US 20090188206A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2009/0188206 A1**

(43) **Pub. Date: Jul. 30, 2009**

Stol et al.

(54) **SYSTEM AND METHOD FOR JOINING DISSIMILAR MATERIALS**

(76) Inventors: **Israel Stol**, Pittsburgh, PA (US); **Trent Chontas**, Braddock Hills, PA (US)

Correspondence Address:
INTELLECTUAL PROPERTY
ALCOA TECHNICAL CENTER, BUILDING C,
100 TECHNICAL DRIVE
ALCOA CENTER, PA 15069-0001 (US)

(21) Appl. No.: **12/193,958**

(22) Filed: **Aug. 19, 2008**

Related U.S. Application Data

(60) Provisional application No. 61/062,268, filed on Jan. 24, 2008.

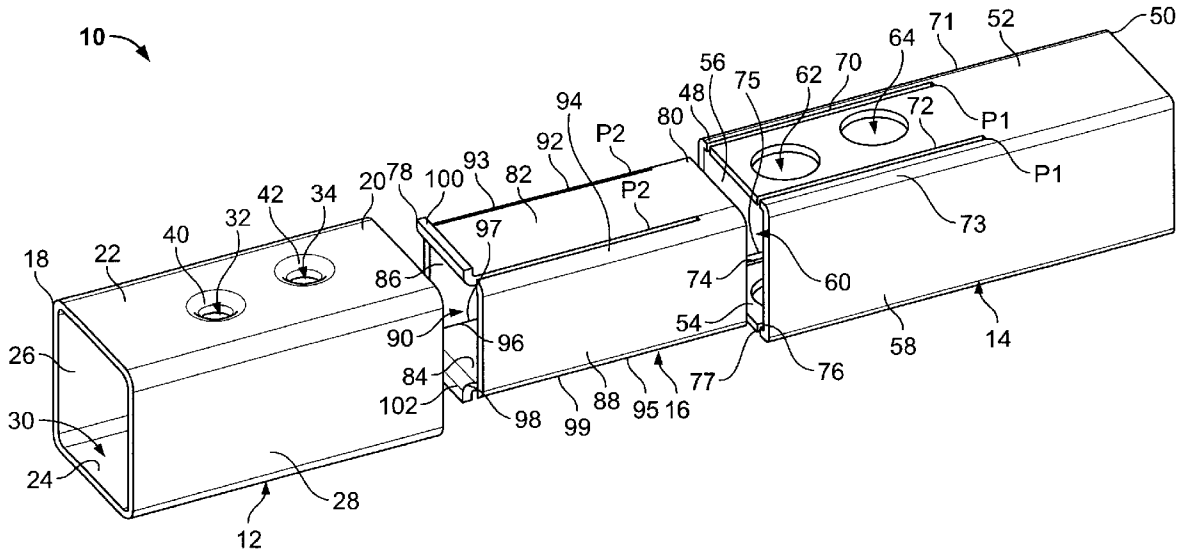
Publication Classification

(51) **Int. Cl.**
E04B 2/32 (2006.01)

(52) **U.S. Cl.** **52/762**

(57) **ABSTRACT**

An assembly includes a first structural member made from a first material, such as aluminum, a second structural member made from a second material, such as magnesium, and adapted to mate and interlock with the first member, and a third structural member made from the first material to facilitate a permanent affixation between the first and second members. The second member fits within the first member and the third member fits within the second member. The second member includes at least one aperture surrounded by a protrusion, and the third member includes at least one aperture that mates and interlocks with the protrusion. A surface of the third member is exposed through the apertures of the first and second members. The first member is welded to the third member through the apertures in order to permanently affix the first and second members to one another without metallurgical altering or local welding of the second member.



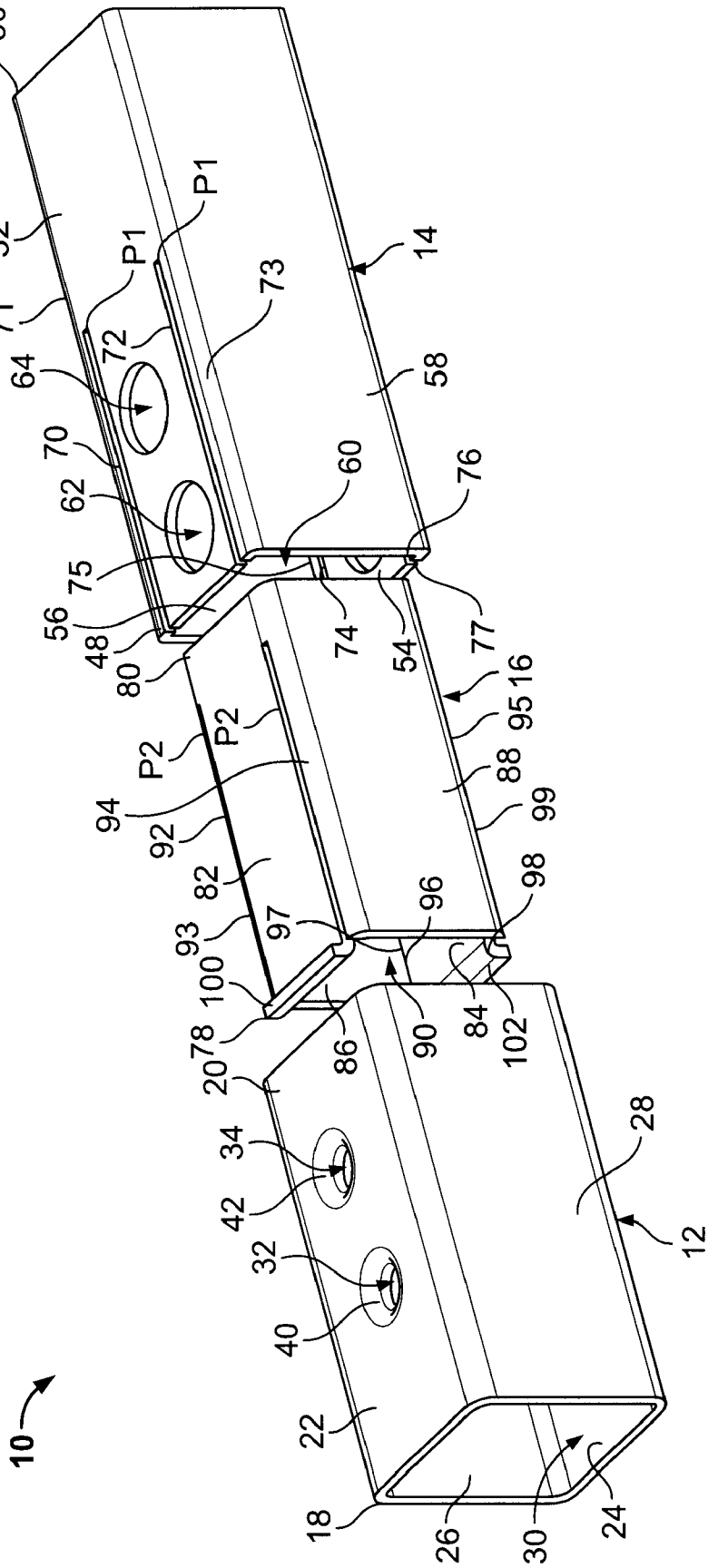

50
52
71
64
70
62
75
56
48
80
72
P1
P1
73
14
58
60
76
74
54
77
16
95
88
99
P2
P2
94
92
82
93
97
96
98
100
78
20
86
90
84
102
34
42
32
40
22
18
26
30
24
28
12
10

