first arm 214, a second arm 236, and a third arm 244 including similar features as described above with respect to the first embodiment 10. The garment closing device 200 includes a first portion 218 of the first arm 214 having a hinged assembly 210 including a hinged plate 212 with a first magnet 220. A spring 222 inside the hinged assembly 210 biases the hinged plate 212 to a closed position shown in FIGS. 2B and 2D. A user can then pry the hinged assembly 210 open, as shown in FIGS. 2A and 2C, to allow for insertion of a portion 230, 232 of a garment.

[0047] Similar to the first embodiment, the first arm 214 of the second embodiment of the device 200 includes a first portion 218 which is slidably received within a first sleeve 216. The first portion 218 of the first arm 214 includes the hinged plate 212 with the first magnet 220, the first arm 214 includes a first bend 226 that bends away from the hinged plate 212 to define a gap 228, and a second portion 240 of the first arm 214 extends away from the gap 228. The second arm 236 includes a second sleeve 238 and the second portion 240 of the first arm 214 is slidably received within the second sleeve 238 of the second arm 236. The third arm 244 includes a third sleeve 246 and a second portion 248 of the second arm 236 is slidably received within the third sleeve 246 of the third arm 244. In an assembled state, as shown in FIGS. 2A, 2B, and 2D, a first portion 252 of the third arm 244 overlaps with the first portion 218 of the first arm 214. The first portion 252 of the third arm 244 includes a second magnet 262 that directly faces and overlaps the first magnet 220 of the first portion 218 of the first arm 214. As shown in FIG. 2D, the first magnet 220 on the hinged plate 212 of the first arm 214 is biased closed against the second magnet 262 of the third arm 244 to grip a first portion 230 of a garment and the first bend 226 of the first arm 214 is dimensioned to grip a second portion 232 of a garment. The first magnet 220 is biased closed to abut against the second magnet 262 after the first portion 230 of the garment is slid between the first magnet 220 and the second magnet 262 such that the device 200 is retained with respect to the garment. Additional magnets are described in more detail below with respect to FIGS. 5A-8B, 10A, and 10B.

[0048] As shown in FIG. 2B, the device 200 includes adjustment mechanisms 270*a*, 270*b*, and 270*c*, which are similar to the adjustment mechanisms 70*a*, 70*b*, 70*c* of the first embodiment of the device 10. The adjustment mechanisms 270*a*, 270*b*, 270*c* similarly allow for adjustment of lengths of the arms 214, 236, 244 of the device 200 in the lateral (X) and longitudinal (Y) directions as described above.

[0049] A third embodiment of a garment closing device 300 is shown in FIGS. 3A-3D. The device 300 has a generally straight profile compared to the triangular profiles of the devices 10, 200. The garment closing device 300 includes a housing 310 with a first bend 320 bending forwards, and an arm 340 with a second bend 350 bending backwards. The device 300 achieves the same v-shaped neckline for a garment having a first and second portion 330, 332 by arranging the first portion 330 of the garment within the first bend 320 and the second portion 332 of the garment within the second bend 350, similar to the configuration described above with respect to the first and second embodiments of the devices 10, 200. As shown in FIGS. 3A-3D, the housing 310 includes the first bend 320 which defines a gap 322 dimensioned to grip the first portion 330 of the garment, and the arm 340 includes the second bend 350 which defines a gap 352 dimensioned to grip the second portion 332 of the garment.

[0050] An adjustment mechanism 360 is provided that allows the arm 340 to be slidably positioned within the housing 310. The adjustment mechanism 360 preferably includes a plurality of openings 310*a*, 310*b*, 310*c* defined on a back face 311 of the housing 310. The housing 310 includes at least one biasing element 370 arranged in an interior 312 of the housing 310. The adjustment mechanism 360 also preferably includes a protrusion 342 defined on a first portion 344 of the arm 340 received within the housing 310. The protrusion 343 is dimensioned to be within each of the openings 310*a*, 310*b*, 310*c* of the housing 310. A user manually presses the protrusion 343 inward with respect to the housing 310 such that the protrusion 343 is recessed within the housing 310 and slides the arm 340 inward or outward with respect to the housing 310. The at least one biasing element **370** biases the protrusion **343** outward with respect to the housing **310** such that the protrusion **343** is captively retained with one of the openings **310***a*, **310***b*, **310***c* of the housing **310**. The at least one biasing element **370** preferably includes two plate springs **370***a*, **370***b* arranged adjacent to each other. Arrows in FIGS. **3**B-**3**D show an insertion direction for the portions **330**, **332** of the garment into the gaps **322**, **352**, respectively.

