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Ferguson

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(54) **FRAME FOR HOLDING LAMINATE DURING PROCESSING**

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(73) Assignee: **United States of America as represented by the Secretary of the Navy**, Washington, DC (US)

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(58) **Field of Classification Search** 269/8; 29/25.01, 29/832; 335/283; 361/679.31; 369/13.01; 379/207.02; 414/416.07; 428/216, 425.9, 428/76, 827, 835.2; 430/311
See application file for complete search history.

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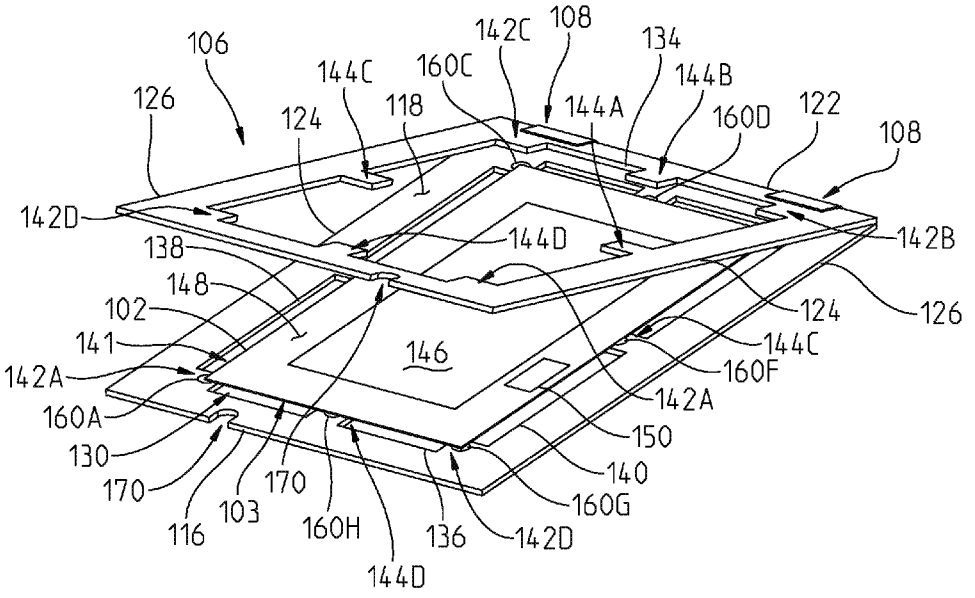
(57) **ABSTRACT**

A rigid holder is provided for supporting a flexible article. The rigid holder may include a first frame member and a second frame member which are held together through magnets.