FIG. 1

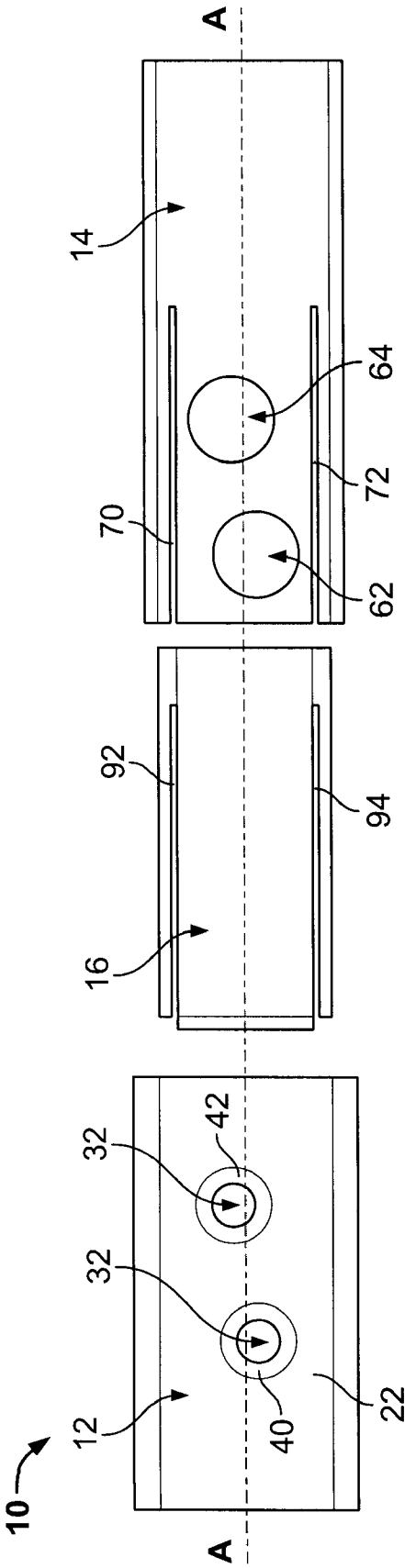

A
14
64
72
70
62
92
94
16
32
42
32
12
40
22
10
A

FIG. 2A

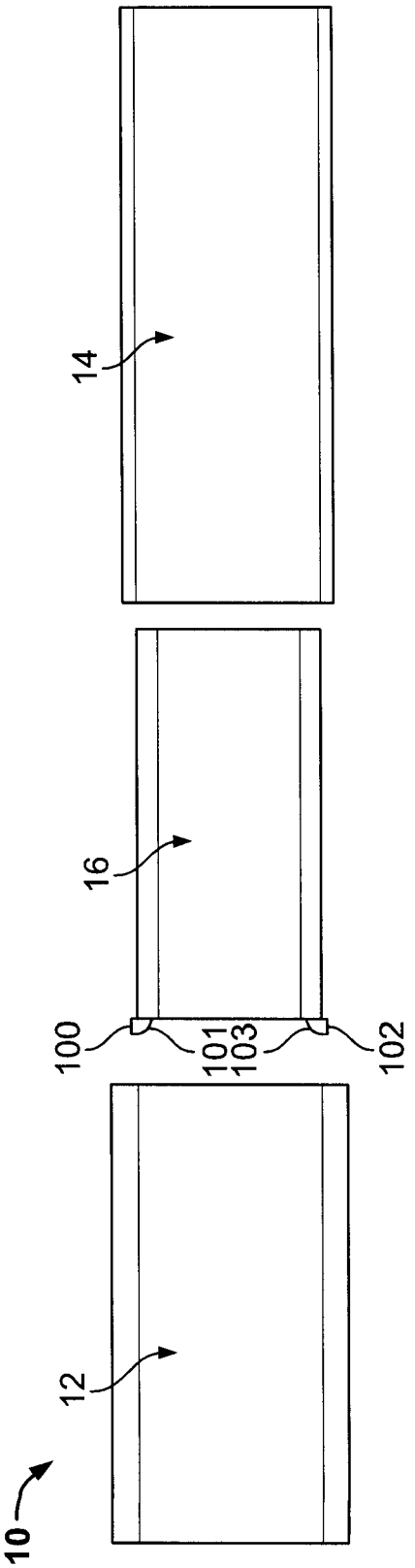

14
16
100
101
103
102
12
10

FIG. 2B

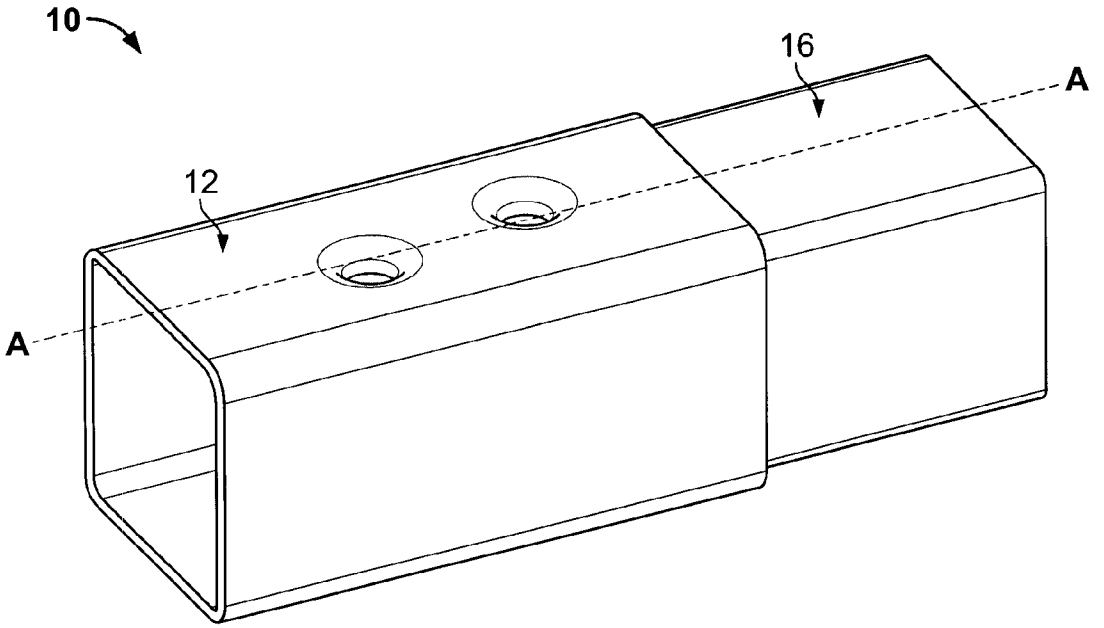

10
16
A
12
A

FIG. 3A

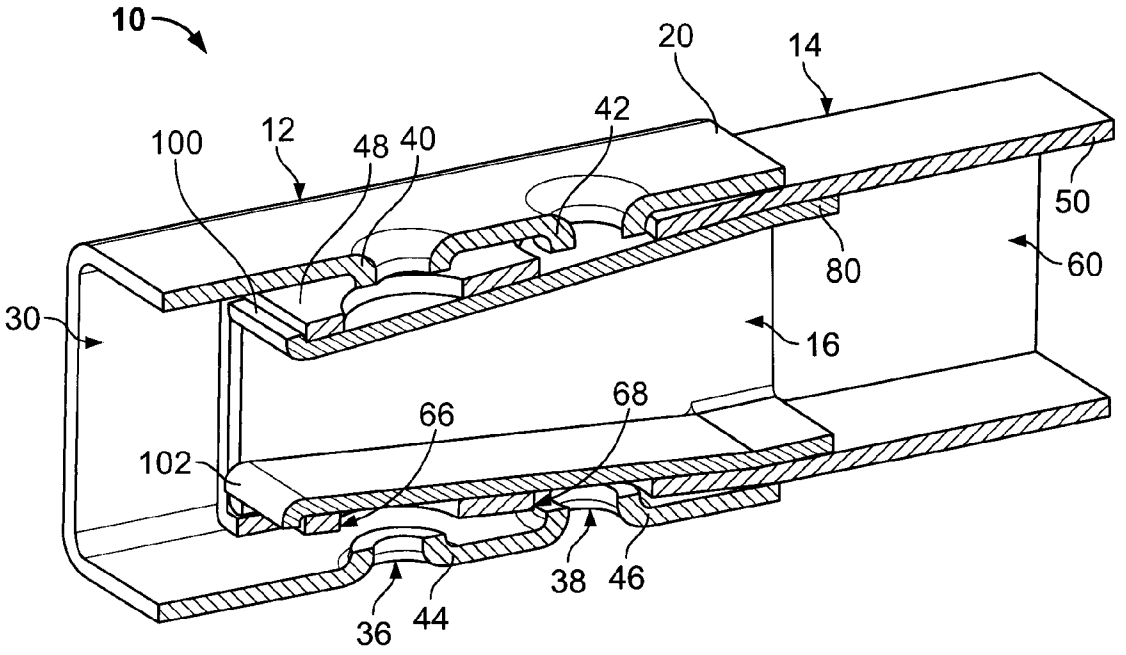

10
20
14
42
100
12
48
40
50
80
60
30
16
68
66
102
38
46
36
44

FIG. 3B

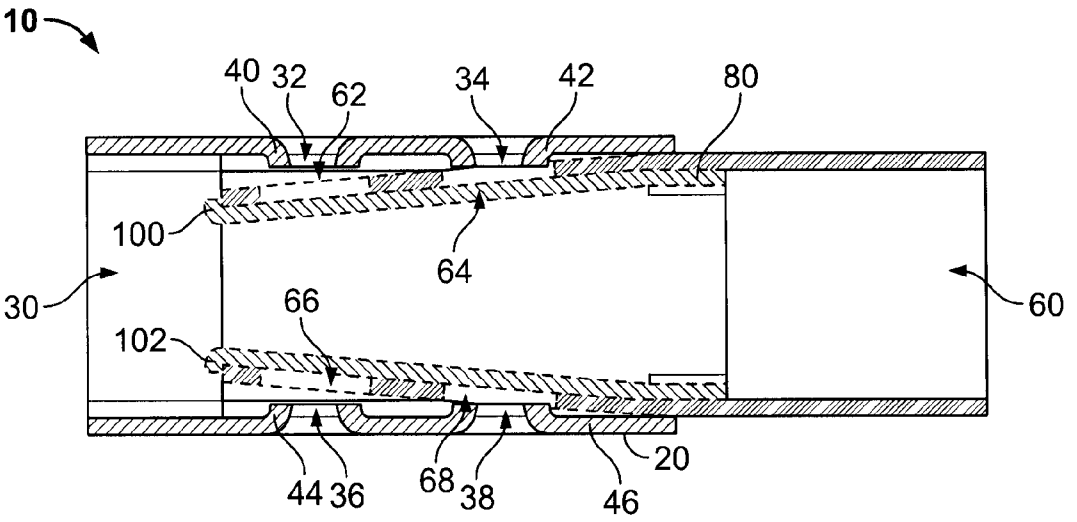

10
40
32
62
34
42
80
100
64
30
66
60
102
20
44
36
68
38
46

FIG. 3C

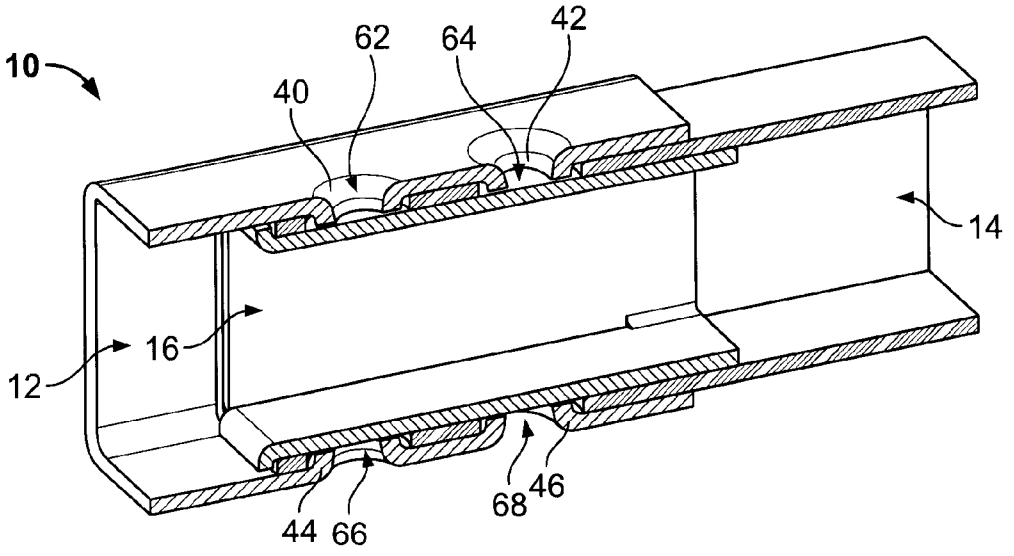

10
62
64
42
40
14
16
12
68
46
44
66

FIG. 4A

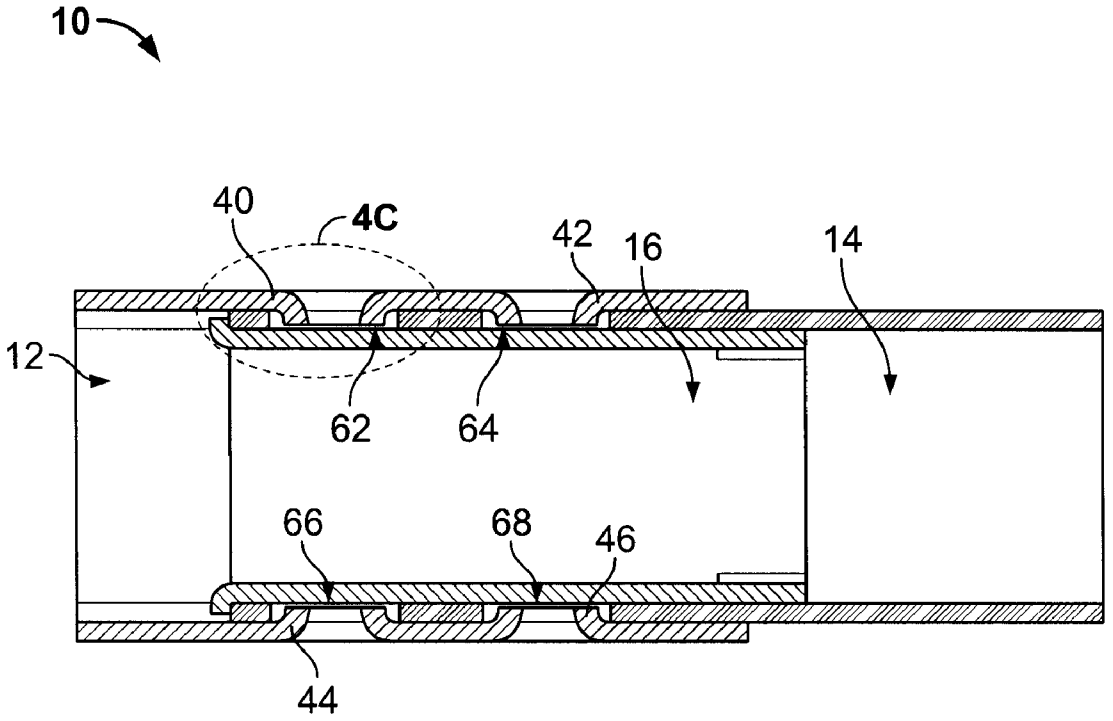


FIG. 4B

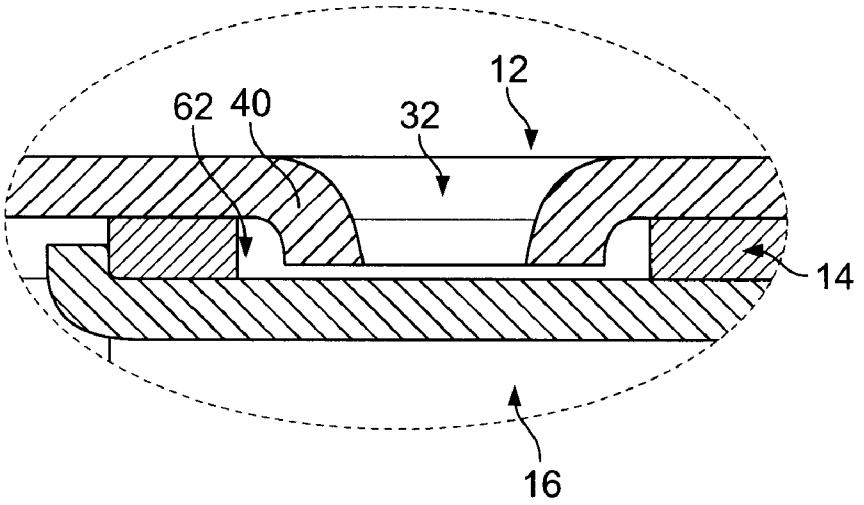


FIG. 4C

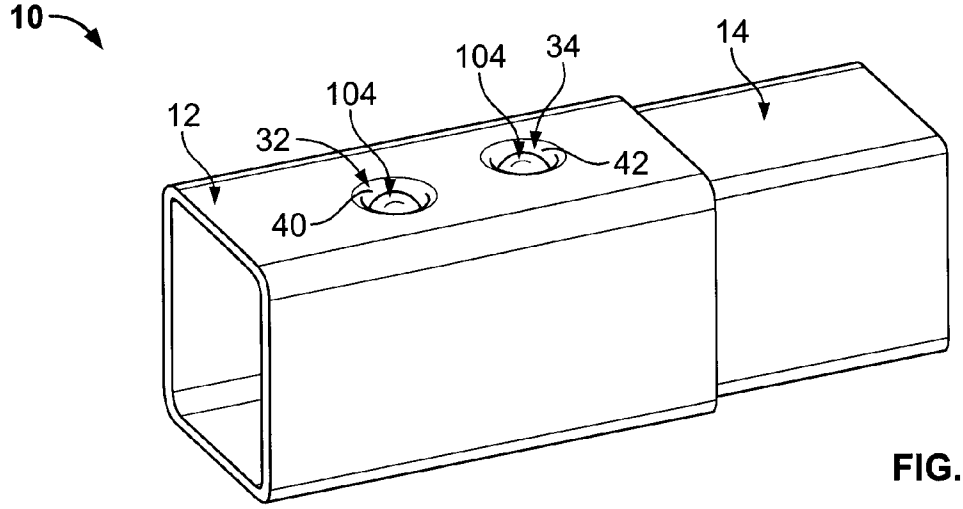


FIG. 5A

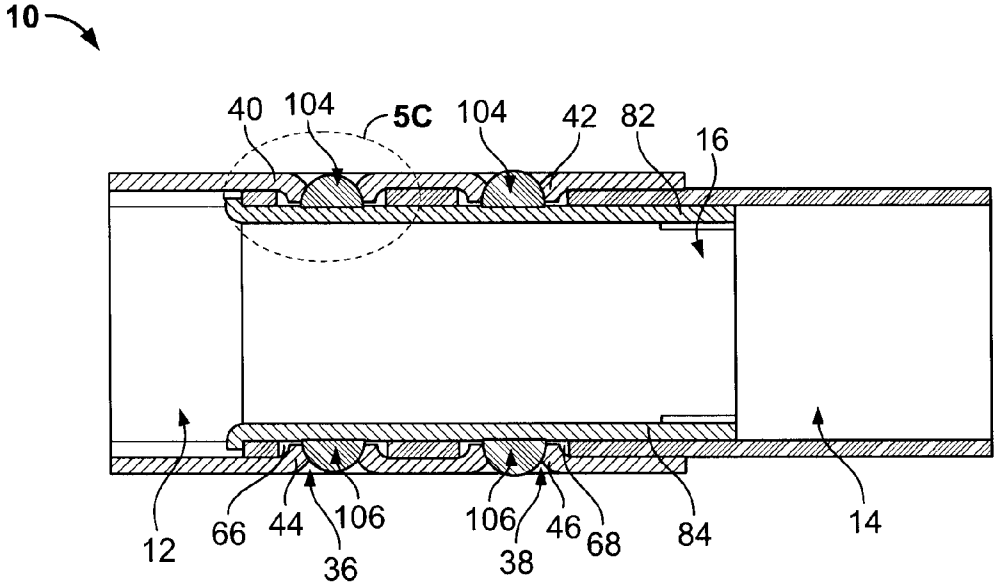


FIG. 5B

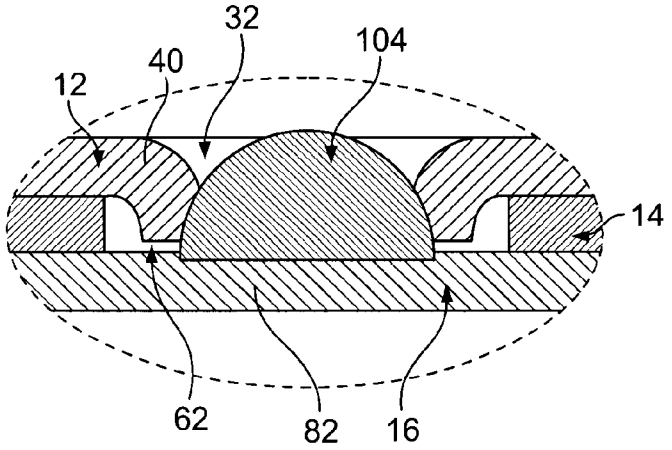


FIG. 5C

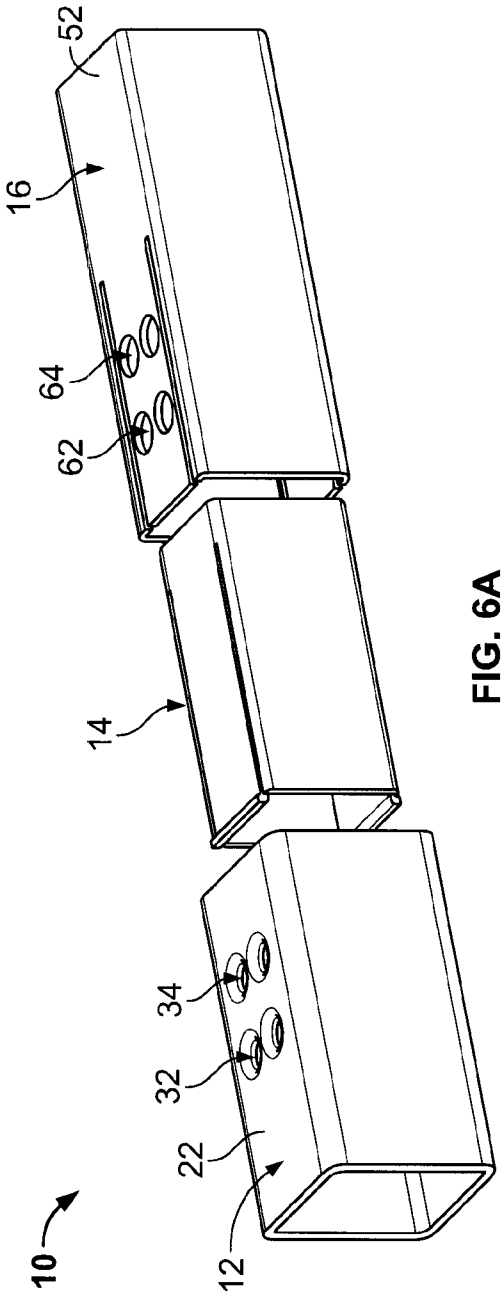


FIG. 6A

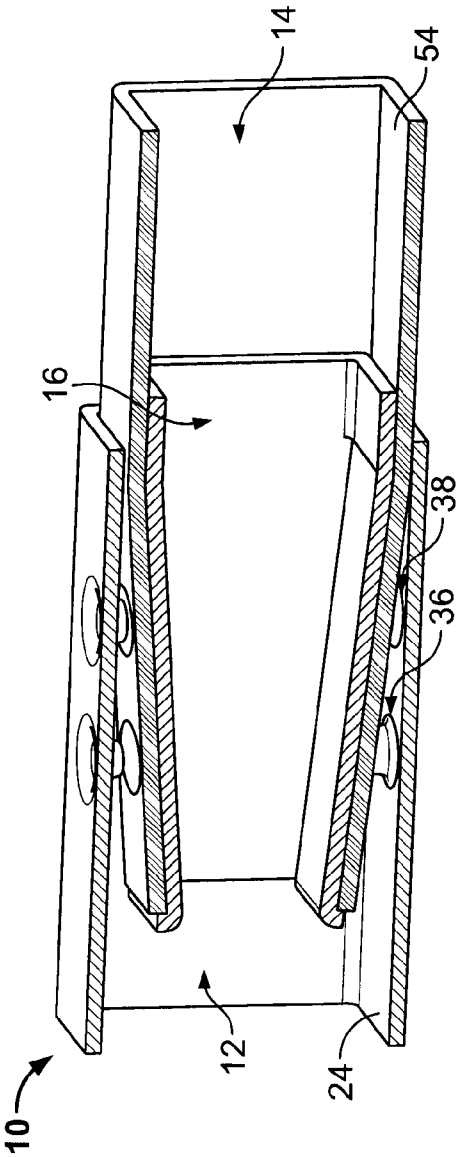


FIG. 6B

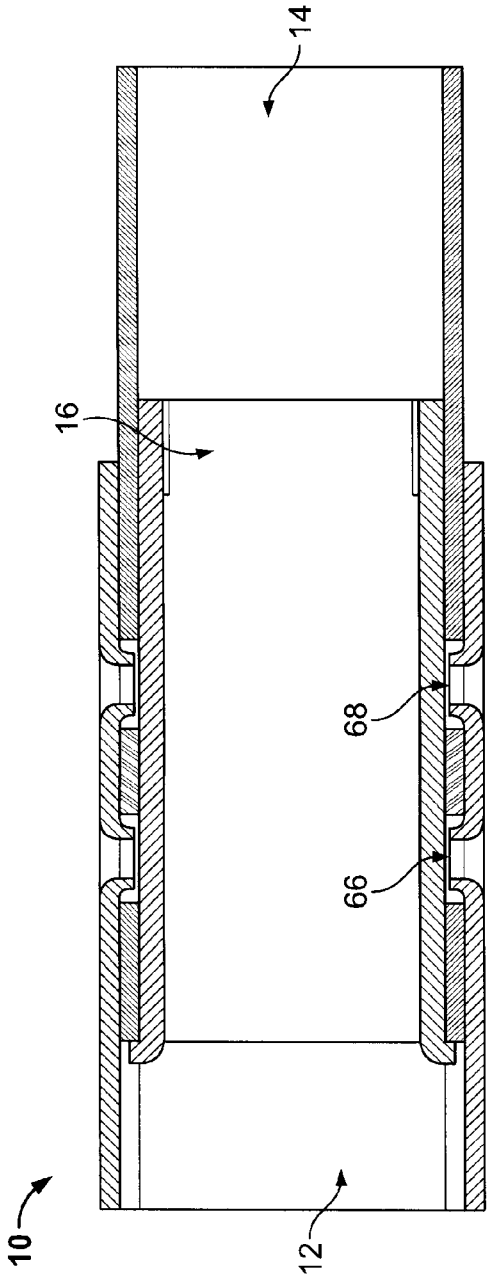


FIG. 6C

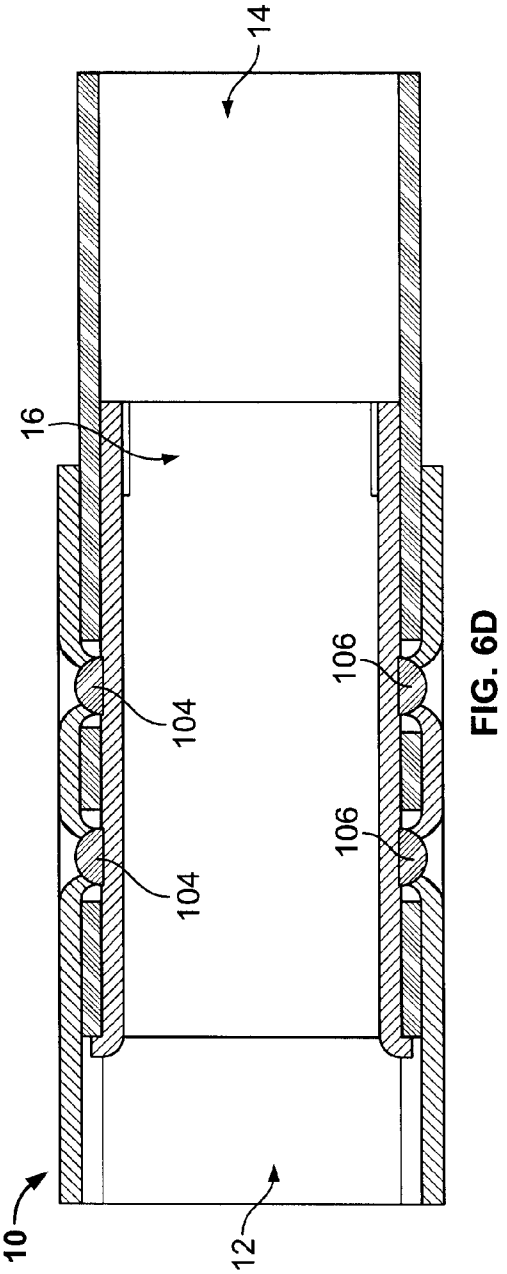


FIG. 6D

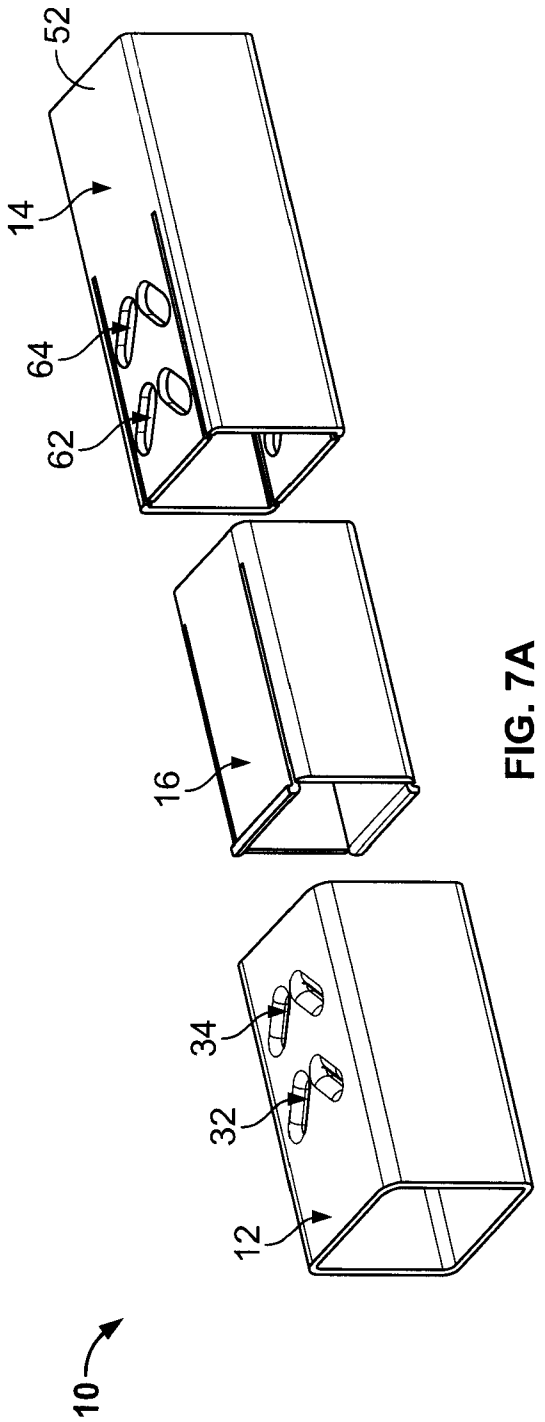


FIG. 7A

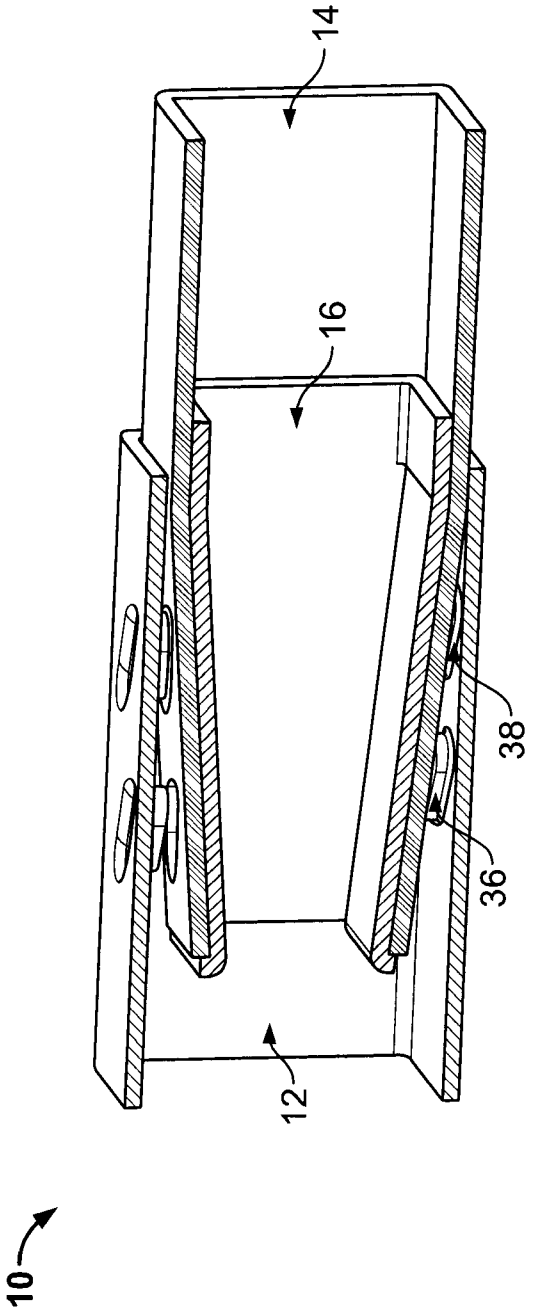


FIG. 7B

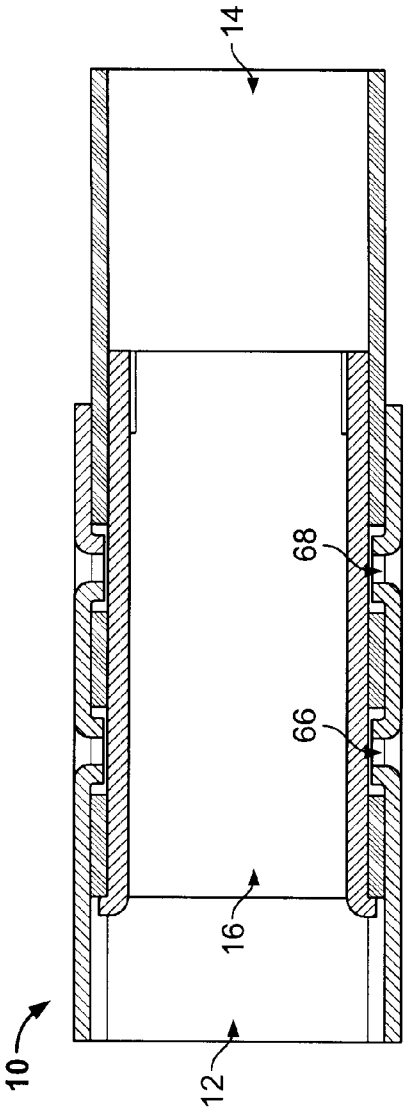


FIG. 7C

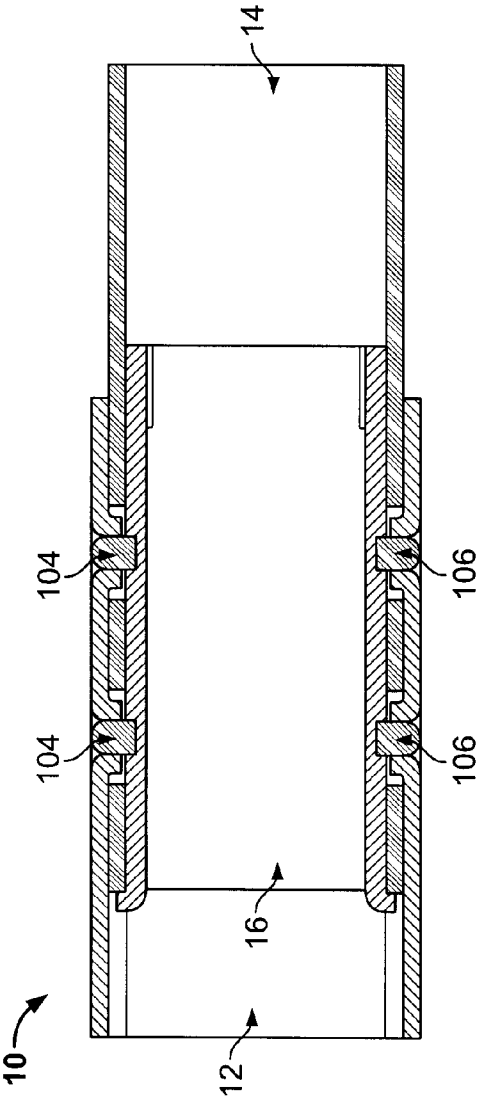


FIG. 7D

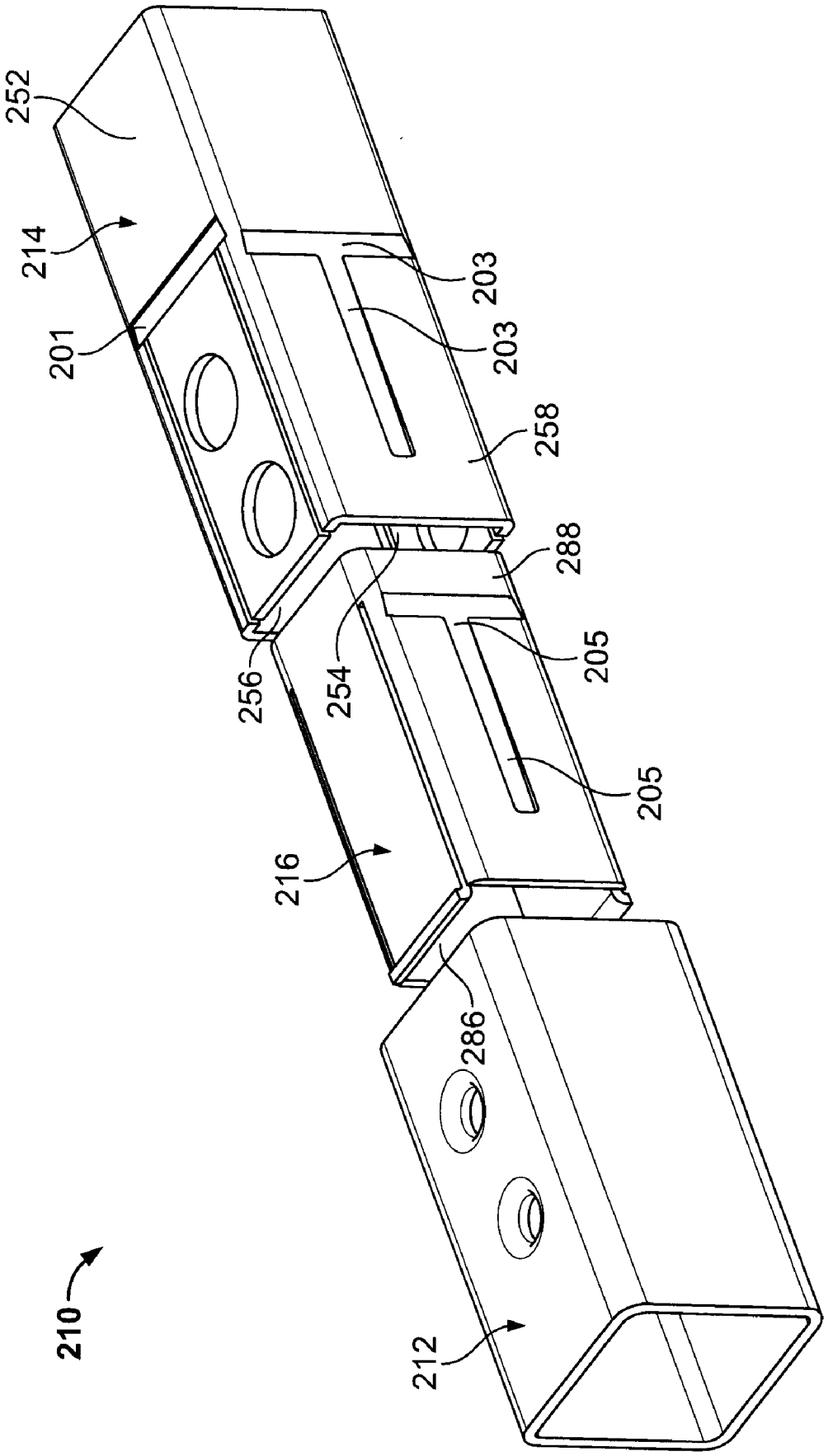


FIG. 8A

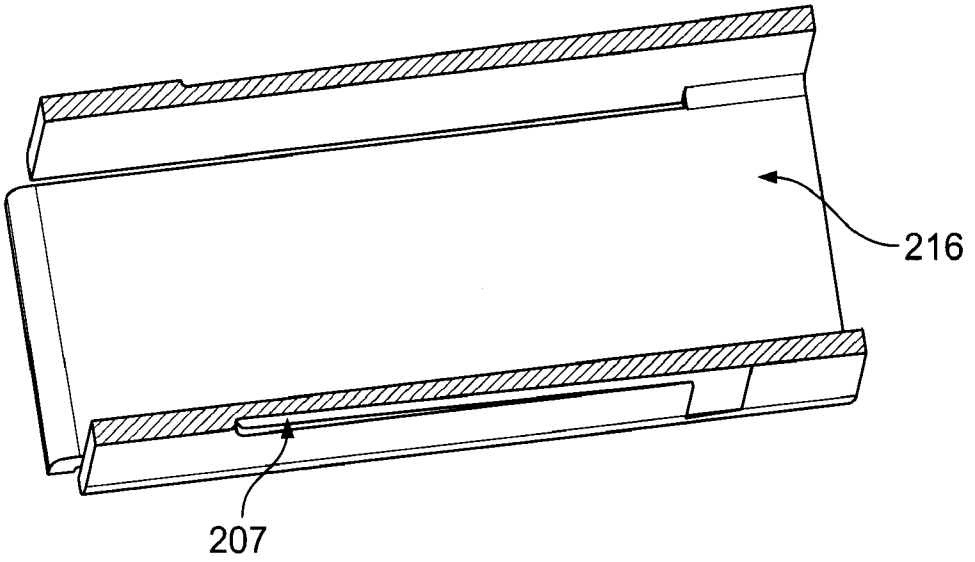


FIG. 8B

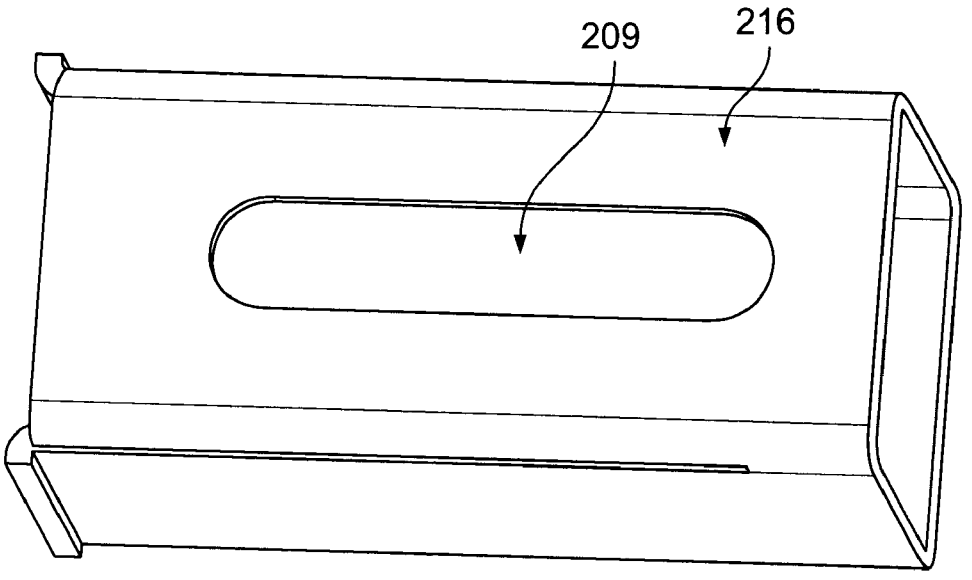


FIG. 8C

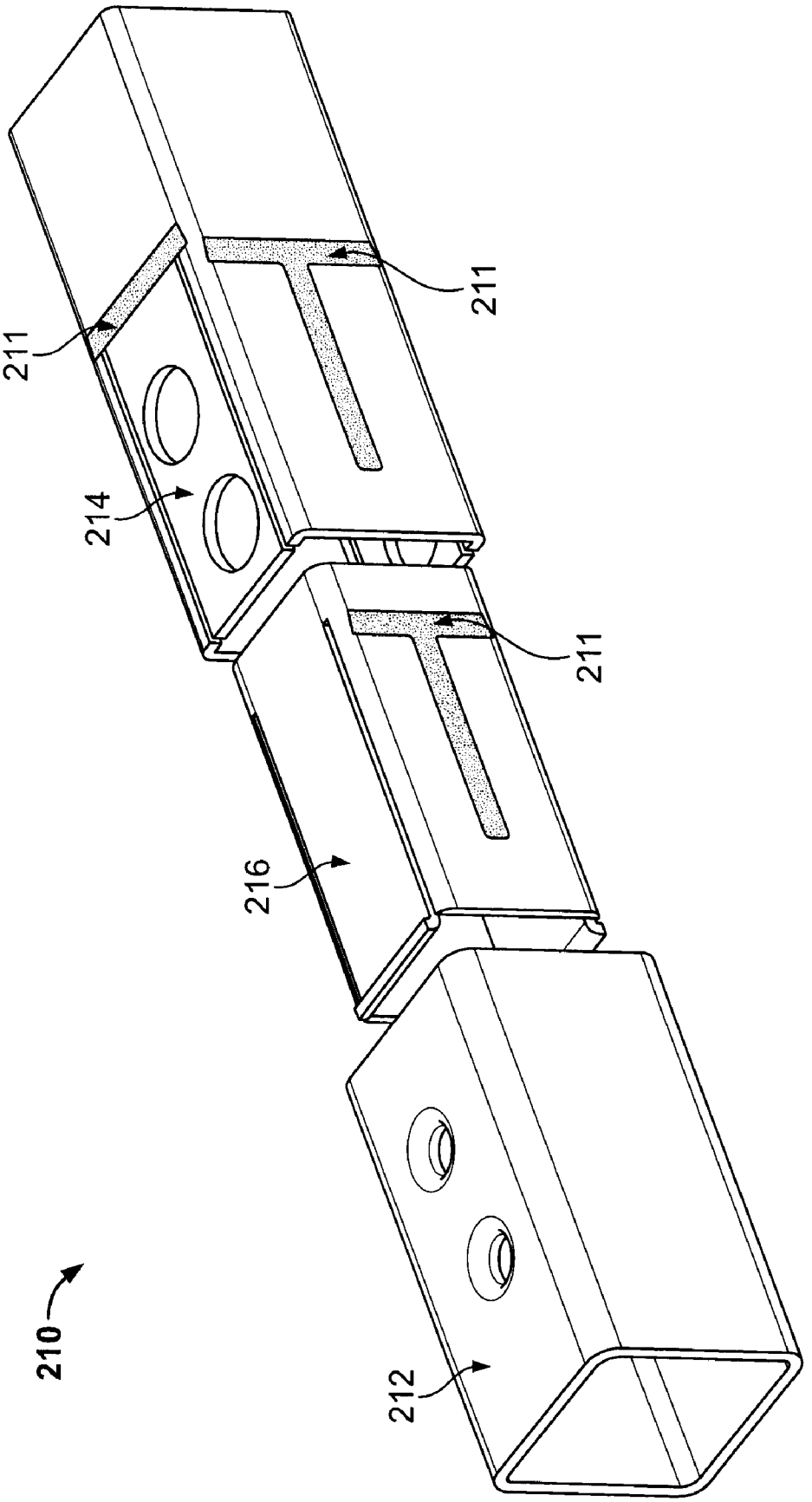


FIG. 8D

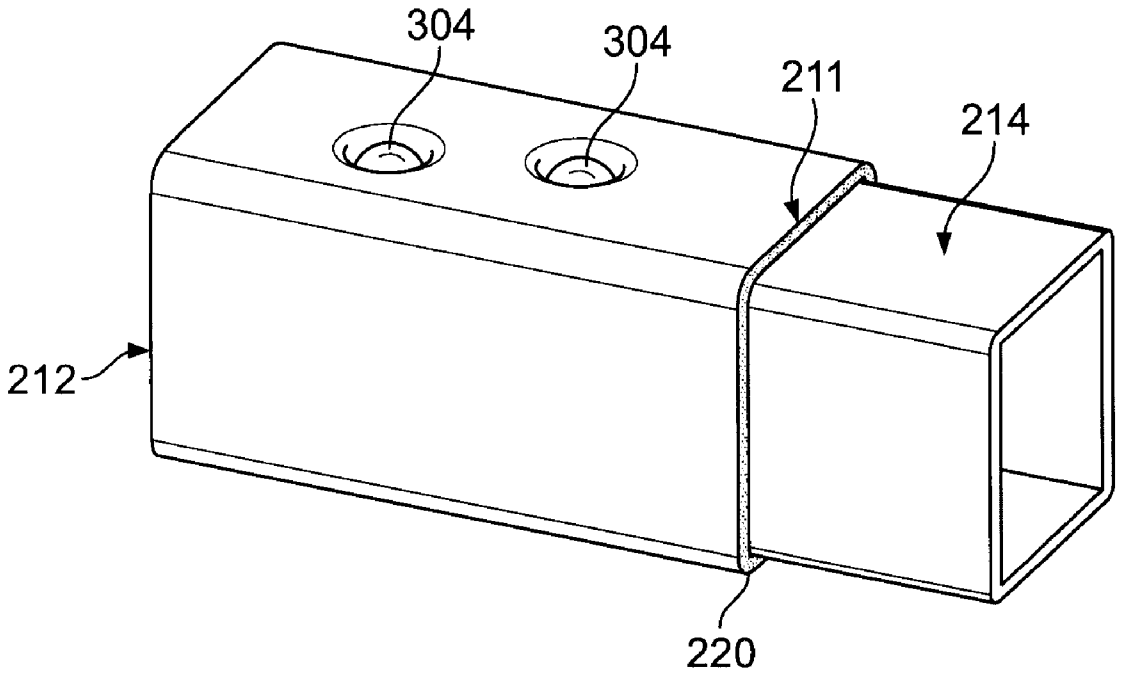


FIG. 8E

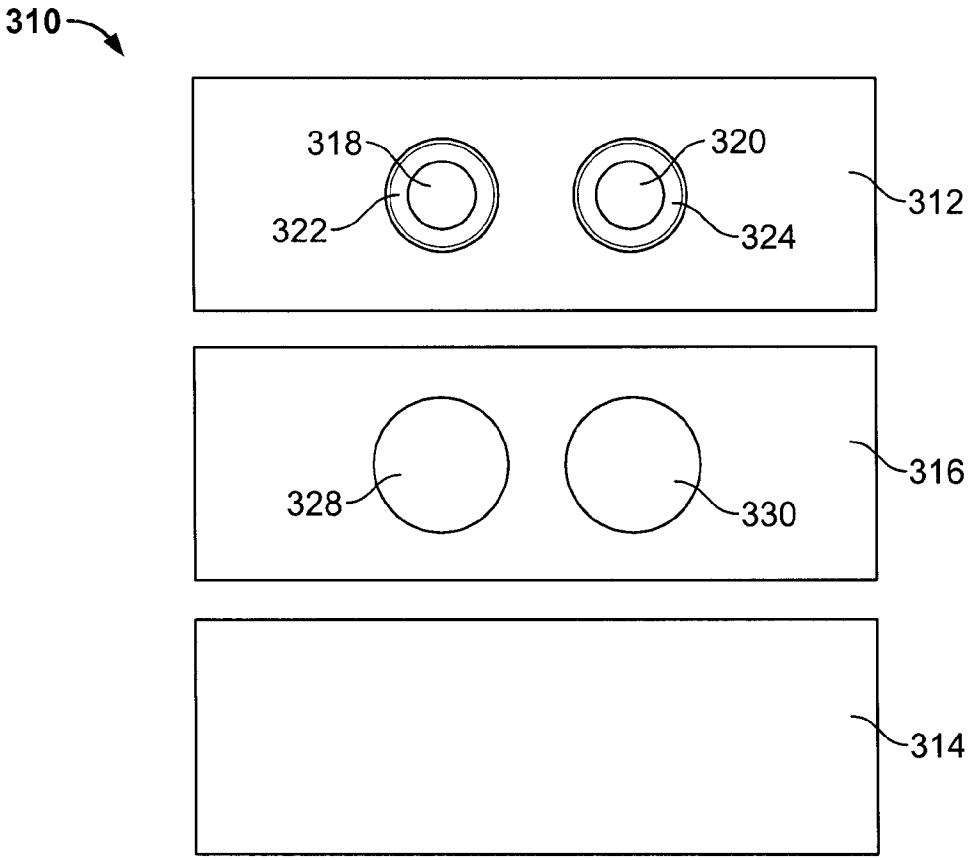


FIG. 9

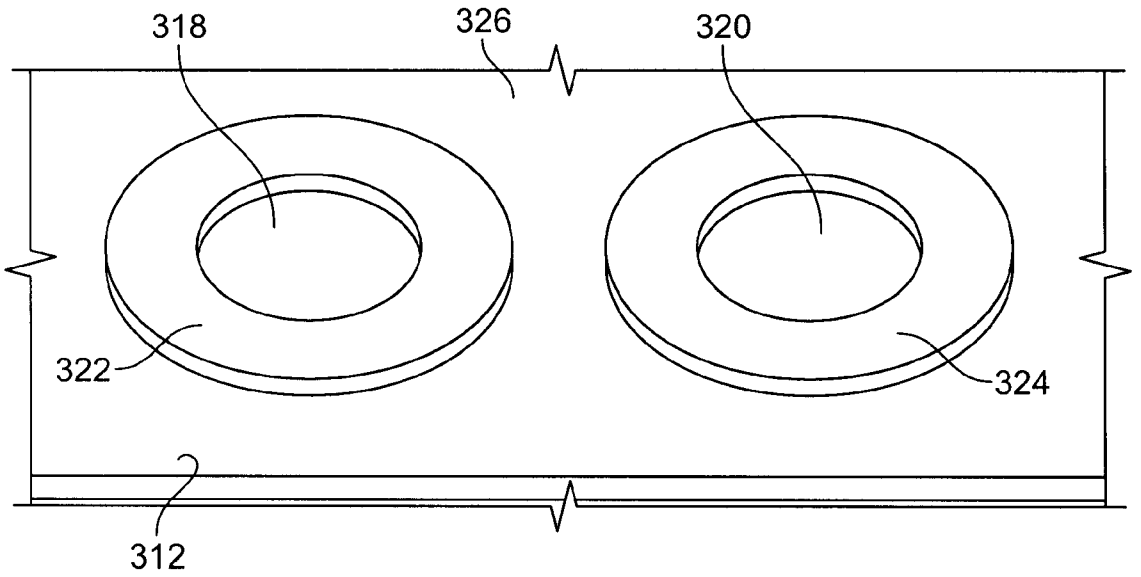


FIG. 10

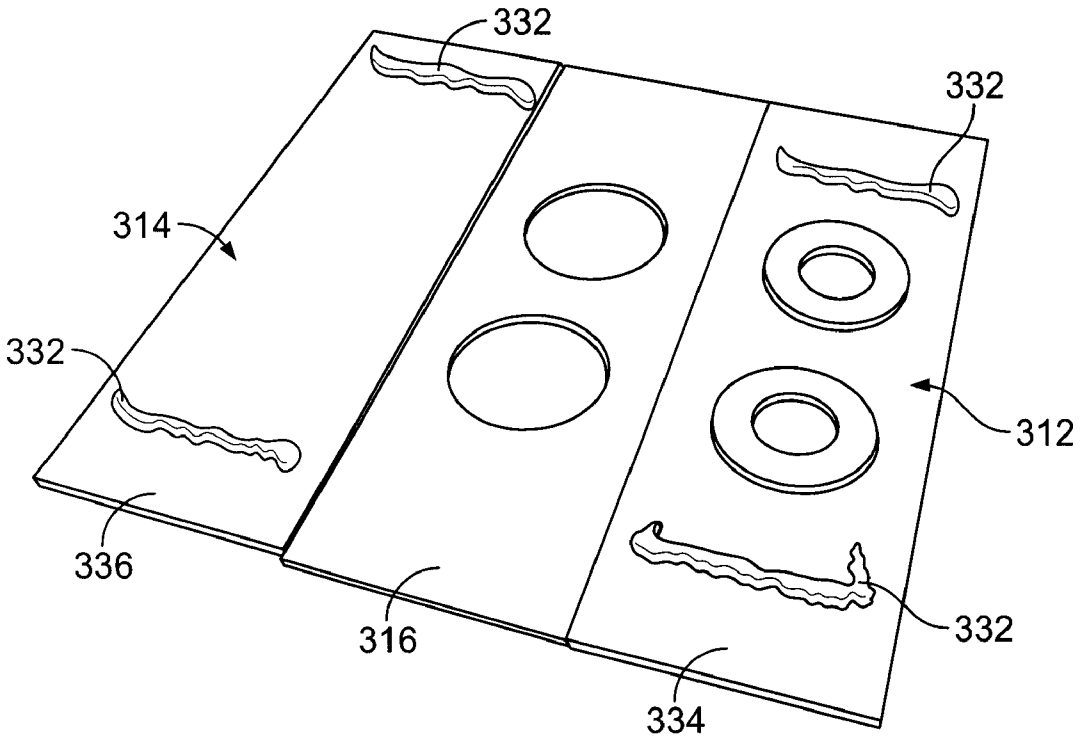


FIG.11

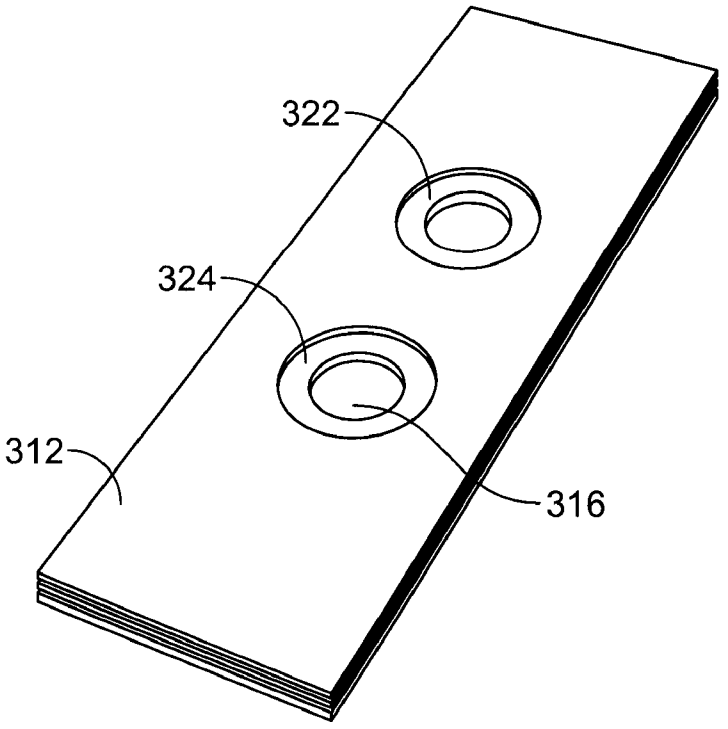


FIG. 12

SYSTEM AND METHOD FOR JOINING DISSIMILAR MATERIALS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Section 111(a) application relating to commonly owned, co-pending U.S. Provisional Application Ser. No. 61/062,268 entitled "SYSTEM AND METHOD FOR JOINING DISSIMILAR MATERIALS" filed Jan. 24, 2008.

FIELD OF THE INVENTION

[0002] The present invention relates to a system and method for joining structural and mechanical parts made from dissimilar materials.

BACKGROUND OF THE INVENTION

[0003] Two main issues with joining dissimilar materials are material compatibility and applicability of the joining process. More particularly, there are issues involved with joining aluminum to magnesium, to steel or to composites with known joining processes, such as fusion welding (e.g., gas metal arc welding) and solid-state welding (e.g., friction stir welding). These include metallurgical incompatibility, which results in uncontrolled cracking in welds and/or formation of brittle intermetallics; drastic differences in electromotive potential, which may lead to severe galvanic corrosion in the presence of salts and/or moisture; and incompatibility in the coefficient of thermal expansion, which could cause formation of intense residual stresses at joints and lead to failure under certain loading conditions, such as stress corrosion. What is needed is an appropriate system and method for proper joining of structural and mechanical parts made from dissimilar materials (e.g., metals and metal composites) to allow, among other things, the proper transmission of loads between them.

