US 20070151213A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2007/0151213 A1**

Butler (43) **Pub. Date: Jul. 5, 2007**

(54) **METHODS FOR MAKING TEMPORARY ELECTRONIC COMPONENT-CARRYING TAPES WITH WEAKENED AREAS**

(76) Inventor: **Michael S. Butler**, Greenleaf, ID (US)

Correspondence Address:
TRASK BRITT, P.C./ MICRON TECHNOLOGY
P.O. BOX 2550
SALT LAKE CITY, UT 84110 (US)

(21) Appl. No.: **11/717,833**

(22) Filed: **Mar. 14, 2007**

Related U.S. Application Data

(63) Continuation of application No. 10/225,829, filed on Aug. 21, 2002.

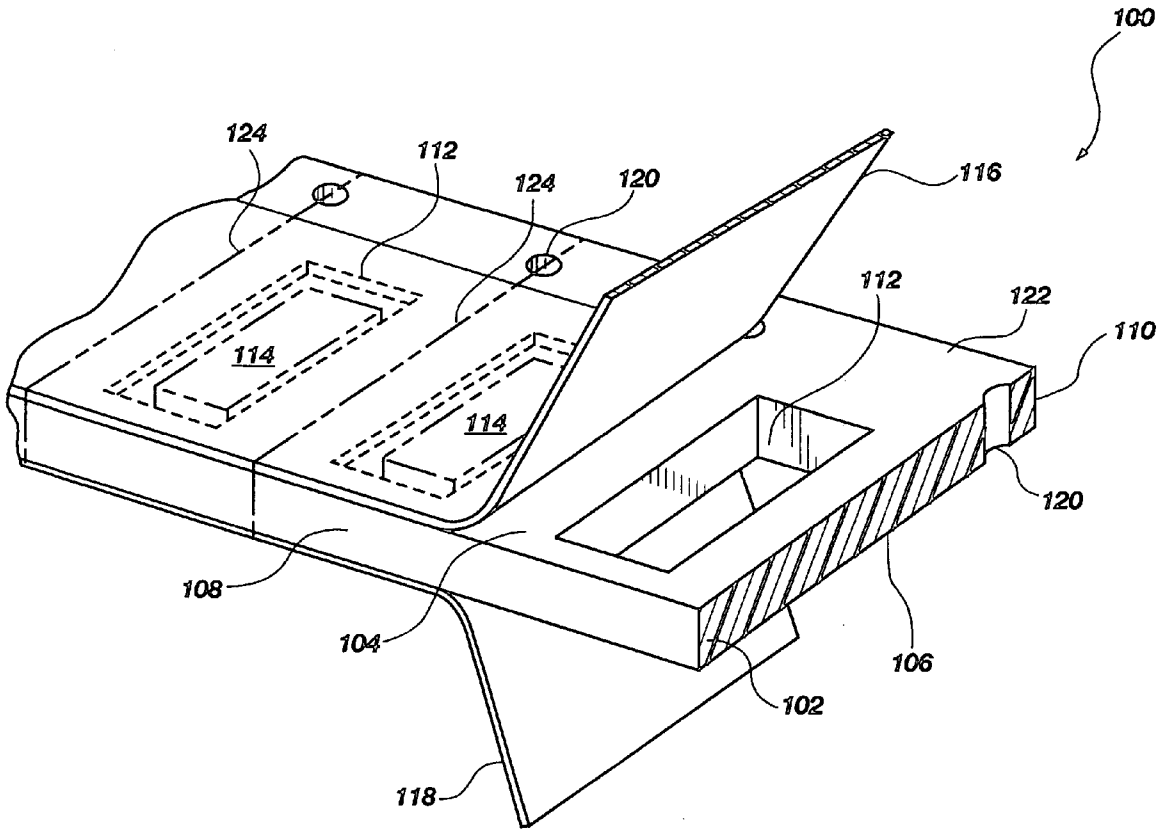
Publication Classification

(51) **Int. Cl.**
B65B 47/00 (2006.01)

(52) **U.S. Cl.** **53/559**

(57) **ABSTRACT**

A method for forming flexible temporary component-carrier tapes, which are used for storing, transporting and supplying components, includes forming apertures for receiving the components in a device-retaining layer, securing a top cover layer to a surface of the device-retaining layer, and securing a bottom layer to an opposite surface of the device-retaining layer. Weakened regions may be formed in one or more of the layers.