25 Claims, 10 Drawing Sheets



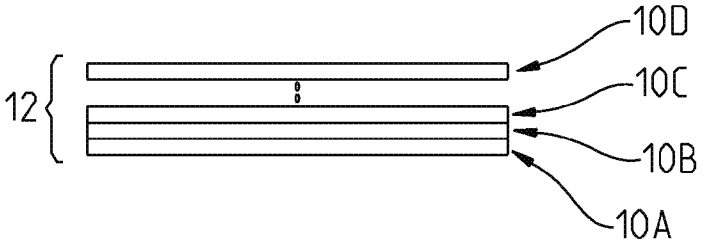


FIG. 1
Prior Art

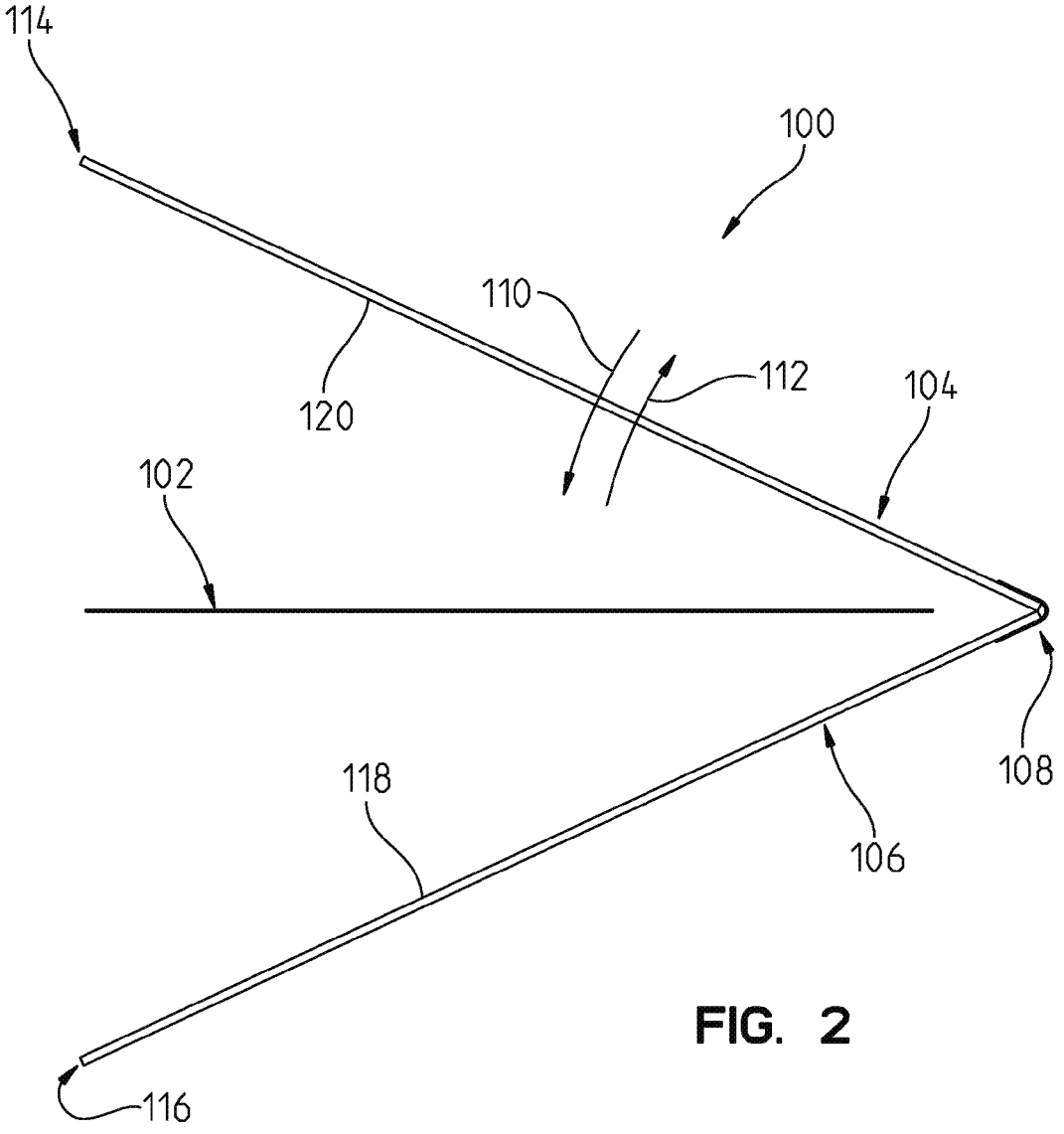


FIG. 2

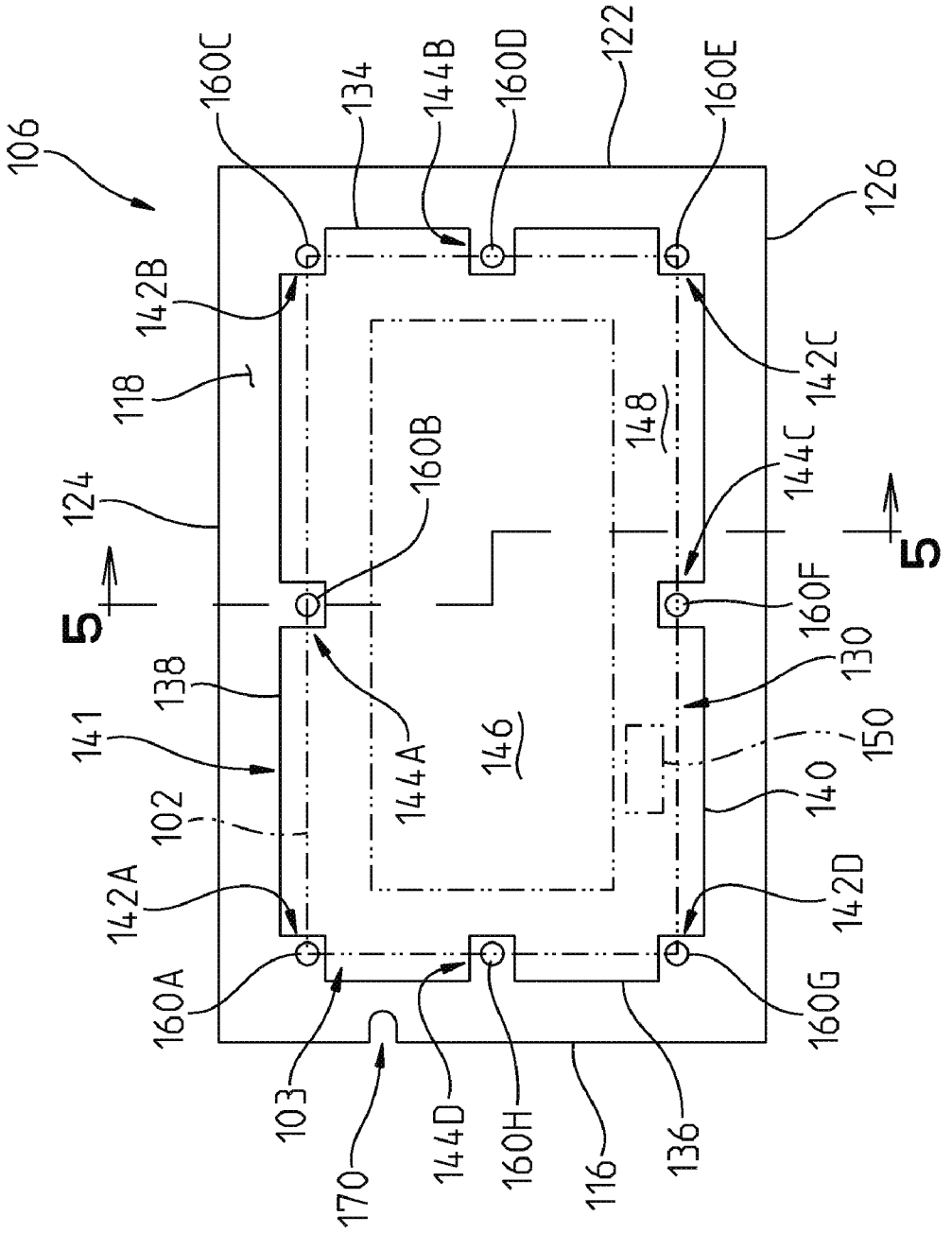

106
160C
134
144B
160D
122
160E
126
142B
118
148
142C
160B
144C
124
5
5
160F
138
130
141
144A
146
150
102
140
142A
142D
160A
160G
103
170
144D
160H
116
136

FIG. 3

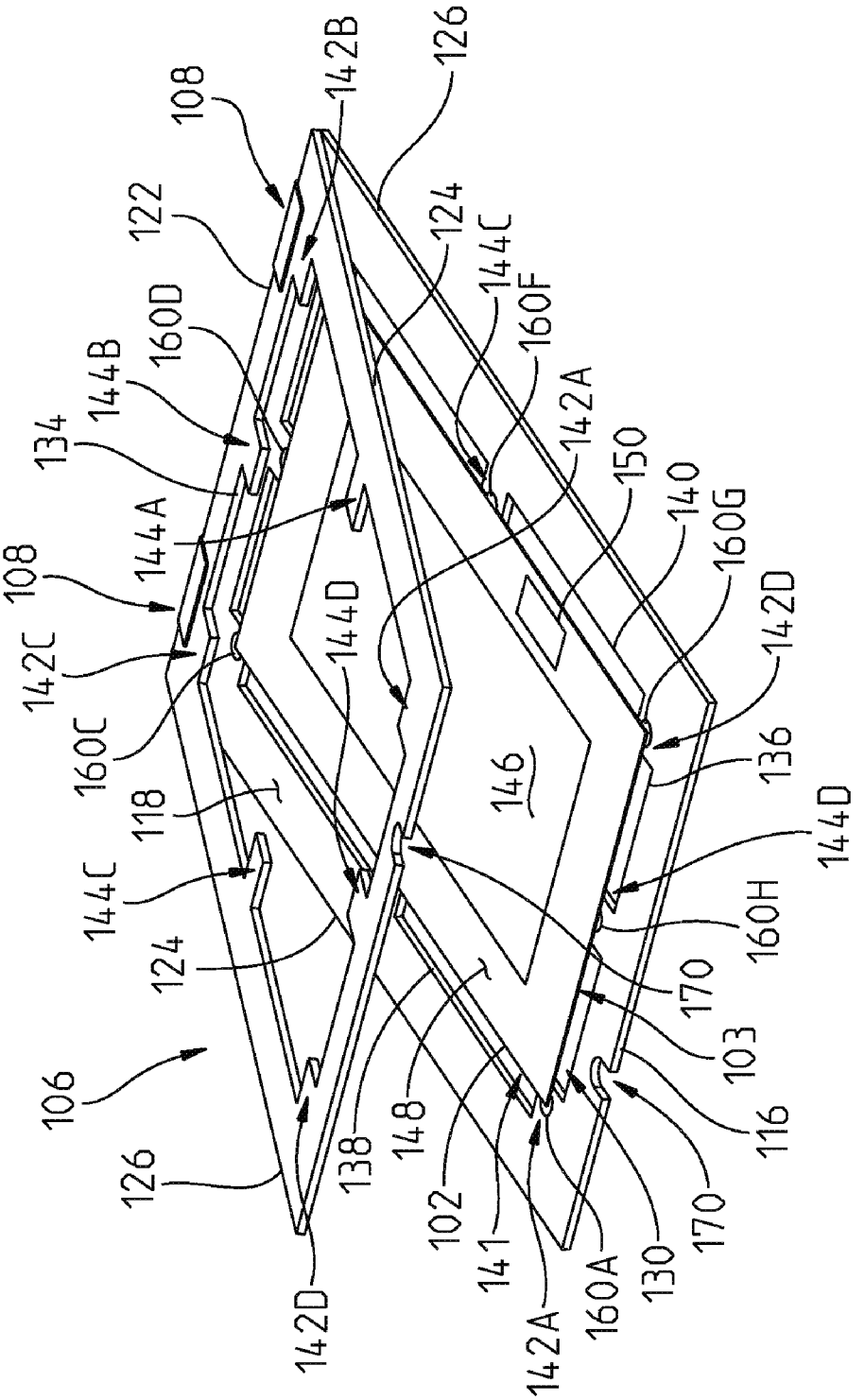

108
142B
126
122
124
144C
160D
160F
144B
134
142A
144A
150
140
108
160G
142C
144D
142D
160C
118
136
146
144D
144C
160H
124
170
103
106
116
126
138
148
102
141
142A
160A
130
170
142D