SUMMARY OF THE INVENTION

[0004] A structural assembly that includes a first structural member made from a first material, a second structural member made from a second material and adapted to mate and interlock with the first structural member, and a third structural member made from the first material to facilitate the permanent affixation between the first and second structural members. More particularly, the first structural member includes a post made from a first material, such as aluminum, the second structural member includes a tube made from a second material, such as magnesium, and is sized and shaped to fit within the post, and an insert made from the first material (e.g., aluminum) that is sized and shaped to fit within the tube. The post includes at least one aperture encircled by an inwardly extending protrusion, and the tube includes at least one aperture that is sized and shaped to mate and interlock with the protrusion when the post and tube are mated and interlocked with one another. When the post, tube and insert are mated and interlocked with one another, a snug fit is formed between the post and the tube and between the tube and the insert. In such configuration, an outer surface of the insert is exposed through the aperture of the post and the aperture of the tube. The aperture of the tube is substantially encased or shielded by the protrusion of the post such that there are no exposed surfaces of the tube in the area of the aperture of the post and the outer surface of the insert. Consequently, the aluminum post may be welded to the aluminum insert, thereby permanently affixing, for example, the aluminum post and the magnesium tube to one another without metallurgical altering or local welding of the magnesium tube.

[0005] Further features and advantages of the invention will appear more clearly on a reading of the detailed description of the embodiments of the invention, which is given below by way of example only with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] For a better understanding of the present invention, reference is made to the following detailed description of the embodiments considered in conjunction with the accompanying drawings, in which:

[0007] FIG. **1** is an exploded top perspective view of a post and tube joint assembly in accordance with an embodiment of the present invention;

[0008] FIG. **2**A is an exploded top plan view of the post and tube joint assembly illustrated in FIG. **1**;

[0009] FIG. **2**B is an exploded side elevational view of the post and tube joint assembly illustrated in FIG. **1**;