[0051] As shown in FIG. **3**D, the back face **311** and a front face **313** of the housing **310** each preferably include an increased friction coating or surface **315***a*, **315***b*. The increased friction coating or surface **315***a*, **315***b* is similar to the friction surfaces **14'**, **36'**, **40'**, **44'** of the first embodiment described above. The friction coating or surface **315***a*, **315***b* is provided to improve gripping against the garment once inserted into the device **300**. The increased friction coating or surface **315***a*, **315***b* has increased friction compared to adjacent surfaces that are non-treated with increased friction materials or processing. A front surface **341** and back surface **343** of the arm **340** can also include an increased friction surface.

[0052] A fourth embodiment of a garment closing device **400** is illustrated in FIGS. **4**A and **4**B. The device **400** is similar to the third embodiment of the garment closing device **300** described above except the bends **320**, **350** of the device **300** are replaced with hinged assemblies **420**, **450** in the device **400** of FIGS. **4**A and **4**B. A first and second hinged assembly **420**, **450** each include a respective first and second hinged plate **425**, **455** having a respective magnet **426**, **456**. The first hinged assembly **420** is arranged on a front face **412** of the housing **410**, and the second hinged assembly **450** is arranged on a rear face **442** of the arm **440**. The front face **412** of the housing **410** includes a housing magnet **414** that directly faces the first magnet **426** of the first hinged assembly **420**. The first hinged plate **425** is biased closed and towards the housing **410** such that the first magnet **426** of the first hinged assembly **420** abuts the housing magnet **414** to grip a first portion **430** of a garment. An arm magnet **444** is arranged on the rear face **442** of the arm **440** that directly faces the second magnet **456** of the second hinged assembly **450**. The second hinged plate **455** is biased closed and towards the arm **440** such that the second magnet **456** of the second hinged assembly **450** abuts the arm magnet **444** to grip a second portion **432** of a garment. The hinged assemblies **420**, **450** of the device **400** are similar to the hinged assembly **210** of FIGS. **2**A-**2**D and can similarly include an internal spring to bias the plates in a closing direction. An adjustment mechanism **460** is also provided that is similar to the adjustment mechanism **360** of the third embodiment. The adjustment mechanism **460** allows the arm **440** to be slidably adjusted with respect to the housing **410** as described above.

[0053] One of ordinary skill in the art recognizes that the housing **410** and arm **440** of the fourth embodiment can similarly include increased friction surfaces as described above with respect to the third embodiment to improve the gripping ability of the device **400** with respect to the garment.

[0054] In a fifth embodiment shown in FIGS. **5**A and **5**B, a clamping device **500** is illustrated. The clamping device **500** includes a magnet **502** including a south pole surface **524** and a north pole surface **526**. In one embodiment, the magnet **502** has a thickness (t_m) between 0.05 inches and 0.07 inches, and more preferably has a thickness (t_m) of 0.0625 inches. The magnet has a diameter (D_m) between 0.5 inches and 0.7 inches, and more preferably has a diameter (D_m) of 0.625 inches. One of ordinary skill in the art would recognize from the present disclosure that alternative shapes for the magnet **502** can be used, such as ring, semi-spherical, rectangle, square, etc. Alternative physical dimensions and magnetic grades for the magnets can be used. In one embodiment of the cylindrical magnet **502**, the magnet has a diameter of 0.75 inches and a thickness of 0.0625 inches. In one embodiment, the magnet **502** is a N52 grade neodymium magnet.

[0055] In one embodiment, the surfaces **524**, **526** include attachment layers **530**. As shown in FIG. **5**A, the attachment layers **530** cover the entire surface of the south pole surface **524** and the north pole surface **526**. In one embodiment, the attachment layers **530** have a thickness (t_a) between 0.005 inches and 0.025 inches, and more preferably have a thickness (t_a) of 0.015 inches.