FIG. 4

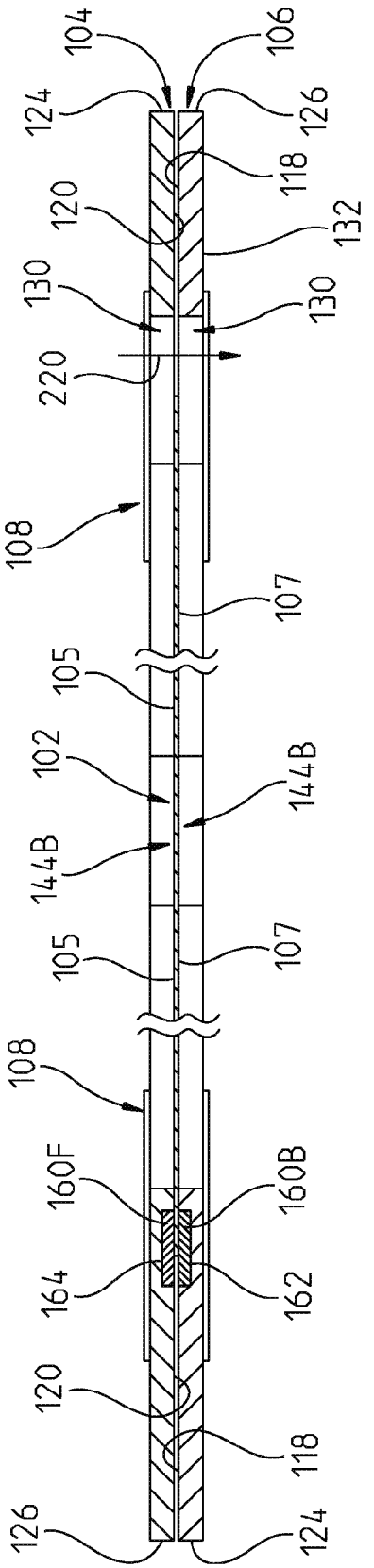

104
106
124
126
118
120
132
130
130
220
108
107
105
102
144B
144B
105
107
108
160F
160B
164
162
120
118
126
124

FIG. 5

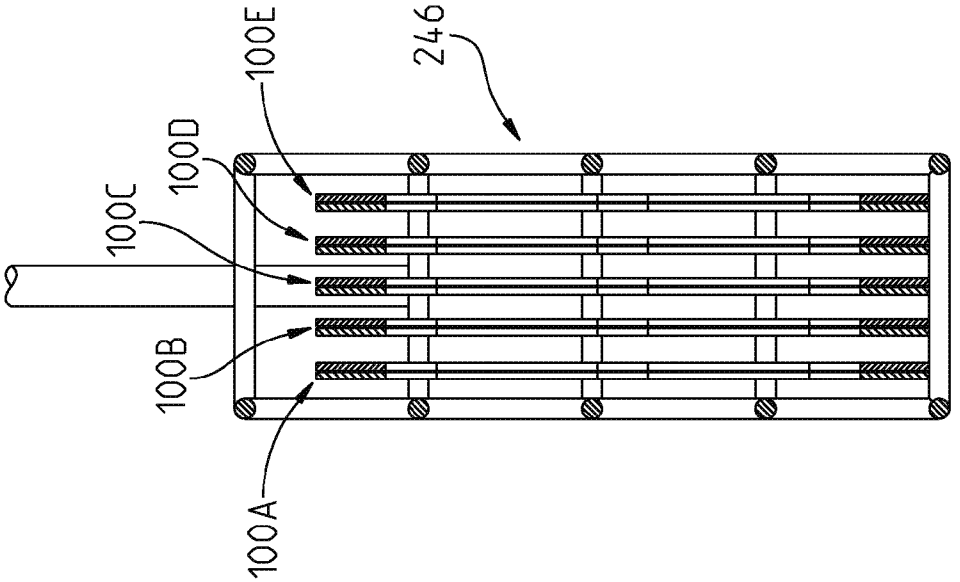

100E
246
100D
100C
100B
100A

FIG. 7A

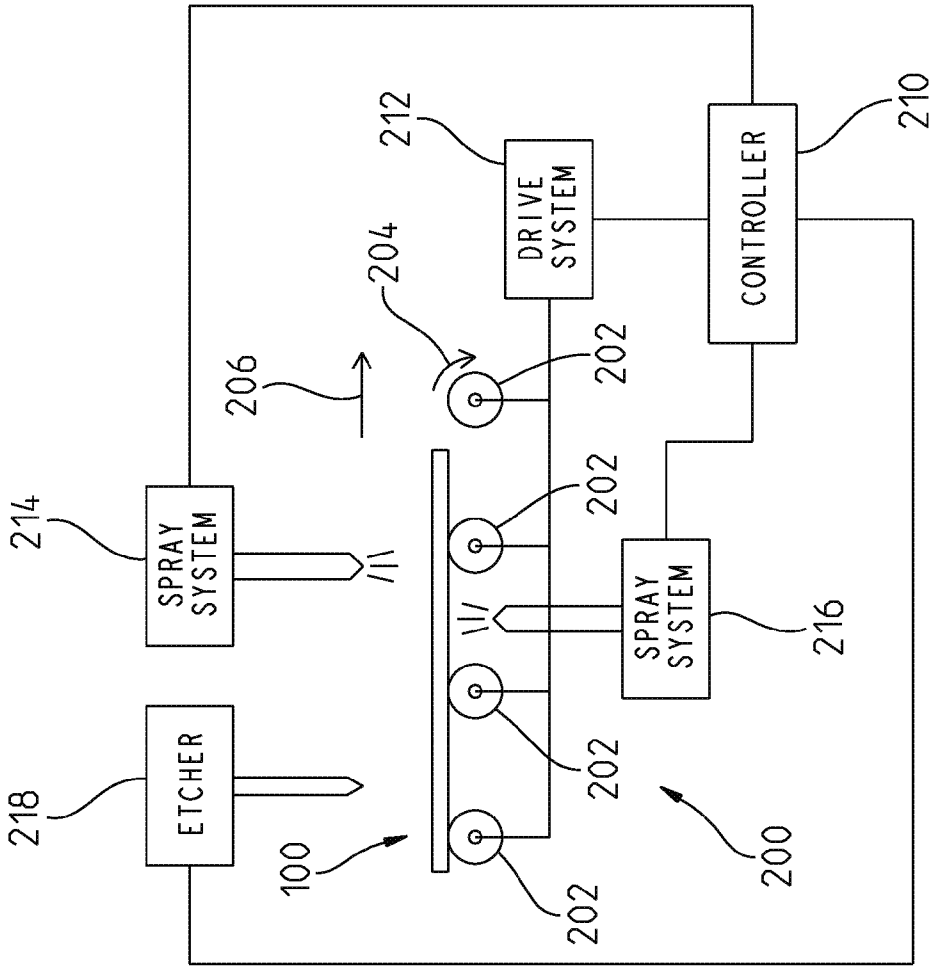

212
DRIVE SYSTEM
210
CONTROLLER
204
206
202
214
SPRAY SYSTEM
216
SPRAY SYSTEM
218
ETCHER
100
200

FIG. 6

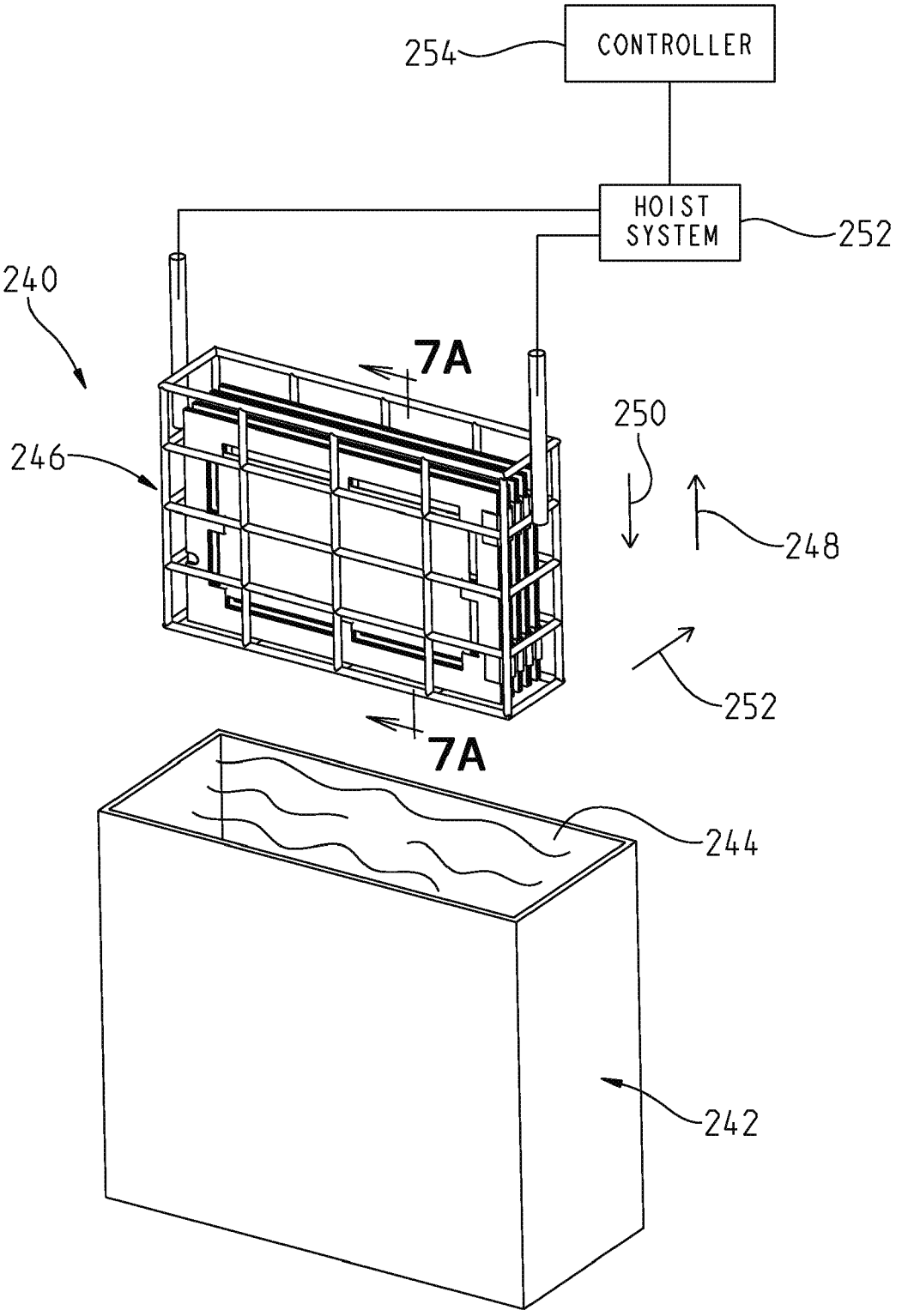

254
CONTROLLER
HOIST SYSTEM
252
240
7A
250
246
248
252
7A
244
242

FIG. 7

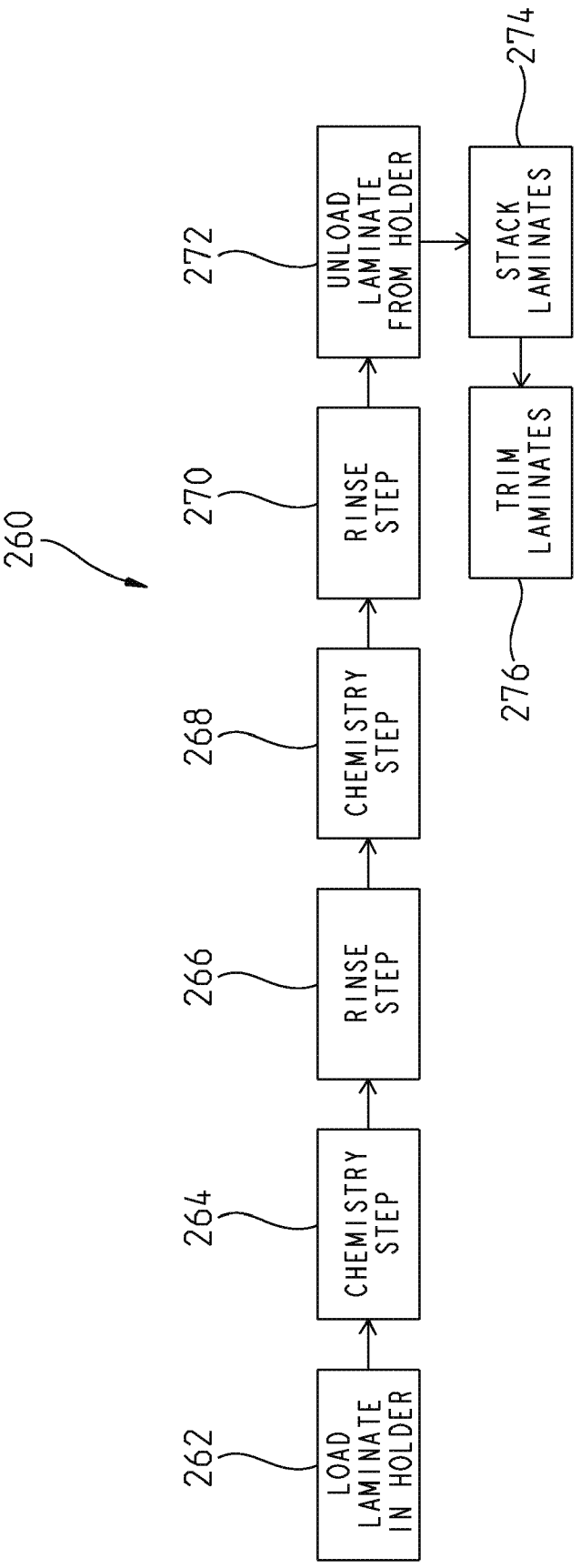

260
262