[0010] FIG. **3**A is a top perspective view of the post and tube joint assembly illustrated in FIG. **1**, showing an intermediate step of the components thereof being interlocked with one another;

[0011] FIG. **3**B is a top perspective, cross-sectional view of the post and tube joint assembly illustrated in FIG. **3**A;

[0012] FIG. **3**C is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **3**A;

[0013] FIG. **4**A is a top perspective cross-sectional view of the post and tube joint assembly illustrated in FIG. **1**, showing the components thereof interlocked with one another;

[0014] FIG. **4**B is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **4**A;

[0015] FIG. **4**C is an enlarged cross-sectional view showing detail **4**B from FIG. **4**B;

[0016] FIG. **5**A is a top perspective view of the post and tube joint assembly illustrated in FIG. **4**A, showing the components thereof welded to one another;

[0017] FIG. **5**B is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **5**A;

[0018] FIG. **5**C is an enlarged cross-sectional view showing detail **5**B from FIG. **5**B;

[0019] FIG. **6**A is an exploded top perspective view of a post and tube joint assembly in accordance with a another embodiment of the present invention;

[0020] FIG. **6**B is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **6**A, showing an intermediate step of the components thereof being interlocked with one another;

[0021] FIG. **6**C is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **6**A, showing the components thereof interlocked with one another;

[0022] FIG. **6**D is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **6**C, showing the components thereof welded to one another;

[0023] FIG. **7**A is an exploded top perspective view of a post and tube joint assembly in accordance with yet another embodiment of the present invention;

[0024] FIG. **7**B is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **7**A, showing an intermediate step of the components thereof being interlocked with one another;

[0025] FIG. **7**C is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **7**A, showing the components thereof interlocked with one another;

[0026] FIG. **7**D is a side cross-sectional view of the post and tube joint assembly illustrated in FIG. **7**C, showing the components thereof welded to one another;

[0027] FIG. **8**A is an exploded top perspective view of a post and tube joint assembly in accordance with another embodiment of the present invention;

[0028] FIG. **8**B is a cross-sectional view of an insert employed by the post and tube joint assembly illustrated in FIG. **8**A;

[0029] FIG. **8**C is perspective view of another embodiment of an insert employed by the post and tube joint assembly illustrated in FIG. **8**A;