[0056] The attachment layers **530** can include an adhesive layer. The attachment layers **530** include a plurality of projections **532**, **534**, preferably tines **532**, **534**. In one embodiment, the attachment layer **530** is omitted, and the tines **532**, **534** are attached directly to the magnet **502**. For example, the tines **532**, **534** can be fixed to the magnet **502** by chemical deposition, thermal bonding, or direct printing.

[0057] The tines **532**, **534** preferably have a thickness (t) of less than 0.020 inches, and more preferably less than 0.010 inches. The tines **532**, **534** have a height (h) between 0.020 inches and 0.040 inches, and more preferably have a height of at least 0.030 inches. The height (h) of the tines **532**, **534** is preferably at least three times greater than the thickness (t) of the tines **532**, **534**. A distance (d) between center points of adjacent tines **532**, **534** is preferably greater than the thickness (t) of the tines **532**, **534**. In one embodiment, the distance (d) is between 0.040 and 0.060 inches. The distance (d) is preferably 0.050 inches. The distance (d) between adjacent tines is at least twice the thickness (t) of a tine, and the distance (d) is more preferably at least four times greater than the thickness (t) of a tine. Increasing the distance between adjacent tines provides an enlarged clamping area for a clamped material.

[0058] As shown in FIG. **5**A, the south pole surface **524** has a first profile and the north pole surface **526** has a second profile. The first profile and the second profile are offset from each other (shown by line (X_O) in FIG. **5**A) such that when two of the clamping devices **500** are facing each other the plurality of tines **532** on the south pole surface **524** of a first one of the two clamping devices **500** are aligned with spaces between the plurality of tines **534** on the north pole surface **526** of a second one of the two clamping devices **500**. This optimizes the pole alignment between the two magnets, which increases the pull force between the magnets and maximizes the combined magnetic attractive forces of the outside surfaces **524**, **526**.

[0059] In one embodiment, the magnet **502** is cylindrical, as most clearly shown in FIG. **5**B. As shown in FIG. **5**B, the tines **532** are arranged on the surface **524** with a waffle-like pattern. The tines **532** pattern preferably extends to an outer circumference of the magnet **502**. The magnet **502** includes at least fifty tines **532**. In a more preferred embodiment, the magnet **502** includes at least one hundred tines **532**. The rows and columns of tines **532** are offset from each other to define a space between the tines **532**. A pattern of the tines **534** on the opposite surface **526** of the magnet **502** is complementary to the pattern of the tines **532** shown in FIG. **5**B. Another magnet can be provided including tines that mesh with the tines **532** shown in FIG. **5**B, which is described in more detail below.

[0060] The height and flexibility of the tines **532**, **534** are selected to ensure that magnetic attractive force between the clamping device **500** and an adjacent magnetic clamping device is essentially unaffected by the tines **532**, **534**. One of ordinary skill in the art recognizes that magnetically attractive forces between two magnetic elements is extremely high at close distances and drops precipitously as distance between the two magnetic elements increases. The tines **532**, **534** have a low profile based on their height (h) and flexibility that allows the tines **532**, **534** to compress when the clamping device **500** is magnetically attracted towards an adjacent magnetic clamping device. In one embodiment, the tines **532**, **534** are flexible. In one embodiment, the tines **532**, **534** have a flexural modulus of elasticity of less than 5.0 GPa. In one embodiment, the tines **532**, **534** have a straight profile. In another embodiment, the tines **532**, **534** have a curved terminal end. The tines **532**, **534** are formed from a non-abrasive material. The tines **532**, **534** are configured to provide a gripping force for a clamped material that does not damage or otherwise mar the clamped material. In one embodiment, the tines **532**, **534** are formed from a plastic material. In one embodiment, the tines **532**, **534** are formed from polyethylene. In another embodiment, the tines **532**, **534** are formed from metal. In another embodiment, alternative friction elements instead of tines can be used. One of ordinary skill in the art recognizes that other non-abrasive friction elements can be used.