LOAD LAMINATE IN HOLDER
264
CHEMISTRY STEP
266
RINSE STEP
268
CHEMISTRY STEP
270
RINSE STEP
272
UNLOAD LAMINATE FROM HOLDER
274
STACK LAMINATES
276
TRIM LAMINATES

FIG. 8

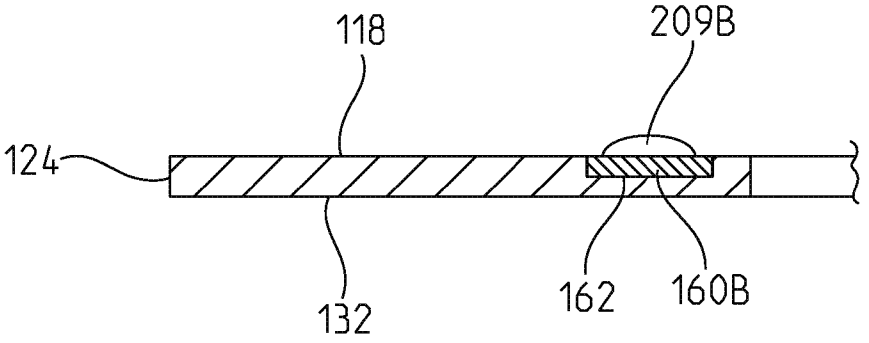

118
209B
124
132
162
160B

FIG. 9

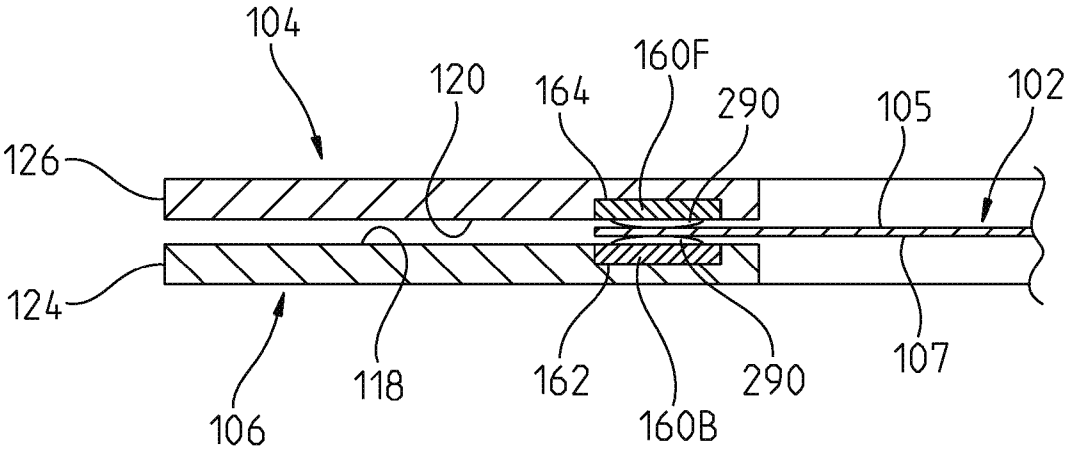

104
120
164
160F
290
105
102
126
124
106
118
162
160B
290
107

FIG. 10

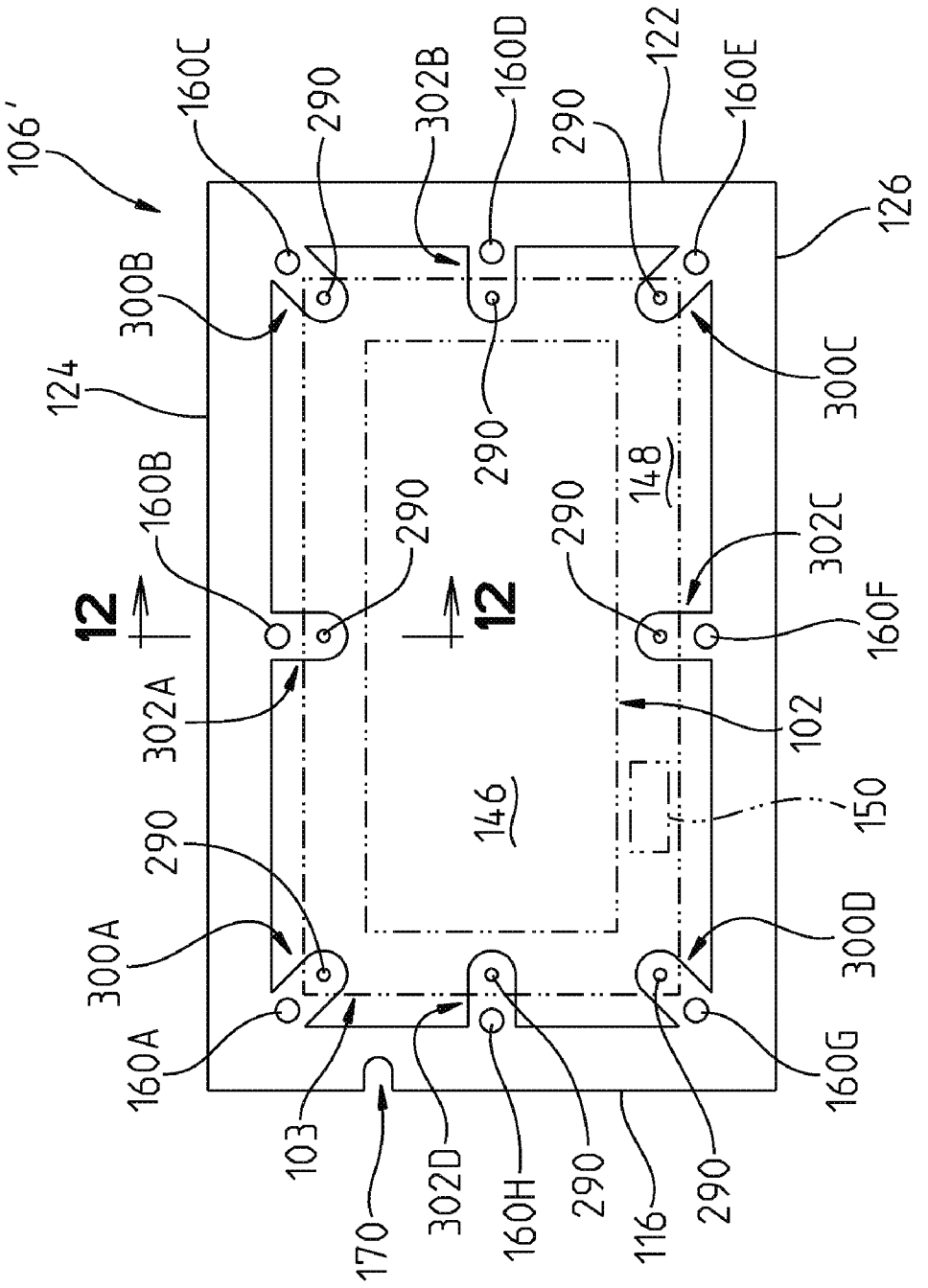

106'
160C
290
302B
160D
290
122
160E
126
300B
124
300C
290
148
160B
290
290
302C
12
12
160F
302A
102
146
150
290
300A
300D
160A
160G
103
170
302D
160H
290
116
290