[0030] FIG. **8**D is an exploded top perspective view of the post and tube joint assembly illustrated in FIG. **8**A, showing an adhesive applied to the components thereof;

[0031] FIG. **8**E is a top perspective view of the post and tube joint assembly illustrated in FIG. **8**A, showing the components thereof interlocked with and welded to one another; and

[0032] FIGS. **9** through **12** show a flat sheet assembly in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0033] Referring to FIGS. **1** through **2**B, a post and tube joint assembly **10** includes a hollow, rectangular-shaped post **12**, a hollow, rectangular-shaped tube **14**, and a hollow, rectangular-shaped insert **16**. While the post **12**, the tube **14** and the insert **16** are each rectangular in shape, they can consist of different shapes and sizes (e.g., cylindrical, triangular, hexagonal, etc.) to suit the purposes of the varied configurations to be appreciated from the teachings herein. In addition, the post **12** and the insert **16** may be manufactured from the same material, while the tube **14** is manufactured from a different material. The post **12** and the insert **16**, as well as the tube **14**, may be made from many types of metals suitable for the characteristics contemplated from the teachings herein. For example, the post **12** and the insert **16** may be made from aluminum, and, more particularly, T6 temper 6061 aluminum alloy, while the tube **14** may be made from steel, an aluminum alloy composite, or magnesium. The tube **14** may also be made from other materials, such as an organic based composite (e.g., carbon fibers bonded together) an inorganic based composite (e.g., metallic fibers braded and adhesively bonded), or similar composites.

[0034] With continued reference to FIGS. **1** through **2**B, the post **12** includes a first end **18** and a second end **20** opposite thereof, a first pair of opposed walls **22**, **24** and a second pair of opposed walls **26**, **28**, which form a rectangular-shaped cavity **30**. The cavity **30** is sized and shaped to slidably receive the tube **14** and the insert **16**, which shall be described in further detail below. The wall **22** includes a first pair of circular-shaped apertures **32**, **34**, while the wall **24** includes a second pair of circular-shaped apertures **36**, **38** (not shown in FIGS. **1** through **2**B, but see FIGS. **3**B and **3**C). Each of the apertures **32**, **34** includes a circular-shaped "tea-cup" protrusion **40**, **42**, respectively, that extends into the cavity **30** from the wall **22**, while each of the apertures **36**, **38** includes a circular-shaped "tea-cup" protrusion **44**, **46**, respectively, that extends into the cavity **30** from the wall **24** (not shown in FIGS. **1** through **2**B, but see FIGS. **3**B and **3**C). The aperture **32** and the aperture **36** are aligned with one another, but they need