[0061] As shown in the cutaway view of FIG. **6**A, a clamping device including two magnets **603**, **605** are provided with tines **632**, **634** on a respective one of the magnets **603**, **605** facing each other. A clamping area is defined between the two magnets **603**, **605** in a region where the tines **632**, **634** face each other. The magnets **603**, **605** each have two predetermined side surface areas. The opposing tines **632**, **634** are slightly offset from each other when the clamping devices **603**, **605** are aligned, which allows for a material layer **610** (shown in FIG. **6**B) to be gripped between the opposing tines. Alignment of the magnets in one embodiment requires alignment of an axis of each of the magnets. As shown in FIG. **6**B, the material layer **610** is clamped between the two magnets **603**, **605** such that the material layer **610** is held secure between the two magnets **603**, **605**. Although a single layer of the material layer **610** is shown in FIG. **6**B, one of ordinary skill in the art would understand that multiple layers could be clamped between the magnets **603**, **605**. The opposing tines **632**, **634** mesh with each other when the opposing polarities of the magnets **603**, **605** are attracted to each other, and meshing of the tines **632**, **634** restricts movement of the material layer **610** relative to the magnets **603**, **605** as well as reduces the distance between the magnets **603**, **605**. The tines **632**, **634** are shown in a non-compressed state in FIG. **6**A, and the tines **632'**, **634'** are shown in a compressed state in FIG. **6**B. Although only two magnets **603**, **605** are illustrated in FIG. **6**A, one of ordinary skill in the art would understand that a plurality of magnets can be provided and stacked relative to each other.

[0062] FIGS. **6**C and **6**D illustrate a pre-clamped state and a clamped stated for magnets **603***a*, **605***a*, respectively. The magnets **603***a*, **605***a* are similar to the magnets of FIGS. **6**A and **6**B, except the tines **632***a*, **634***a* have increased rigidity and do not compress or deform in the clamped position shown in FIG. **6**D.

[0063] In a first loading case, the magnets **603**, **605** are grade N52, have a diameter of 0.375 inches, a thickness of 0.0625 inches, and are spaced apart from each other by a distance of 0.020 inches. The distance between the magnets **603**, **605** is dependent on a thickness of a material that is being clamped as well as the height of the tines **632**, **634**. In the first loading case, a pull force of 1.47 lbs. is exhibited between the two magnets **603**, **605**.

[0064] In a second loading case, a single magnet **603** is provided that has a grade N52, a diameter of 0.375 inches, a thickness of 0.0625 inches, and is spaced apart from a ferrous plate by a distance of 0.020 inches. In one embodiment, the ferrous plate is formed from steel. In the second loading case, a pull force of 1.28 lbs. is exhibited between the magnet **603** and the ferrous plate.

[0065] In a third loading case, the magnets **603**, **605** are grade N52, have a diameter of 0.625 inches, a thickness of 0.0625 inches, and are spaced apart from each other by a distance of 0.020 inches. In the third loading case, a pull force of 3.06 lbs. is exhibited between the two magnets **603**, **605**.

[0066] In a fourth loading case, a single magnet **603** is provided that has a grade N52, a diameter of 0.625 inches, a thickness of 0.0625 inches, and is spaced apart from a ferrous plate by a distance of 0.020 inches. In the fourth loading case, a pull force of 2.92 lbs. is exhibited between the magnet **603** and the ferrous plate.

[0067] FIGS. **7**A and **7**B illustrate another embodiment of a clamping device **700** that includes a housing **710** secured around the magnet **702**. In this embodiment, a first magnetic surface **705** (south end) lacks tines, and a second magnetic surface (north end) includes tines **734**. In another embodiment, the first magnetic surface **705** can also include tines. One of ordinary skill in the art would understand that alternative shapes and types of housing **710** can be provided for the magnets, or the housing can be omitted. The housing **710** can be formed from a non-ferrous material. The housing **710** preferably has a smooth outer surface to prevent irritation and abrasion of a user's skin and clothing. The housing **710** can include ornamental designs and/or shapes. In one embodiment, the housing **710** can include jewelry elements, such as diamonds or other ornamental stones.

[0068] FIGS. **8**A and **8**B illustrate an embodiment of the clamping device including multiple magnets **802** in strips **800***a*, **800***b*. Strip **800***a* includes a plurality of magnets **802** with tines **834** on a north pole surface, and strip **800***b* includes a plurality of magnets **804** including tines **832** on a south pole surface. The strips **800***a*, **800***b* can be aligned to face each other and the magnets **802**, **804** are magnetically attracted to each other. The magnets **802**, **804** can be embedded within the strips **800***a*, **800***b*, or can be otherwise attached to the strips **800***a*, **800***b*. The strips **800***a*, **800***b* can be incorporated into a belt, bracelet, or other type of garment or jewelry.