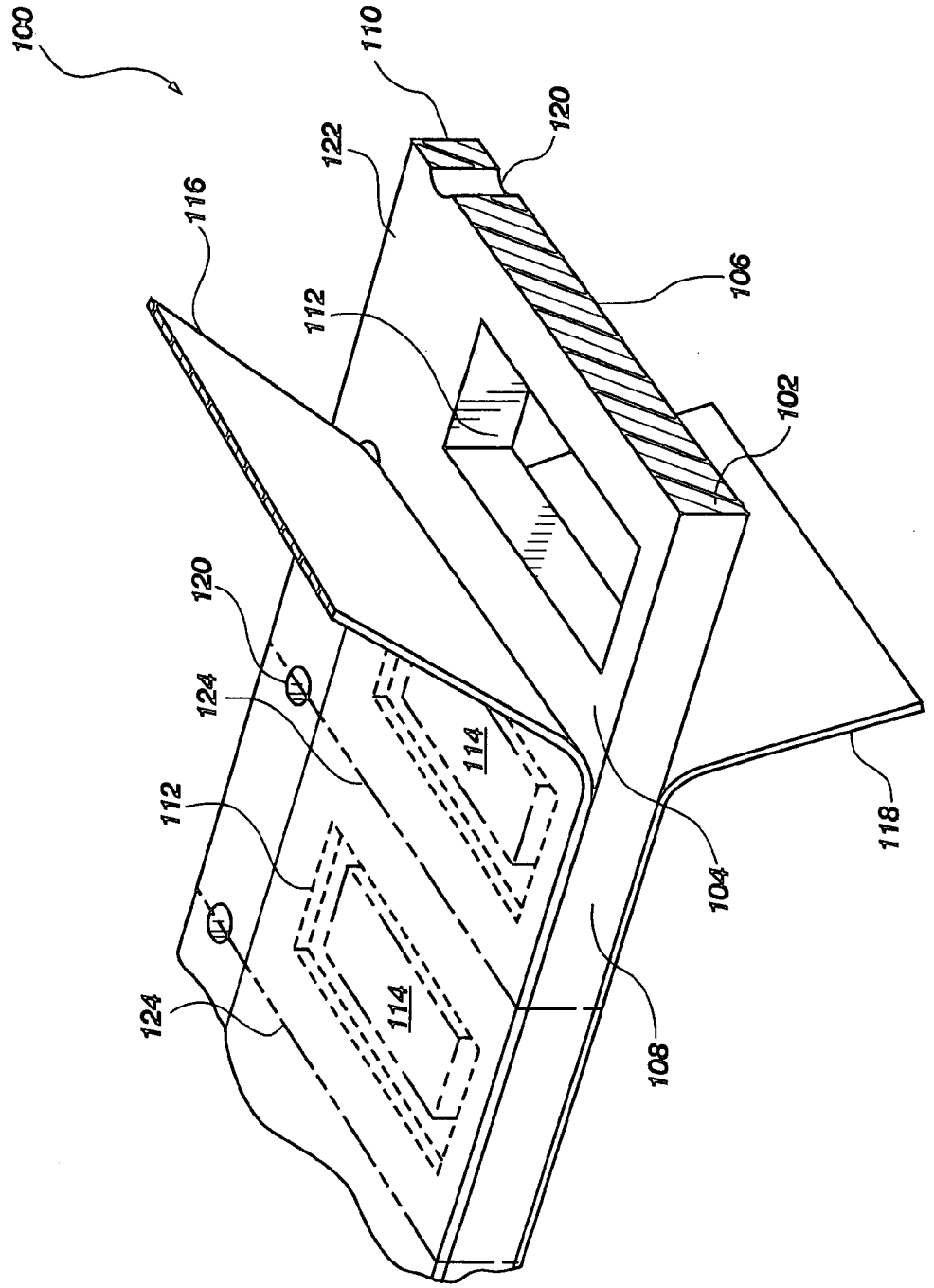

100
110
120
122
116
112
106
102
120
124
114
112
104
118
124
114
108