not be. Similarly, the aperture **34** and the aperture **38** are aligned with one another, but they need not be. While the post **12** includes the apertures **32**, **34** and the apertures **36**, **38** (for a total of four apertures), it may include more or less than four apertures. While each of the apertures **32**, **34** and the apertures **36**, **38** are each circular in shape, and each of the protrusions **40**, **42** and the protrusions **44**, **46** are circular in shape, they may consist of other shapes and sizes to suit the purposes of the varied configurations to be appreciated from the teachings herein. The apertures **32**, **34**, the apertures **36**, **38**, the protrusions **40**, **42**, and the protrusions **44**, **46** may be formed from any means known in the art, such as, for example, machining, punch forming into dies (i.e., "tea cupping"), cast or forged.

[0035] Still referring to FIGS. **1** through **2**B, the tube **14** includes a first end **48** and a second end **50** opposite thereof, a pair of opposed walls **52**, **54** and a pair of opposed walls **56**, **58**, which form a rectangular-shaped cavity **60**. The cavity **60** is sized and shaped to slidably receive the insert **16**, which shall be described in further detail below. The wall **52** includes a pair of circular-shaped apertures **62**, **64**, while the wall **54** includes a pair of circular-shaped apertures **66**, **68** (not shown in FIGS. **1** through **2**B, but see FIGS. **3**B and **3**C). The aperture **62** and the aperture **66** are aligned with one another, but they need not be. The aperture **64** and the aperture **68** are aligned with one another, but they need not be. While the apertures **62**, **64** and the apertures **66**, **68** are each circular in shape, they may consist of other shapes and sizes to suit the purposes of the varied configurations to be appreciated from the teachings herein. A slot **70** is formed within the wall **52** proximate to a corner **71** where the wall **52** and the wall **56** intersect, while a slot **72** is formed with the wall **52** proximate to a corner **73** where the wall **52** and the wall **58** intersect. Similarly, a slot **74** is formed within the wall **54** proximate to a corner **75** where the wall **54** and the wall **56** intersect, while a slot **76** is formed with the wall **54** proximate to a corner **77** where the wall **54** and the wall **58** intersect. Each of the slots **70**, **72** and the slots **74**, **76** have lengths that extend from the end **48** of the tube **14** to a point P**1** intermediate the ends **48**, **50** of the tube **14**. The length of the slots **70**, **72** and the length of the slots **74**, **76** are the same, but the lengths can be different. The functions of the slots **70**, **72** and the slots **74**, **76** shall be described below.