[0069] As shown in FIGS. **9**A-**9**F, the individual tines **900** can have a variety of profiles. As shown in FIG. **9**A, the tine **900***a* is cylindrical and has a straight profile with a flat tip **901***a*. In FIG. **9**B, the tine **900***b* is cylindrical with a frusto-conical tip **901***b*. The tine **900***c* of FIG. **9**C is cylindrical, with a straight profile and a slanted tip **901***c*. The tines of FIGS. **9**D, **9**E, and **9**F are illustrated with a curved terminal end. In FIG. **9**D, the tine **900***d* has a curved profile and a flat tip **901***d*. The tine **900***e* of FIG. **9**E has a curved profile with a frusto-conical tip **901***e*. In FIG. **9**F, the tine **900***f* has a curved profile and a slanted tip **901***f*. The tines **900** of FIGS. **9**A-**9**F are shown in the non-clamped position, i.e. prior to engagement with a clamped material and application of any magnetically attractive force between their associated magnets. FIGS. **9**D-**9**F show a bent or curved profile, which can be further bent or compressed during clamping. Tips **901***a*-**901***f* illustrate a plurality of different contact profiles for material **610**. The differing tip geometries produce slight friction indentations in the material **610**, and the tips can temporarily engage with threads of the material **610**. One of ordinary skill in the art would recognize from the present disclosure that other shapes and geometries can be used for the tines **900**.

[0070] FIG. **10**A shows three stacked magnets **1003**, **1005**, **1007**. Magnet **1003** includes tines **1032** on a surface facing away from the other magnets **1005**, **1007**, and tines **1034** on an opposite base surface **1035** that faces towards the other magnets **1005**, **1007**. The tines **1032**, **1034** are offset from each other relative to an axis of the magnet **1003**. The tines **1034** mesh with tines **1036** on the second magnet **1005**. The tines **1034** of the first magnet **1003** fully mesh with the tines **1036** of the second magnet **1005**, and the tines **1034** of the first magnet **1003** engage against a base surface **1037** of the second magnet **1005** while the tines **1036** of the second magnet **1005** engage against the base surface **1035** of the first magnet **1003**. Similarly, tines **1038** on the second magnet **1005** mesh with tines **1040** of the third magnet **1007**, and the tines **1038** on the second magnet **1005** engage a base surface **1041** of the third magnet **1007**. The tines **1040** of the third magnet **1007** mesh with the tines **1038** of the second magnet **1005**, and the tines **1040** of the third magnet **1007** engage against a base surface **1039** of the second magnet **1005**. As shown in FIG. **10**A, the magnets **1003**, **1005**, **1007** are configured to fully mesh with each other, such that the total distance between adjacent magnets **1003**, **1005**, **1007** is only limited by the height of the tines. The base surfaces **1035**, **1037**, **1039**, **1041** can include indentations in the spacing between the tines to provided increased depth for penetration of the opposing tines into the base surfaces, which increases the requisite lateral force for separating the magnets.

[0071] FIG. **10**B illustrates the three magnets **1003**, **1005**, **1007** with two layers of material **1010***a*, **1010***b* arranged between the first magnet **1003** and the second magnet **1005**, and the second magnet **1005** and the third magnet **1007**, respectively. FIGS. **10**A and **10**B demonstrate the additional stacking ability of the magnets. The magnets can be stacked to achieve any desired strength, and the stacked magnets provide additive magnetic attractive forces. One of ordinary skill in the art would recognize from the present disclosure that any number of layers of material can be provided between adjacent magnets. In one embodiment, the middle magnet **1005** can be a ferrous plate. A thickness of the middle ferrous plate can be reduced compared to the required thickness of a magnet. In one embodiment, the thickness of the middle ferrous plate is less than 0.010 inches. The middle ferrous plate provides an increase in the pull force between end magnets **1003**, **1007**.

[0072] The magnets of FIGS. **5**A-**8**B, **10**A, and **10**B can be incorporated into any one or more of the embodiments of FIGS. **1**A-**4**B. Similarly, the tines of any one of the embodiments of FIGS. **5**A-**10**B can be incorporated into any one or more of the embodiments of FIGS. **1**A-**4**B. One of ordinary skill in the art would recognize from the present application that any one of the features from the devices in FIGS. **1**A-**10**B can be used in any one of the other embodiments. Any one of the magnets described herein can be used by itself in a free form manner. Additionally, any single one of the magnets described herein can be attracted to a backing plate or other ferrous material element.