FIG. 11

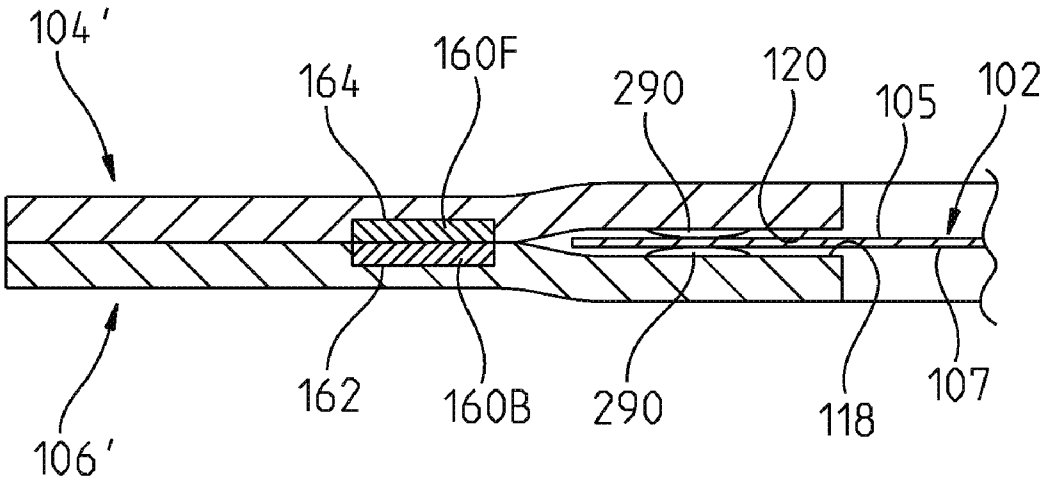


FIG. 12

FRAME FOR HOLDING LAMINATE DURING PROCESSING

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

The invention described herein was made in the performance of official duties by employees of the Department of the Navy and may be manufactured, used and licensed by or for the United States Government for any governmental purpose without payment of any royalties thereon.

BACKGROUND OF THE INVENTION

The present invention relates generally to devices for transporting a flexible article, and, more particularly, to devices for transporting a thin laminate through one or more processing stations.

Flexible articles often need to be held generally flat for various processing operations. An exemplary flexible article is a thin laminate which is processed to be part of a printed circuit board. Referring to FIG. **1**, a plurality of thin laminates **10**A-D are shown. These laminates **10** are stacked and coupled together to form a printed circuit board **12**. In some circuit boards **12** between 10 and 20 laminates **10** are stacked together to form the circuit board **12**. As is known, each of laminates **10** may be processed to provide electrical connections and components on the laminate **10**. Further, the electrical connections for a given laminate may be connected to the electrical connections of other laminates **10** in the final printed circuit board **12**.

Printed Circuit Board (PCB) fabrication involves a sequence of process steps that are performed on the thin laminates **10**. The type and number of steps depends on the complexity of the PCB being fabricated, however, most if not all multilayer PCB boards will require a photolithography operation and an surface treatment operation.

Photolithography involves coating a copper-clad laminate with a thin photosensitive film called photoresist. After coating the laminate, it is placed in an exposure unit, where areas of the photoresist can be exposed with light to polymerize that area. Other areas of the laminate which do not receive the light will remain unpolymerized. The next step, commonly known as DES (Develop/Etch/Strip), is where unexposed photoresist will be washed away (Develop), the copper will be etched (Etch), and the remaining exposed photoresist will be washed away (Strip). This leaves a circuit pattern of copper left on the laminate which provides electrical connections for the PCB.

The developer portion of DES will subject the photoresist covered laminate to a caustic solution, typically potassium carbonate. Any unpolymerized photoresist is broken down and rinsed away leaving a polymerized photoresist pattern on the laminate which protects the copper underneath. Upon exiting the developer processing machine, the laminate may be inserted into a copper etching machine wherein exposed copper is etched by a Cupric Chloride or Ammoniacal solution. The copper which is protected by the polymerized photoresist remains unharmed. Upon exiting the etcher processing machine, the laminate is rinsed and transported into a photoresist stripping machine which exposes the laminate to an aggressive base solution. In the photoresist stripping machine, the photoresist's molecular bonds produced during the exposure step are torn apart and rinsed away leaving the copper circuit image on the laminate.

Often times a single machine performs the DES processes. One such machine is a horizontal conveyorized spray line in which laminates are supported by rollers which pass the laminate from roller to roller as they rotate. A laminate which is thick spans across the rollers, even while getting sprayed by solution from sprayers located above and below the rollers. However, thin laminates often cannot span from one roller to the next because they are too flimsy. This results in the front edge of a thin laminate commonly falling between the rollers. Rollers that are closer together will transport a thin laminate, but the presence of the rollers themselves will block the sprayer reducing the likelihood of adequate solution coverage. This results in the circuit image being incorrect. In one example, s-wheels may be added to the conveyor to reduce the amount of blockage of the thin laminate relative to the spray.

PCB process engineers often advise operators to use adhesive tape to fasten a thin laminate to an item commonly referred to as a leader board. The leader board will pull or tow the thin laminate through a conveyor. The leader board does not get caught in the rollers because it is thicker and more rigid. An exemplary leader board is a thicker dielectric. A problem with using the leader board is that the tape must be removed from the thin laminate at the end of the conveyor. This takes time and care because the operator must ensure that the thin laminate is not distorted when the tape is removed. In another example, the thin laminate is taped to a frame member which is thicker than the thin laminate. The thin laminate is typically taped at each of the of four corners. Once again, the tape must be removed at the end of the processing which takes operator time and may distort the thin laminate.

Another step in fabricating printed circuit boards after the circuit pattern is etched on a laminate is surface treatment (commonly called oxide coating). The practice of surface treatment promotes better adhesion between laminates when pressed together to form a PCB. The surface treatment is typically accomplished with a vertical dip tank, but may be accomplished with horizontal conveyor lines, as well. A single dip tank typically holds about 50 gallons of solution. Processes that require a series of solutions will have a line of dip tanks, each tank containing a solution for cleaning, coating, or rinsing the part. An automated hoist system may be employed to move a laminate from tank to tank and to leave the laminate in a given tank a preset amount of time.

The hoist system includes a basket into which multiple laminates are loaded. The laminates must be kept separated during the dipping process. This is not a problem with thick laminates. A problem for thin laminates is that during dipping laminates do not remain flat. Warping of the thin laminate will occur, and the mechanical agitation of the solution will cause waviness for the thin laminate. To counter this, the thin laminate may be taped to a frame made of a thicker dielectric. However, this once again causes additional operator time and potential damage to the thin laminate when the tape is removed. Further, if multiple thin laminates are nearby in the same basket, the thin laminates will tend to stick together by natural fluid adhesion. This disrupts fluid from passing along the surface of the thin laminate and therefore causes the coating of thin laminate to be uneven or inconsistent.

SUMMARY OF THE INVENTION

In an exemplary embodiment of the present disclosure, an apparatus for holding a flexible article is provided. In another exemplary embodiment of the present disclosure, an apparatus for holding a flexible article is provided wherein the flexible article is held between a plurality of frame members. In yet another exemplary embodiment of the present disclosure, an apparatus for holding a flexible article is provided

wherein the flexible article is held between a plurality of frame members which are held together through magnets.

In still another exemplary embodiment, an apparatus for holding a flexible article is provided. The apparatus comprising: a first frame member having an outer periphery and an inner periphery, the inner periphery of the first frame member defining a window of the first frame member; a second frame member having an outer periphery and an inner periphery, the inner periphery of the second frame member defining a window of the second frame member, the second frame member being rotatably coupled to the first frame member and movable between an opened position relative to the first frame member and a closed position relative to the first frame member; a first plurality of magnets coupled to the first frame member and spaced around the window of the first frame member; and a second plurality of magnets coupled to the second frame member and spaced around the window of the second frame member, the first plurality of magnets and the second plurality of magnets cooperating to hold the second frame member in the closed position relative to the first frame member.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description when taken in conjunction with the accompanying drawings.

FIG. **1** is a representative view of a printed circuit board formed from a plurality of thin laminates;

FIG. **2** illustrates a thin laminate being positioned in a holder which holds the thin laminate;

FIG. **3** illustrates the thin laminate of FIG. **2** positioned on top of a lower frame member of the holder of FIG. **2**;

FIG. **4** illustrates a perspective view of the thin laminate of FIG. **2** positioned in the holder of FIG. **2**;

FIG. **5** is a sectional view along lines **5-5** in FIG. **3** through both an upper frame member (not shown in FIG. **3**), the thin laminate, and the lower frame member;

FIG. **6** illustrates the holder of FIG. **2** with a thin laminate being transported through an exemplary horizontal conveyor system;

FIG. **7** illustrates the holder of FIG. **2** with a thin laminate being transported through an exemplary vertical dip system;

FIG. **7A** is a sectional view along lines **7A-7A** in FIG. **7**;

FIG. **8** is a representative processing sequence of using the holder of FIG. **2** in the manufacture of a printed circuit board;

FIG. **9** illustrates a standoff added to the lower frame member of the holder of FIG. **2**;

FIG. **10** illustrates a portion of the sectional view of FIG. **5** including the standoffs of FIG. **9**;

FIG. **11** illustrates a top view of a lower frame member having supports which include standoffs spaced apart from magnets; and

FIG. **12** is a sectional view along lines **12-12** in FIG. **11** through both an upper frame member (not shown in FIG. **11**), the thin laminate, and the lower frame member.