[0036] Still referring to FIGS. **1** through **2**B, the insert **16** includes a first end **78** and a second end **80** opposite thereof, a first pair of opposed walls **82**, **84** and a second pair of opposed walls **86**, **88**, which form a rectangular-shaped cavity **90**. A slot **92** is formed within the wall **82** proximate to a corner **93** where the wall **82** and the wall **86** intersect, while a slot **94** is formed within the wall **82** proximate to a corner **95** where the wall **82** and the wall **88** intersect. Similarly, a slot **96** is formed within the wall **84** proximate to a corner **97** where the wall **84** and the wall **86** intersect, while a slot **98** is formed within the wall **84** proximate to a corner **99** where the wall **84** and the wall **88** intersect. Each of the slots **92**, **94** and the slots **96**, **98** has a length that extends from the end **78** of the insert **16** to a point P**2** intermediate the ends **78**, **80** of the insert **16**. The length of the slots **92**, **94** and the length of the slots **96**, **98** are the same, but the lengths can be different. The insert **16** includes a first retainment tab **100** that extends outwardly

from the wall **82** at the end **78** of the insert **16**, while a second retainment tab **102** extends outwardly from the wall **84** at the end **78** of the insert **16**. Each of the tabs **100**, **102** has a length that is substantially the width of the walls **82**, **84**, respectively. The tab **100** includes a curved outer surface **101**, while the tab **102** includes a curved outer surface **103** (see FIG. **2**B). The functions of the slots, **92**, **94**, the slots **96**, **98**, and the retainment tabs **100**, **102** shall be described below.

[0037] FIGS. **3**A through **3**C show an intermediate step of assembling the post **12**, the tube **14** and the insert **16** with one another. More particularly, the end **80** of the insert **16** is inserted into the cavity **60** of the tube **14** at the end **48** thereof. In such position, the retainment tabs **100**, **102** of the insert **16** abut against the end **48** of the tube **14**, which inhibit the insert **16** from sliding out the end **50** of the tube **14** during assembly. The cavity **60** of the tube **14** is sized and shaped to accommodate the receipt of the insert **16** and firmly retain the insert **16** therein.

[0038] Next, the tube **14** and the insert **16** assembly as described above are slidably inserted into the cavity **30** of the post **12** at an end **20** thereof. The cavity **30** of the post **12** is sized and shaped such that the tube **14** and the insert **16** elastically deflect inwardly when the tube **14** and the insert **16** are inserted into the post **12** (see FIGS. **3**B and **3**C). More particularly, as the tube **14** and the insert **16** assembly are inserted into the post **12**, the tab **100** of the insert **16** reaches the protrusion **42** of the post **12** and the tab **102** reaches the protrusion **46** of the post **12**. At this point, the curved surfaces **101**, **103** of the tabs **100**, **102** and the "tea-cup" shapes of the protrusions **42**, **46** enable the tabs **100**, **102** to travel over (i.e., ramp over) the protrusions **42**, **46**, respectively. As the tabs **100**, **102** travel over the protrusions **42**, **46**, resulting forces act against the tabs **100**, **102** and, in turn, against the first end **48** of the tube **14**. As a result of such forces, the walls **52**, **54** of the tube **14** deflect inwardly, while the walls **82**, **84** of the insert **16** deflect inwardly. The slots **70**, **72** of the tube **14** facilitate the deflection of the wall **52** of the tube **14** inwardly, while the slots **74**, **76** of the tube **14** facilitate the deflection of the wall **54** of the tube **14** inwardly. Similarly, the slots **92**, **94** of the insert **16** facilitate the deflection of the wall **82** of the insert **16** inwardly, while the slots **96**, **98** of the insert **16** facilitate the deflection of the wall **84** of the insert **16** inwardly. As indicated above, the lengths of the slots **70**, **72** and the slots **74**, **76** of the tube **14** are equal in order to facilitate uniform deflection of the walls **52**, **54** of the tube **14**. Similarly, the lengths of the slots **92**, **94** and the slots **96**, **98** of the insert **16** are equal in order to facilitate uniform deflection of the walls **82**, **84** of the insert. However, the aforesaid lengths can be adjusted (e.g., shortened or lengthened) to suit the purposes of the varied configurations to be appreciated from the teachings herein.

[0039] It is also noted that the apertures **32**, **34** of the post **12** are not aligned with one another along axis A-A, as shown in FIGS. **2**A and **3**A, and that the apertures **36**, **38** of the post **12** are not aligned with one another along axis A-A. This configuration prevents the aperture **62** from mating with the protrusion **40** and the aperture **66** from mating with the protrusion **44**. As a result, the tube **14** and the insert **16** assembly are prevented from interlocking with the post **12** prematurely.

[0040] As the tube **14** and the insert **16** assembly continues to be inserted within the post **12**, the protrusions **42**, **46** act against the wall **52** of the tube **14** to maintain the deflection of the tube **14** and the insert **16** as discussed above. Once again, the curved surfaces **101**, **103** of the tabs **100**, **102** and the "tea-cup" shapes of the protrusions **42**, **46** enable the tabs **100**, **102** to slide over the protrusions **44**, **48**, respectively.

[0041] FIGS. **4**A through **4**C show the tube **14** and the insert **16** assembly fully inserted within the post **12** and snapped into place. More particularly, the apertures **62**, **64** of the tube **14** engage and cooperate with the protrusions **40**, **42** of the post **12**, respectively, while the apertures **66**, **68** of the tube **14** engage and cooperate with the protrusions **44**, **46** of the post, respectively. In such manner, the walls **52**, **54** of the tube **14** and the walls **82**, **84** of the insert **16** spring back into their substantially same original position (i.e., before deflection) and are locked into place within the post **12**. As a result, the protrusions **40**, **42**, are aligned and interlocked with the apertures **62**, **64**, respectively, while the protrusions **44**, **46** are aligned and interlocked with the apertures **66**, **68**, respectively. The thickness of the walls **52**, **54** of the tube **14** is sized appropriately to enable the protrusions **40**, **42**, **44**, **46** to sufficiently mate and interlock with the respective apertures **62**, **64**, **66**, **68**. It is also noted that the tube **14** and the insert **16** are designed and manufactured such that their elastic deformation is within the range of approximately 99-100% (e.g., no plastic deformation at >0.2 yield strengths); and, therefore, such components can carry out the mechanical interlocking process described herein.

[0042] FIGS. **5**A through **5**C show the welding of the post **12** to the insert **16**, which are made from the same material (e.g., aluminum). More particularly, welds **104** are placed within each of the apertures **32**, **34** of the post **12** and the apertures **62**, **64** of the tube **14**, resulting in welded joints between the protrusions **40**, **42** and the wall **82** of the insert **16**. Similarly, welds **106** are placed within the apertures **36**, **38** of the post **12** and the apertures **66**, **68** of the tube **14**, resulting in welded joints between the protrusions **44**, **46** and the wall **84** the insert **16**. Since the post **12** and the insert **16**, which are made from the same material (e.g., aluminum), are permanently welded to one another by the welds **104**, **106**, the tube **14**, which is made from a different material (e.g., magnesium) is permanently retained within the post **12**. Consequently, the mechanical interlock between the post **12** and the tube **14** described above is permanently affixed.

[0043] The welds **102**, **104** may be made from any welding process known in the art, such as fusion-based (e.g., GMAW, GTAW, LBW, LSBW, etc.) or solid-state based (e.g., FSW, FW Plunge, etc.). Alternatively, the welds **102**, **104** need not be included, and the welding process described above could be substituted with any other joining and fixation processes known in the art, such as rivets, bolts, screws, etc. that enable the post **12** and tube **14** to be secured together in a manner that ensures the mechanical interlocks between them do not separate.

[0044] The mechanical interlocking features of the post and joint assembly **10** enable load transmission through the post **12** and the tube **14**, while simultaneously keeping the subsequent joining operations localized and confined to joining the post **12** and the insert **16** (which are made of the same material) and separate from the tube **14**.

[0045] Another embodiment of the present invention is illustrated in FIGS. **6**A through **6**D. The embodiment shown in FIGS. **6**A through **6**D includes the same features and is assembled in the same manner as the embodiment shown in FIGS. **1** through **5**C, with the exception that the post **12** has two pairs of circular-shaped apertures **32**, **34** on the wall **22** thereof and two pairs of circular-shaped apertures **36**, **38** on the wall **24** thereof, while the tube **14** has two pairs of circular-

shaped apertures **62**, **64** on the wall **52** thereof and two pairs of circular-shaped apertures **66**, **68** on the wall **54** thereof. In the same manner as the embodiment shown in FIGS. **1** through **5**C, the insert **16** is slidably inserted into the tube **14**, and the tube **14** and the insert **16** assembly is slidably inserted into the post **16** and locked into place (see FIGS. **6**B and **6**C). Afterwards, the mechanical interlock between the post **12** and the tube **14** are permanently affixed by welding the post **12** to the insert **16** by welds **104** through each of the apertures **32**, **34** of the post **12** and the apertures **62**, **64** of the tube **14** and welds **106** through each of the apertures **36**, **38** of the post **12** and the apertures **62**, **64** of the tube **14**.

[0046] Another embodiment of the present invention is illustrated in FIGS. **7**A through **7**D. The embodiment shown in FIGS. **7**A through **7**D includes the same features and is assembled in the same manner as the embodiment shown in FIGS. **1** through **5**C, with the exception that the post **12** has two pairs of oblong-shaped slots **32**, **34** on the wall **22** thereof and two pairs of oblong-shaped slots **36**, **38** on the wall **24** thereof, while the tube **14** has two pairs of oblong-shaped slots **62**, **64** on the wall **52** thereof and two pairs of oblong-shaped slots **66**, **68** on the wall **54** thereof. In the same manner as the embodiment shown in FIGS. **1** through **5**C, the insert **16** is slidably inserted into the tube **14**, and the tube **14** and the insert **16** assembly is slidably inserted into the post **16** and locked into place (see FIGS. **7**B and **7**C). Afterwards, the mechanical interlock between the post **12** and the tube **14** are permanently affixed by welding the post **12** to the insert **16** by welds **104** through each of the slots **32**, **34** of the post **12** and the slots **62**, **64** of the tube **14** and by welds **106** through each of the slots **36**, **38** of the post **12** and the slots **66**, **68** of the tube **14**.

[0047] Another embodiment of the present invention is illustrated in FIGS. **8**A through **8**D. Elements illustrated in FIGS. **8**A through **8**D that correspond to the elements described above with reference to FIGS. **1** though **5**C have been designated by corresponding reference numerals increased by two hundred (200). The embodiment of FIGS. **8**A through **8**D operates in the same manner as the embodiment of FIGS. **1** through **5**C, unless it is otherwise stated.

[0048] FIGS. **8**A through **8**D show a post and tube joint assembly **210** that includes a hollow, rectangular-shaped post **212**, a hollow, rectangular-shaped tube **214**, and a hollow, rectangular-shaped insert **216**. These components include the same features as those corresponding to the embodiment shown in FIGS. **1** though **5**C described above, with the exception that the tube **214** includes rectangular-shaped channels **201** formed within and extending transversely across an outer surface of a wall **252** and an outer surface of a wall **254** (not shown in the Figures), and T-shaped channels **203** formed within an outer surface of a wall **258** and an outer surface of a wall **256** (not shown in the Figures). In addition, the insert **216** includes oblong-shaped channels **205** formed within an outer surface of a wall **288** and an outer surface of a wall **286** (not shown in the Figures). FIGS. **8**B and **8**C show additional embodiments of the insert **216**, which include channels **207** and **209**, respectively, that consist of different shapes and sizes. Accordingly, the channels **201**, **203**, **205** can consist of a variety shapes and sizes and in any number other than those shown in the Figures. Each of the channels **201**, **203** of the tube **214** and the channels **205** of the insert **214** are adapted to receive a sealant and/or an adhesive **211**, which provides additional bonding when the post **212**, the tube **214** and the insert **216** are interlocked with and welded to one another (see FIG. **8**D). In addition, when the post **212** and the tube **214** are interlocked, a sealant and/or adhesive **211** may be applied between the post **212** and the tube **214** around the perimeter of an end **220** of the post **212**, as shown in FIG. **8**E. The sealant/adhesive **211** is used to improve the overall performance and strength (e.g., mechanical strength, corrosion resistance, etc.) of the assembly **210**, as well as to seal area A between the post **212** and the tube **214** to prevent the intrusion of foreign elements (see FIG. **8**E). The adhesive/sealant **211** may be applied by injection or manually brushed on. Alternatively, the use of heat-activated or non-heat activated adhesives and/or sealing tapes can be utilized. The adhesive or sealant **211** may be applied prior to or after the mechanical interlocking of the assembly **210**, as appropriate.