[0073] Having thus described various embodiments of the present devices in detail, it will be appreciated and apparent to those skilled in the art that many changes, only a few of which are exemplified in the detailed description above, could be made in the devices according to the invention without altering the inventive concepts and principles embodied therein. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore to be embraced therein.

What is claimed is:

1. A clamping device comprising:

a first magnet with predetermined first and second side surface areas;

a first friction element on at least one of the first and second side surface areas;

a second magnet with predetermined third and fourth side surface areas; and

a second friction element on at least one of the third and fourth side surface areas;

wherein the first friction element of the first magnet and the second friction element of the second magnet are arranged opposite to each other and define a clamping area between the first magnet and the second magnet.

2. The clamping device of claim **1**, wherein the first friction element includes a first plurality of tines and the second friction element includes a second plurality of tines.

3. The clamping device of claim **2**, wherein the first plurality of tines define a first profile, and the second plurality of tines define a second profile, and the first profile and the second profile are different from each other.

4. The clamping device of claim **3**, wherein the first profile and the second profile are offset relative to each other when the first magnet is aligned with the second magnet.

5. The clamping device of claim **2**, wherein the first plurality of tines and the second plurality of tines are flexible and are each configured to compress when the first magnet and the second magnet clamp a material layer.

6. The clamping device of claim **2**, wherein the first plurality of tines and the second plurality of tines are inflexible.

7. The clamping device of claim **2**, wherein a distance between adjacent tines of the first plurality of tines is greater than a thickness of an individual tine of the first plurality of tines.

8. The clamping device of claim **2**, wherein the first plurality of tines includes at least fifty tines arranged at a uniform spacing from each other.

9. The clamping device of claim **2**, wherein at least one of the first plurality of tines or the second plurality of tines has a preformed bent terminal end.

10. The clamping device of claim **2**, wherein tines of at least one of the first plurality of tines or the second plurality of tines include a frusto-conical tip.

11. The clamping device of claim **2**, wherein tines of at least one of the first plurality of tines or the second plurality of tines includes an angled tip.

12. The clamping device of claim **1**, further comprising a third magnet arranged between the first magnet and second magnet, the third magnet including a third friction element.

13. The clamping device of claim **1**, wherein at least one of the first magnet or the second magnet is enclosed in a housing, and the housing includes a decorative element.

14. The clamping device of claim **1**, wherein the first magnet and the second magnet are each a neodymium magnet.

15. The clamping device of claim **2**, wherein the first plurality of tines fully mesh with the second plurality of tines such that the first plurality of tines contact one of the third and fourth side surface areas, and the second plurality of tines contact one of the first and second side surface areas.

16. The clamping device of claim **2**, wherein the first and second side surface areas each include the first plurality of tines, and the first plurality of tines on the first side surface area is offset relative to the first plurality of tines on the second side surface area.

17. The clamping device of claim **2**, wherein the first plurality of tines cover an entire area of the at least one of the first and second side surface areas.

18. The clamping device of claim **2**, wherein the first plurality of tines define a first profile, and the second plurality of tines define a second profile, and the first profile and the second profile are different from each other, the first profile and the second profile are offset relative to each other when the first magnet is aligned with the second magnet, the first plurality of tines and the second plurality of tines are flexible and are each configured to compress when the first magnet and the second magnet clamp a material layer, the first plurality of tines and the second plurality of tines each include at least fifty tines arranged at a uniform spacing from each other, and a distance between adjacent tines of the first plurality of tines is greater than a thickness of an individual tine of the first plurality of tines.

19. A garment closing mechanism including the clamping device of claim **1**, wherein the garment closing mechanism comprises a plurality of adjustable arms, and at least one of the plurality of adjustable arms includes a clamp with the first magnet and the second magnet.

20. A clamping device comprising:

a first magnet with predetermined first and second side surface areas;

a first friction element on at least one of the first and second side surface areas;

a ferrous plate with predetermined third and fourth side surface areas;

wherein the first friction element of the first magnet and one of the third and fourth side surface areas of the ferrous plate are arranged opposite to each other and define a clamping area between the first magnet and the ferrous plate.

* * * * *