Corresponding reference characters indicate corresponding parts throughout the several views. Although the drawings represent embodiments of various features and components according to the present disclosure, the drawings are not necessarily to scale and certain features may be exaggerated in order to better illustrate and explain the present disclosure. The exemplification set out herein illustrates embodiments of the invention, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE DRAWINGS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings, which are described below. The embodiments disclosed below are not intended to be exhaustive or limit the invention to the precise form disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art may utilize their teachings. It will be understood that no limitation of the scope of the invention is thereby intended. The invention includes any alterations and further modifications in the illustrated devices and described methods and further applications of the principles of the invention which would normally occur to one skilled in the art to which the invention relates.

Referring to FIG. **2**, a holder **100** for supporting a flexible article **102** is shown. An exemplary flexible article **102** is a thin laminate **10** which is processed to form a layer of PCB **12**. As used herein the term thin laminate **10** is defined to be a flexible article having a thickness of up to 125 micrometers. The thin laminate **10** may be used as a portion of a PCB **12**. Exemplary thin laminates include a substrate, a dielectric substrate, an integrated circuit substrate, and any other device processed as a portion of a PCB **12**. In one embodiment, the thin laminate **10** is at least about 8 micrometers thick. In one embodiment, copper is provided on at least one side of thin laminate **10**. In one embodiment, copper is provided on both sides of the thin laminate **10**. In one embodiment, the thin laminate **10** is about 18 inches in length by about 12 inches in width. In one embodiment, the thick laminate is about 24 inches in length and about 18 inches in width.

As shown in FIG. **2**, holder **100** includes a first frame member **104** and a second frame member **106**. First frame member **104** and second frame member **106** are rotatably coupled together. In the illustrated embodiment, first frame member **104** and second frame member **106** are coupled together along their respective top edges with an adhesive tape **108**. In alternative embodiments, first frame member **104** and second frame member **106** may be rotatably coupled together through a hinge or other suitable devices for coupling first frame member **104** and second frame member **106**.

In one embodiment, the thickness of first frame member **104** and second frame member **106** are selected to provide adequate rigidity to the thin laminate while still being able to pass through the horizontal conveyor system. In one embodiment, first frame member **104** and second frame member **106** are both approximately 0.050 inches thick. In one embodiment, first frame member **104** and second frame member **106** are each at least about 10 times the thickness of flexible article **102**. In one embodiment, first frame member **104** and second frame member **106** are each at least about 160 times the thickness of flexible article **102**. In one embodiment, first frame member **104** and second frame member **106** are each between about 10 times to about 160 times the thickness of flexible article **102**. In one embodiment, first frame member **104** and second frame member **106** are made of epoxy woven glass.

Assuming that an operator is holding second frame member **106** stationary, first frame member **104** may be moved in direction **110** to bring a lower edge **114** of first frame member **104** proximate to a lower edge **116** of second frame member **106**. First frame member **104** may be moved in direction **112**

to separate lower edge **114** of first frame member **104** from lower edge **116** of second frame member **106**.

Referring to FIG. **3**, a top view of second frame member **106** is shown. The layout of second frame member **106** and first frame member **104** are identical. Upper surface **118** of second frame member **106** matches lower surface **120** of first frame member **104**. As shown in FIG. **3**, second frame member **106** is generally rectangular in shape having a top edge **122**, a lower edge **116**, a first side edge **124**, and a second side edge **126**. Although shown as being generally rectangular, second frame member **106** may have any suitable shape.

Second frame member **106** further includes a window **130**. As shown in FIG. **5**, window **130** extends completely through second frame member **106** from upper surface **118** to lower surface **132**. Window **130** includes a top edge **134**, a lower edge **136**, a first side edge **138**, and a second side edge **140**. Top edge **134**, lower edge **136**, first side edge **138**, and second side edge **140** define a portion of a periphery **141** of window **130**. Periphery **141** is larger than a periphery **103** of flexible article **102**.

Second frame member **106** includes a plurality of corner supports **142**A-D which extend inwardly. As shown in FIG. **3**, corner supports **142**A-D support respective corners of flexible article **102**. Second frame member **106** further includes a plurality of side supports **144**A-D which extend inwardly. As shown in FIG. **3**, side supports **144**A-D support respective sides of flexible article **102**. A single support **144** is shown for each respective side of window **130**. In the illustrated embodiment, each of support **144** is centered between two of supports **142**. In one embodiment, more than one supports **144** are provided for at least one of top edge **134**, lower edge **136**, first side edge **138**, and second side edge **140**. In one embodiment, supports **142** are replaced with additional supports **144**.

In one embodiment, a maximum separation between adjacent supports is about 12 inches (either between one of supports **142** and one of supports **144**, or between two of supports **142**, or between two of supports **144**). In one embodiment, a maximum separation between adjacent supports is about 9 inches (either between one of supports **142** and one of supports **144**, or between two of supports **142**, or between two of supports **144**). In one embodiment, a separation between adjacent supports is up to about 12 inches (either between one of supports **142** and one of supports **144**, or between two of supports **142**, or between two of supports **144**). In one embodiment, a separation between adjacent supports is up to about 9 inches (either between one of supports **142** and one of supports **144**, or between two of supports **142**, or between two of supports **144**).

As shown in FIG. **3**, each of supports **142** and supports **144** support an outer portion of flexible article **102**. Flexible article **102** is generally divided into two portions, an inner portion **146** and an outer portion **148**. Inner portion **146** includes the space of flexible article **102** which is to be processed for use as part of a PCB **12**. Outer portion **148** includes one or more coupon regions **150**. which provide space for registration coupons and test coupons to be provided on flexible article **102**. Generally in the manufacture of PCB **12**, outer portion **148** is removed during processing.

First frame member **104** and second frame member **106** further include a plurality of magnets **160**. Illustratively eight magnets **160**A-H are shown for second frame member **106**. First frame member **104** also includes eight magnets **160**A-H. In one embodiment, one of first frame member **104** and second frame member **106** includes a plurality of magnets **160** while the other of first frame member **104** and second frame member **106** is made of a ferromagnetic material. Exemplary ferromagnetic materials include iron, steel, stainless steel, or other suitable materials which magnetically couple with magnets **160**.

Referring to FIG. **5**, flexible article **102** is sandwiched between magnet **160**B of second frame member **106** and magnet **160**F of first frame member **104**. Each of magnets **160**, illustratively magnet **160**B and magnet **160**F, are received in a respective recess **162** of second frame member **106** and recess **164** of first frame member **104** such magnet **160**B and magnet **160**F, are generally flush with upper surface **118** of second frame member **106** and lower surface **120** of first frame member **104**, respectively. The magnets **160** of first frame member **104** and second frame member **106** are held in their respective recesses with an adhesive or other coupling mechanism. In one embodiment, magnets **160** are about 0.5 inches in diameter and have a thickness of about 0.063 inches. In one embodiment, a conformal coating is applied over each magnet **160** and the adjacent portion of the frame to prevent the chemicals used during the processing of flexible article from attacking the magnet. An exemplary conformal coating is a polyurethane coating.

Referring to FIG. **5**, magnet **160**B of second frame member **106** is attracted to magnet **160**F of first frame member **104**. The same is the case for the remainder of the magnets of first frame member **104** and second frame member **106**. As such, when first frame member **104** is rotated in direction **110**, first frame member **104** is held proximate to second frame member **106** due to the attraction of magnets **160**. Further, magnets **160** hold flexible article **102** in place between first frame member **104** and second frame member **106**. In one embodiment, the strength of magnets **160** is at least about 2.7 pounds. In one embodiment, the strength of magnets **160** is about 2.7 pounds. In one embodiment, magnets **160** are permanent magnets. An exemplary permanent magnet is made from an alloy of Neodymium, Iron and Boron. Other types of magnets may be used such as electromagnets, strip magnets, or other types of magnetic devices.

To aid in the separation of first frame member **104** from second frame member **106**, both first frame member **104** and second frame member **106** include a thumb slot **170**, respectively, which permits an operator to push on the other of first frame member **104** and second frame member **106**. Thumb slots **170** give each of first frame member **104** and second frame member **106** a different outside periphery.

Referring to FIG. **6**, holder **100** (holding a flexible article **102**) is shown as it travels through a representative horizontal conveyor system **200**. Horizontal conveyor system **200** includes a plurality of rollers **202** which support holder **100** and which rotate in direction **204** to transport holder **100** in direction **206**. Rollers **202** are arranged in rows which extend back in the page to support holder **100** along its width. Holder **100** prevents flexible article **102** from contacting rollers **202** thereby preventing rollers **202** from making any impressions on flexible article **102**.