[0049] FIGS. **9** through **14** show a similar system and method with respect to a flat sheet assembly **310**. More particularly, FIG. **9** shows the assembly **310** prior to lock-joining the components thereof, which include a first rectangular-shaped sheet **312**, a second rectangular-shaped sheet **314**, and a third rectangular-shaped sheet **316** that is sandwiched between the first and second sheets **312**, **314**. While the sheets **312**, **314**, **316** are each rectangular in shape, they can consist of different shapes and sizes (e.g., square, triangular, circular, oblong, etc.) to suit the purposes of the varied configurations to be appreciated from the teachings herein. In addition, the sheets **312**, **314** are each manufactured from the same material, such as aluminum, while the sheet **316** is manufactured from a different material, such as magnesium. Alternatively, the sheets **312**, **314**, as well as the sheet **316**, may be made from other types of metals suitable for the characteristics contemplated from the teachings herein. For example, the sheets **312**, **314** may be made from aluminum, while the sheet **316** may be made from steel or an aluminum based composite. The sheet **316** may also be made from other materials, such as an organic based composite (e.g., carbon fibers bonded together) an inorganic based composite (e.g., metallic fibers braded and adhesively bonded), or similar composites.

[0050] Referring to FIGS. **9** and **10**, the sheet **312** includes a pair of circular-shaped apertures **318**, **320** encircled by "tea-cup" shaped protrusions **322**, **324** that outwardly extend from a surface **326** of the sheet **312**. Referring only to FIG. **9**, the sheet **316** includes two circular-shaped apertures **328**, **330** that are sized and shaped to receive the protrusions **322**, **324** of the sheet **312**. As shown in FIG. **11**, an adhesive **332** may be applied to a surface **334** of the sheet **312** and a surface **336** of the sheet **314**. FIG. **12** shows the assembly of the sheets **312**, **314**, **316**, whereby the protrusions **322**, **324** of the sheet **312** are received by the apertures **328**, **330** of the sheet **316**. In FIG. **13**, the sheets **312**, **314**, **316** are clamped together for preparation of a welding process and facilitating the adhesion between them. FIG. **14** shows the deposition of a GMA spot weld **338** between the sheets **312**, **314** which are made from the same material (e.g., aluminum) with the sheet **316** (which is made from magnesium) interlocked between them. As a result the sheet **316** is interlocked with the between the aluminum sheets **312**, **314**.

[0051] The method includes lock-joining together parts made from dissimilar materials through the use of interlocking means on the parts at the joints betwee n them, and the use of another (i.e., secondary) joining process whose application is separate from and confined to joining two parts made from the same material, which ensures that the mechanical interlocks between the parts of dissimilar materials do not become separated.

[0052] The term "snug fit" is defined as a gap or space (or a lack thereof between each of the protrusions **40**, **42**, **44**, **46** of the post **12** and the outer surface of the insert **16** being in the range of zero up to a dimension that does not expose a surface of the tube **14** to the welding process. The term "mate" is defined as to join, fit, associate, assemble or couple parts or components with one another. The term "interlock" means to lock, fasten or fix parts or components with one another to ensure a stable and desirable coordinately functioning structure or action.

[0053] It should be understood that the embodiments described herein are merely exemplary and that a person skilled in the art may make many variations and modifications without departing from the spirit and scope of the invention. Accordingly, all such variations and modifications are intended to be included within the scope of the embodiments described herein as defined in the appended claims.

We claim:

1. An assembly, comprising:

a first structural member made from a first material and having at least one locking member;

a second structural member made from a second material and having at least one retention structure, the at least one locking member of the first structural member is sized and shaped to mate with the at least one retention structure of the second structural member so as to interlock the first and second structural members with one another;

a third structural member made from the first material and mated with the first and second structural members, the first structural member and the third structural member being joined directly to one another so as to facilitate a permanent connection between the first and second structural members.

2. The assembly of claim **1**, wherein the first structural member includes a first surface and a second surface opposite the first surface, and wherein the at least one locking member of the first structural member includes at least one protrusion extending from the second surface, and wherein the second structural member includes a first surface and a second surface opposite the first surface of the second structural member, the at least one retention structure of the second structural member includes an aperture extending from the first surface of the second structural member to the second surface of the second structural member.

3. The assembly of claim **2**, wherein the first structural member includes at least one aperture that extends from the first surface of the first structural member to the second surface of the first structural member, the at least one protrusion surrounds the at least one aperture of the first structural member, the at least one aperture of the first structural member and the at least one aperture of the second structural member being aligned substantially with one another.

4. The assembly of claim **3**, wherein the third structural member includes a first surface, the first, second and third structural members being positioned relative to one another such that the first surface of the third structural member is exposed through the at least one aperture of the first structural member and the at least one aperture of the second structural member.

5. The assembly of claim **4**, wherein the at least one protrusion of the first structural member includes a plurality of protrusions, and the at least one aperture of the second structural member includes a plurality of apertures, one of the plurality of protrusions of the first structural member being sized and shaped to mate with a corresponding one of the plurality of apertures of the second structural member.

6. The assembly of claim **5**, wherein the at least one aperture of the first structural member includes a plurality of apertures, one of the plurality of protrusions of the first structural member surrounds a corresponding one of the plurality of apertures of the first structural member, and one of the plurality of apertures of the first structural member and a corresponding one of the plurality of apertures of the second structural member being aligned substantially with one another.

7. The assembly of claim **6**, wherein each of the plurality of protrusions of the first structural member is welded to the first surface of the third structural member.

8. The assembly of claim **7**, wherein each of the plurality of apertures of the first structural member is circular in shape, and each of the plurality of apertures of the second structural members is circular in shape.

9. The assembly of claim **7**, wherein the first material is aluminum.

10. The assembly of claim **8**, wherein the second material is magnesium.

11. The assembly of claim **8**, wherein the second material is steel.

12. The assembly of claim **8**, wherein the second material is an organic based composite.

13. The assembly of claim **8**, wherein the second material is an inorganic based composite.

14. An assembly, comprising:

a first structural member made from a first material and having a first end, a second end opposite the first end, and a cavity extending from the first end to the second end;

a second structural member made from a second material and having a first end, a second end opposite the first end of the second structural member, and a cavity extending from the first end of the second structural member to the second end of the second structural member; and

a third structural member made from the first material and having a first end and a second end opposite thereof,

the cavity of the second structural member is sized and shaped to receive slidably the third structural member at the first end of the second structural member, the cavity of the first structural member is sized and shaped to receive slidably the second and third structural members at the second end of the first structural member, the first structural member and the third structural member being joined directly to one another so as to facilitate a permanent connection between the first and second structural members.

15. The assembly of claim **14**, wherein the first structural member includes a first wall having a first surface, a second surface opposite the first surface, and at least one protrusion extending from the second surface, the second structural member includes a first wall having a first surface, a second surface opposite the first surface of the first wall of the second structural member, and at least one aperture extending from the first surface of the first wall of the second structural member to the second surface of the first wall of the second structural member, the at least one protrusion is sized and shaped to mate with the at least one aperture so as to interlock the first and second structural members with one another.

16. The assembly of claim **15**, wherein the first structural member includes at least one aperture that extends from the first surface of the first wall of the first structural member to the second surface of the first wall of the first structural member, the at least one protrusion surrounds the at least one aperture of the first structural member, and the at least one aperture of the first structural member and the at least one aperture of the second structural member being aligned substantially with one another.

17. The assembly of claim **16**, wherein the third structural member includes a first wall having a first surface and a second surface opposite the first surface of the third structural member, the first, second and third structural members being positioned relative to one another such that the first surface of the first wall of the third structural member is exposed through the at least one aperture of the first structural member and the at least one aperture of the second structural member.

18. The assembly of claim **17**, wherein the at least one protrusion of the first structural member is welded to the first surface of the first wall of the third structural member.

19. The assembly of claim **18**, wherein the at least one protrusion of the first structural member includes a plurality of protrusions, and the at least one aperture of the second structural member includes a plurality of apertures, one of the plurality of protrusions of the first structural member being sized and shaped to mate with a corresponding one of the plurality of apertures of the second structural member.

20. The assembly of claim **19**, wherein the at least one aperture of the first structural member includes a plurality of apertures, one of the plurality of protrusions of the first structural member surrounds a corresponding one of the plurality of apertures of the first structural member, and one of the plurality of apertures of the first structural member and a corresponding one of the plurality of apertures of the second structural member being aligned substantially with one another.

21. The assembly of claim **20**, wherein the first structural member includes a second wall having a first surface, a second surface opposite the first surface of the second wall, and at least one protrusion extending from the second surface of the second wall, the second structural member includes a second wall having a first surface, a second surface opposite the first surface of the second wall of the second structural member, and at least one aperture extending from the first surface of the second wall of the second structural member to the second surface of the second wall of the second structural member, the at least one protrusion of the second wall of the first structural member is sized and shaped to mate with the at least one aperture of the second wall of the second structural member so as to interlock the first and second structural members with one another.

22. The assembly of claim **21**, wherein the first structural member includes at least one aperture that extends from the first surface of the second wall of the first structural member to the second surface of the second wall of the first structural member, the at least one protrusion of the second wall of the first structural member surrounds the at least one aperture of the second wall of the first structural member, and the at least one aperture of the second wall of the first structural member and the at least one aperture of the second wall of the second structural member being aligned substantially with one another.

23. The assembly of claim **22**, wherein the third structural member includes a second wall having a first surface and a second surface opposite the first surface of the second wall of the third structural member, the first, second and third structural members being positioned relative to one another such that the first surface of the second wall of the third structural member is exposed through the at least one aperture of the second wall of the first structural member and the at least one aperture of the second wall of the second structural member.

24. The assembly of claim **23**, wherein the at least one protrusion of the first structural member is welded to the first surface of the second wall of the third structural member.

25. The assembly of claim **24**, wherein the at least one protrusion of the second wall of the first structural member includes a plurality of protrusions, and the at least one aperture of the second wall of the second structural member includes a plurality of apertures, one of the plurality of protrusions of the second wall of the first structural member being sized and shaped to mate with a corresponding one of the plurality of apertures of the second wall of the second structural member.

26. The assembly of claim **25**, wherein the at least one aperture of the second wall of the first structural member includes a plurality of apertures, one of the plurality of protrusions of the second wall of the first structural member surrounds a corresponding one of the plurality of apertures of the second wall of the first structural member, and one of the plurality of apertures of the second wall of the first structural member and a corresponding one of the plurality of apertures of the second wall of the second structural member being aligned substantially with one another.

27. The assembly of claim **26**, wherein the third structural member includes a cavity extending from the first end of the third structural member to the second end of the third structural member, and wherein the second structural member includes a pair of slots formed within the first wall of the second structural member and each extending from the first end of the second structural member to a point distal from the first end of the second structural member, and the third structural member includes a pair of slots formed within the first wall of the third structural member and each extending from the first end of the third structural member to a point distal from the first end of the third structural member,

each of the pair of slots of the second structural member being sized and shaped to enable the first wall of the second structural member to move between an undeflected position to a deflected position, the first wall of the second structural member is urged from the undeflected position toward the deflected position when the second structural member is partially inserted within the cavity of the first structural member, and the first wall of the second structural member returns from the deflected position to substantially its the undeflected position when the second structural member is fully inserted within the cavity of the first structural member, and

each of the pair of slots of the third structural member being sized and shaped to enable the first wall of the third structural member to move between an undeflected position to a deflected position, the first wall of the third structural member is urged from its the undeflected position toward its the deflected position when the second structural member is partially inserted within the cavity of the first structural member, and the first wall of the third structural member returns from its the deflected position to substantially its the undeflected position

when the second structural member is fully inserted within the cavity of the first structural member.

28. The assembly of claim **27**, wherein the second structural member includes a second pair of slots formed within the second wall of the second structural member and each extending from the first end of the second structural member to a point distal from the first end of the second structural member, and the third structural member includes a second pair of slots formed within the second wall of the third structural member and each extending from the first end of the third structural member to a point distal from the first end of the third structural member,

each of the second pair of slots of the second structural member being sized and shaped to enable the second wall of the second structural member to move between an undeflected position to a deflected position, the second wall of the second structural member is urged from its the undeflected position toward its the deflected position when the second structural member is partially inserted within the cavity of the first structural member, and the second wall of the second structural member returns from its the deflected position to substantially its the undeflected position when the second structural member is fully inserted within the cavity of the first structural member, and

each of the second pair of slots of the third structural member being sized and shaped to enable the second wall of the third structural member to move between an undeflected position to a deflected position, the second wall of the third structural member is urged from its the undeflected position toward its the deflected position when the second structural member is partially inserted within the cavity of the first structural member, and the second wall of the third structural member returns from its the deflected position to substantially its the undeflected position when the second structural member is fully inserted within the cavity of the first structural member.

29. The assembly of claim **28**, wherein each of the first, second and third structural members is generally rectangular in cross section.

30. The assembly of claim **28**, wherein the first material is aluminum.

31. The assembly of claim **30**, wherein the second material is magnesium.

32. The assembly of claim **30**, wherein the second material is steel.

33. The assembly of claim **30**, wherein the second material is an organic based composite.

34. The assembly of claim **30**, wherein the second material is an inorganic based composite.

35. A method, comprising the steps of:

providing a first structural member made from a first material and having at least one locking member;

connecting a second structural member, made from a second material and having at least one retention structure, to the first structural member, the at least one locking member of the first structural member is sized and shaped to mate with the at least one retention structure of the second structural member so as to interlock the first and second structural members when the are connected to one another;

providing a third structural member, made from the first material, and mating it with the first and second structural members; and

joining directly the first structural member and the third structural member with one another so as to facilitate a permanent connection between the first and second structural members.

* * * * *