The rotational speed of rollers **202** is controlled with a controller **210** which drives a drive system **212**. An exemplary drive system includes a motor and a linkage connecting the motor to the rows of rollers. Exemplary linkages include a chain and sprockets.

Controller **210** also controls one or more of upper spray systems **214** and one or more lower spray systems **216**. Upper spray systems **214** sprays fluid down on holder **100** from above rollers **202**. Lower spray systems **216** sprays fluid up on holder **100** from below rollers **202**. Controller **210** may also control other types of devices in addition to upper spray systems **214** and lower spray systems **216**, such as etcher **218**. An exemplary controller is a microprocessor programmed to

control the operation of upper spray systems **214**, lower spray systems **216**, and etcher **218** while also controlling the speed of rollers **202**. Although an exemplary horizontal conveyor system **200** is shown, holder **100** may work to support flexible article **102** through any type of processing sequence.

Holder **100** provides a rigid holder for flexible article **102** and prevents flexible article **102** from falling between rollers **202**. Further, holder **100** allows a spacing of rollers **202** to be increased. Referring to FIGS. **3** and **5**, holder **100** by having an inner periphery **141** larger than the periphery **103** of flexible article **102**, allows fluid **220** to migrate from an upper surface **105** of flexible article **102** to below a lower surface **107** of flexible article **102**.

Referring to FIG. **7**, holder **100** may also be used to support flexible article **102** when flexible article **102** is being processed in a vertical dip tank system **240**. Vertical dip tank system **240** includes a tank **242** containing a solution **244**. A basket **246** is provided which holds one or more holders **100** in a vertical fashion. Basket **246** permits solution **244** to enter an interior of basket **246** to contact flexible articles **102** and permits solution **244** to exit the interior of basket **246**.

Basket **246** is raised in direction **248** and lowered in direction **250** by a hoist system **252**. Hoist system **252** also transports basket **246** in direction **252** to present the flexible articles **102** in basket **246** to another tank **242** or to an unloading station. Hoist system **252** is controlled by a controller **254**. An exemplary controller is a microprocessor programmed to control the operation of hoist system **252** to move basket **246** in directions **248**, **250**, and **252**. Further, controller **254** controls an amount of time that basket **246** and hence flexible articles **102** are immersed in solution **244**.

Referring to FIG. **7**A, multiple holders **100** may be positioned in basket **246** at the same time. Each of holders **100** are shown being generally vertically disposed. In one embodiment, basket **246** includes individual cradles for holding each of holder **100** generally vertical. However, since flexible article **102** is not flush with an outer surface of holder **100**, holder **100** may be tilted to rest on the side of basket **246** without the flexible article **102** of holder **100** contacting adjacent flexible articles **102**. Further, holder **100** sandwiches flexible article **102** and prevents flexible article **102** from being manipulated by fluid currents in tank **242**.

Referring to FIG. **8**, an exemplary process **260** is shown. Flexible article **102** is loaded into holder **100**, as represented by block **262**. The loading of flexible article **102** into holder **100** may be accomplished as follows. An operator places holder **100** on a flat surface, second frame member **106** resting the flat surface. The operator separates first frame member **104** from second frame member **106**, thereby disengaging all of magnets **160**. The operator then transports flexible article **102** on top of second frame member **106**, ensuring the magnets **160** (or standoff **290** as explained herein) will sandwich flexible article **102** once first frame member **104** is brought to rest on second frame member **106**. The operator brings first frame member **104** to rest on second frame member **106**. At this point holder **100** may be lifted off of the flat surface.

Returning to FIG. **8**, flexible article **102** is then passed through a plurality of chemistry steps and rinse steps, as represented by blocks **264-270**. The plurality of chemistry steps and rinse steps may be performed through a conveyorized spray line (such as represented in FIG. **6**), a series of dip tanks full of solution (as represented in FIG. **7**) or combination thereof. In one embodiment, the hinged end of holder **100** is loaded first into a conveyorized spray line to reduce the likelihood that first frame member **104** will become separated from second frame member **106** as holder **100** passes through the conveyorized spray line. Holder **100** also keeps the respective flexible article **102** separated, if the holders **100** are stacked to transport a plurality of flexible articles **102** from one conveyorized system or dip system to another conveyorized system or dip system.

Flexible article **102** is unloaded from holder **100**, as represented by block **272**. Holder **100** does not physically adhere to flexible article **102** like an adhesive would. As such, when first frame member **104** is rotated away from second frame member **106** the operator may easily remove a clean flexible article **102** from holder **100**. A plurality of flexible articles **102** are stacked together and pressed, as represented by block **274**. The outer region of flexible article **102** is trimmed, as represented by block **276**.

The chemistry steps **264** and **268** may be any suitable processing steps for altering the flexible article, such as a developer step, an etcher step, a stripper step, or any other suitable steps.

Referring to FIG. **9**, in one embodiment, a standoff **290** is provided on top of magnets **160**. In one embodiment, standoff **290** is made of silicone. In one embodiment, standoff **290** is made of rubber. In one embodiment, standoff **290**, in an uncompressed state as shown in FIG. **9**, has a height of about 0.125 inches. Each of magnet **160**A-H has an associated standoff **290**.

Referring to FIG. **10**, flexible article **102** is shown sandwiched between first frame member **104** and second frame member **106** when first frame member **104** and second frame member **106** both include standoffs **290**. As shown in FIG. **10** when compared to FIG. **5**, standoffs **290** provide a gap between lower surface **120** of first frame member **104** and upper surface **105** of flexible article **102** and a gap between upper surface **118** of second frame member **106** and lower surface **107** of flexible article **102**. These gaps facilitate in the draining of fluid from between first frame member **104** and second frame member **106**.

Referring to FIG. **11**, another version of second frame member **106'** is shown. A second version of first frame member **104'** is also provided. First frame member **104'** is identical to second frame member **106'**. Second frame member **106'** includes a plurality of corner supports **300**A-D which extend inward. As shown in FIG. **11**, corner supports **300**A-D support respective corners of flexible article **102** on standoff **290**. Second frame member **106** further includes a plurality of side supports **302**A-D which extend inward. As shown in FIG. **11**, side supports **302**A-D support respective sides of flexible article **102** on standoffs **290**. A single support **302** is shown for each respective side of window **130**. In the illustrated embodiment, each of supports **302** are centered between two of supports **300**. In one embodiment, more than one support **302** is provided for at least one of top edge **134**, lower edge **136**, first side edge **138**, and second side edge **140**. In one embodiment, supports **300** are replaced with additional supports **302**.

In one embodiment, a maximum separation between adjacent supports is about 12 inches (either between one of supports **300** and one of supports **302**, or between two of supports **300**, or between two of supports **302**). In one embodiment, a maximum separation between adjacent supports is about 9 inches (either between one of supports **300** and one of supports **302**, or between two of supports **300**, or between two of supports **302**). In one embodiment, a separation between adjacent supports is up to about 12 inches (either between one of supports **300** and one of supports **302**, or between two of supports **300**, or between two of supports **302**). In one embodiment, a separation between adjacent supports is up to

about 9 inches (either between one of supports **300** and one of supports **302**, or between two of supports **300**, or between two of supports **302**).

In one embodiment, the width of supports **300** and supports **302** are about twice the diameter of magnets **160**. In one embodiment, magnets **160** are about 0.5 inches in diameter and about 0.063 inches in thickness. In one embodiment, each of standoffs **290** are at least about 0.375 inches from an edge of the respective supports **300** and supports **302**. In one embodiment, each of standoffs **290** are at least about 0.5 inches from an edge of the respective supports **300** and supports **302**.

In one embodiment, magnets **160** are positioned as shown in FIG. **11**, at the intersection of the main body of second frame member **106** and the respective supports **300** or supports **302**. In one embodiment, magnets **160** may be contained solely in the body portion of second frame member **106**. In one embodiment, magnets **160** may be contained solely in supports **300** or supports **302** of second frame member.

While this invention has been described as having an exemplary design, the present invention may be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

The invention claimed is:

1. A method of transporting a flexible article, the method comprising the steps of:

supporting the flexible article on a first frame member which supports a portion of a periphery of the flexible article at a first side of each corner of said flexible article and a plurality of sections of said first side of said flexible article, each said plurality of sections is between different sets of said corners of said flexible article, wherein said flexible article further comprises an inner section formed within said periphery, said inner section is a section of said flexible article which is to be subjected to processing for use as part of a printed circuit structure and said periphery is to be removed from said flexible article after said processing;

rotatably placing a second frame member relative to the first frame member so that the flexible article is positioned between the first frame member and the second frame member, wherein said second frame is in contact with said flexible article at a second side of each said corner of said flexible article and said plurality of sections of said second side of said flexible article;

magnetically holding the second frame member relative to the first frame member by a plurality of magnetic sections formed in recesses in said first and second frames at each of said corners and each of said plurality of sections, wherein each of said magnetic sections are substantially flush with an adjacent section of said first or second frame where each of said magnetic sections are disposed within a respective one of said recesses, the first frame member having a window to permit access to said first side of the flexible article and the second frame member having a window to permit access to said second side of the flexible article; and

coupling at least one edge of said first and second frame members together to prevent said first and second frame members from moving relative to each other using a releasably coupling structure.

2. The method of claim **1**, wherein said plurality of magnetic sections are formed with a plurality of magnets in one of the first frame member and the second frame member, and the other of the first frame member and the second frame member is made of a ferromagnetic material.

3. The method of claim **1**, wherein the first frame member includes a plurality of compressible standoffs formed on said plurality of magnetic sections and the step of supporting the flexible article on the first frame member includes placing the flexible article on top of the compressible standoffs.

4. The method of claim **3**, wherein the second frame member includes a plurality of compressible standoffs, the flexible article being held between the plurality of compressible standoffs of the first frame member and the plurality of standoffs of the second frame member during the step of magnetically holding the second frame member relative to the first frame member.

5. The method of claim **1**, wherein the first frame member includes a plurality of supports at each of said corners and said plurality of sections extending inwardly and the second frame member includes a plurality of supports extending inwardly and the step of supporting the flexible article on the first frame member includes placing the flexible article on top of the plurality of supports of the first frame member, wherein each one of said recesses are formed in a respective one of each of said plurality of supports, each one of said plurality of magnetic sections are disposed within respective each of said recesses.

6. The method of claim **5**, wherein the flexible article is held between the plurality of supports of the first frame member and the plurality of supports of the second frame member during the step of magnetically holding the second frame member relative to the first frame member.

7. A method of transporting a thin laminate through a conveyor system to process the thin laminate as a part of a printed circuit board, the method comprising the steps of:

installing the thin laminate in a rigid holder comprising a first frame member and a second frame member, said step of installing comprising:

supporting the thin laminate on said first frame member which supports a portion of a periphery of the thin laminate at a first side of each corner of said thin laminate and a plurality of sections of said first side of said thin laminate, each said plurality of sections is between different sets of said corners of said thin laminate, wherein said thin laminate further comprises an inner section formed within said periphery, said inner section is a section of said thin laminate which is to be subjected to processing for use as part of a printed circuit structure and said periphery is to be later removed from said thin laminate after said processing;

rotatably placing said second frame member relative to the first frame member so that the thin laminate is positioned between the first frame member and the second frame member, wherein said second frame is in contact with said thin laminate at a second side of each said corner of said thin laminate and said plurality of sections of said second side of said thin laminate;

magnetically holding the second frame member relative to the first frame member by a plurality of magnetic sections formed in recesses in said first and second frames at each of said corners and each of said plurality of sections, wherein each of said magnetic sections are substantially flush with an adjacent section of said first or second frame where each of said mag-

netic sections are disposed within a respective one of said recesses, the first frame member having a window to permit access to said first side of the thin laminate and the second frame member having a window to permit access to said second side of said thin laminate; and

coupling at least one edge of said first and second frame members together to prevent said first and second frame members from moving relative to each other using a releasable coupling structure;

placing the rigid holder on the conveyor of the conveyor system;

advancing the rigid holder through the conveyor system to expose the thin laminate to at least one chemistry treatment;

removing the rigid holder from the conveyor of the conveyor system; and separating the thin laminate from the rigid holder.

8. The method of claim **7**, wherein the step of magnetically holding the second frame member relative to the first frame member includes the step of:

coating said plurality of magnetic sections with a material which is resistant to fluids used in said processing and the coating contacts the thin laminate.

9. The method of claim **7**, wherein the step of rotatably placing said second frame member relative to the first frame member includes the steps of:

placing the thin laminate between said first frame member and said second frame member, the first frame member being rotatably coupled to the second frame member along a first edge.

10. The method of claim **9**, wherein the first edge is the leading edge of the rigid holder as the rigid holder is advanced through the conveyor system.

11. The method of claim **7**, wherein the step of advancing the rigid holder through the conveyor system to expose the thin laminate to said processing which comprises at least one chemistry treatment includes the steps of:

advancing the rigid holder in a generally horizontal direction; and

spraying a chemical treatment on the thin laminate from a generally vertical direction.

12. The method of claim **7**, wherein the step of advancing the rigid holder through the conveyor system to expose the thin laminate to said processing which comprises at least one chemistry treatment includes the steps of:

advancing the rigid holder in a generally vertical direction; and

spraying a chemical treatment on the thin laminate from a generally horizontal direction.

13. A method of transporting a thin laminate through a vertical dip system to process the thin laminate as a part of a printed circuit board, the method comprising the steps of:

installing the thin laminate in a rigid holder comprising a first frame member and a second frame member, said step of installing comprising:

supporting the thin laminate on said first frame member which supports a portion of a periphery of the thin laminate at a first side of each corner of said thin laminate and a plurality of sections of said first side of said thin laminate, each said plurality of sections is between different sets of said corners of said thin laminate, wherein said thin laminate further comprises an inner section formed within said periphery, said inner section is a section of said thin laminate which is to be subjected to processing for use as part of a printed circuit structure and said periphery is to be later removed from said thin laminate after said processing;

rotatably placing said second frame member relative to the first frame member so that the thin laminate is positioned between the first frame member and the second frame member, wherein said second frame is in contact with said thin laminate at a second side of each said corner of said thin laminate and said plurality of sections of said second side of said thin laminate;

magnetically holding the second frame member relative to the first frame member by a plurality of magnetic sections formed in recesses in said first and second frames at each of said corners and each of said plurality of sections, wherein each of said magnetic sections are substantially flush with an adjacent section of said first or second frame where each of said magnetic sections are disposed within a respective one of said recesses, the first frame member having a window to permit access to said first side of the thin laminate and the second frame member having a window to permit access to said second side of said thin laminate; and

coupling at least one edge of said first and second frame members together to prevent said first and second frame members from moving relative to each other using a releasably coupling structure;

placing the rigid holder in a basket of the vertical dip system along with at least one additional rigid holder holding another thin laminate, the rigid holder and the at least one additional rigid holder keeping the thin laminate and the another thin laminate spaced apart;

positioning the rigid holder in a tank of the vertical dip system to expose the thin laminate to at least one chemistry treatment;

removing the rigid holder from the basket of the vertical dip system; and

separating the thin laminate from the rigid holder.

14. The method of claim **13**, wherein the step of magnetically holding the second frame member relative to the first frame member includes the step of:

coating said plurality of magnetic sections with a material which is resistant to fluids used in said processing and the coating contacts the thin laminate.

15. The method of claim **7**, wherein the first frame member includes a plurality of compressible standoffs formed on said plurality of magnetic sections and the step of supporting the thin laminate on the first frame member includes placing the thin laminate on top of the compressible standoffs.

16. The method of claim **15**, wherein the second frame member includes a plurality of said compressible standoffs, the thin laminate being held between the plurality of compressible standoffs of the first frame member and the plurality of standoffs of the second frame member during the step of magnetically holding the second frame member relative to the first frame member.

17. The method of claim **7**, wherein the first frame member includes a plurality of supports at each of said corners and said plurality of sections extending inwardly and the second frame member includes a plurality of supports extending inwardly and the step of supporting the thin laminate on the first frame member includes placing the thin laminate on top of the plurality of supports of the first frame member, wherein each one of said recesses are formed in a respective one of

each of said plurality of supports, each one of said plurality of magnetic sections are disposed within respective each of said recesses.

18. The method of claim **17**, wherein the thin laminate is held between the plurality of supports of the first frame member and the plurality of supports of the second frame member during the step of magnetically holding the second frame member relative to the first frame member.

19. The method of claim **13**, wherein the first frame member includes a plurality of compressible standoffs formed on said plurality of magnetic sections and the step of supporting the thin laminate on the first frame member includes placing the thin laminate on top of the compressible standoffs.

20. The method of claim **19**, wherein the second frame member includes a plurality of said compressible standoffs, the thin laminate being held between the plurality of compressible standoffs of the first frame member and the plurality of standoffs of the second frame member during the step of magnetically holding the second frame member relative to the first frame member.

21. The method of claim **13**, wherein the first frame member includes a plurality of supports at each of said corners and said plurality of sections extending inwardly and the second frame member includes a plurality of supports extending inwardly and the step of supporting the thin laminate on the first frame member includes placing the thin laminate on top of the plurality of supports of the first frame member, wherein each one of said recesses are formed in a respective one of each of said plurality of supports, each one of said plurality of magnetic sections are disposed within respective each of said recesses.

22. The method of claim **21**, wherein the thin laminate is held between the plurality of supports of the first frame member and the plurality of supports of the second frame member during the step of magnetically holding the second frame member relative to the first frame member.

23. The method of claim **1**, wherein said first frame member further comprises a thumb slot comprising a cutout formed in an outer periphery of said first frame member on one side of said frame member, said thumb slot is adapted to permit an operator to push on said second frame and rotatably move said first and second frame members apart in order to remove said flexible article from said first and second frame.

24. The method of claim **3**, wherein said compressible standoffs are formed with silicone.

25. The method of claim **1**, wherein said first and second frame members are rotatably coupled on one side by a hinge which is adapted to rotatably couple said first and second frame members on said one side.

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