Fig. 1

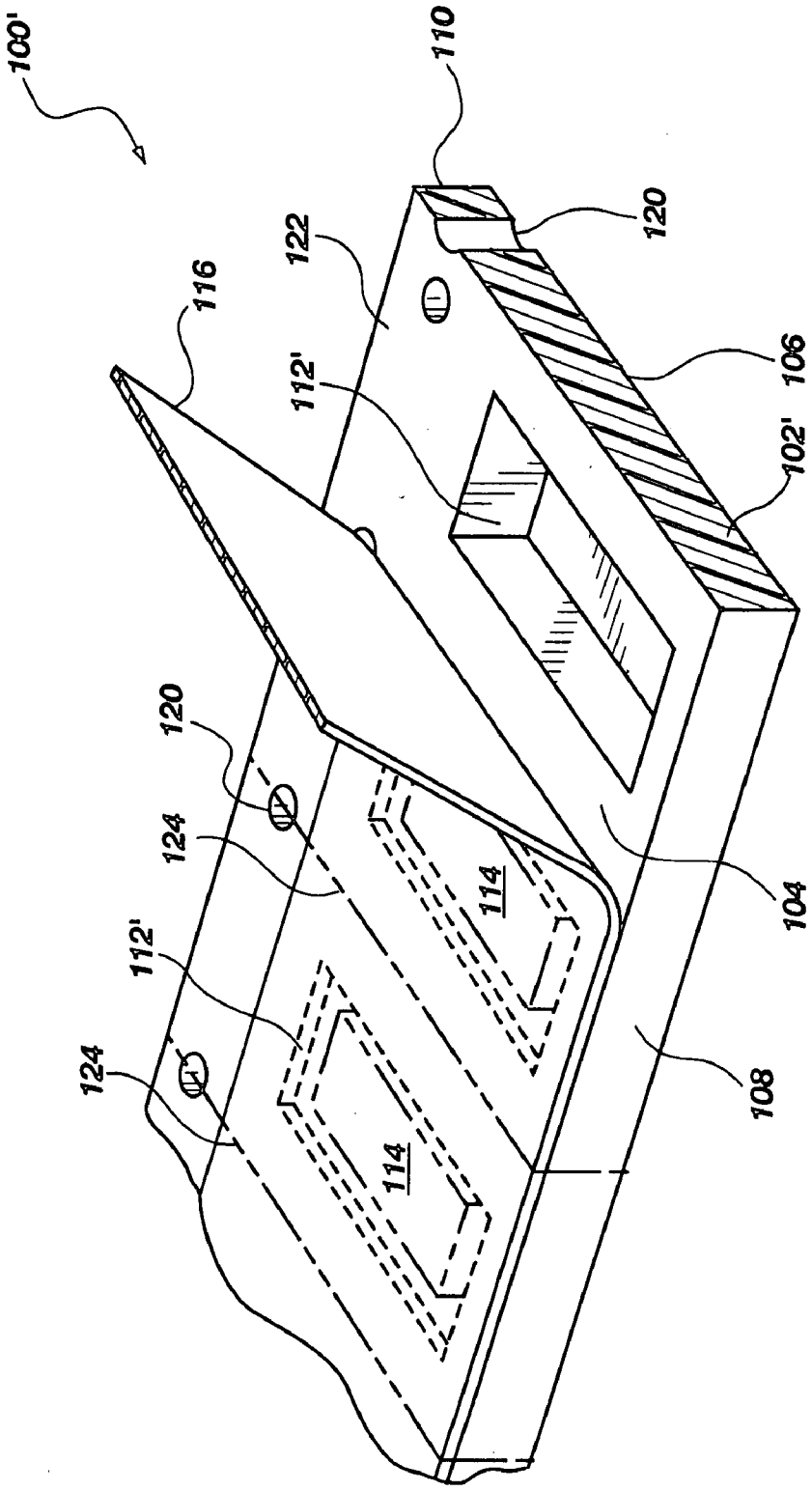


Fig. 2

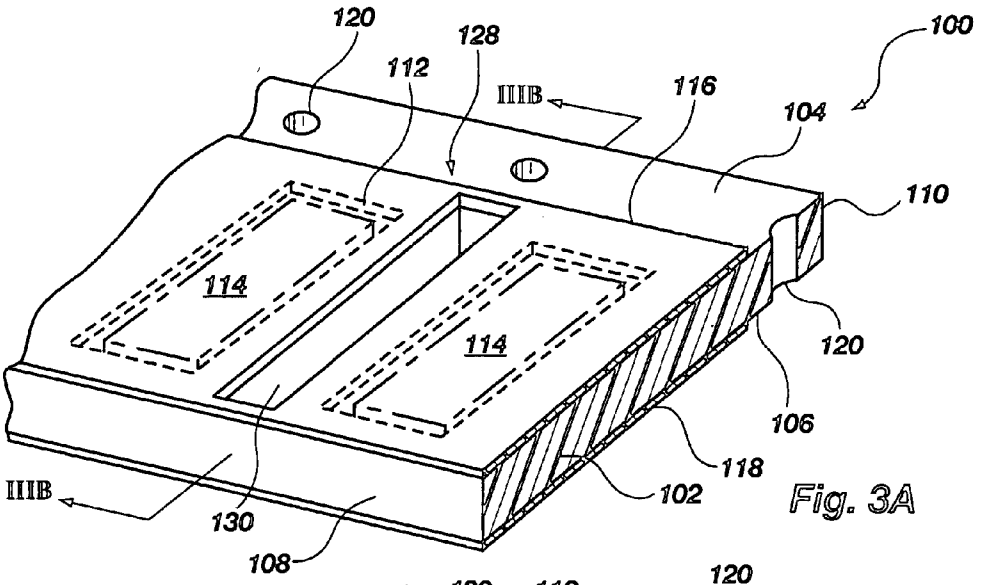


Fig. 3A

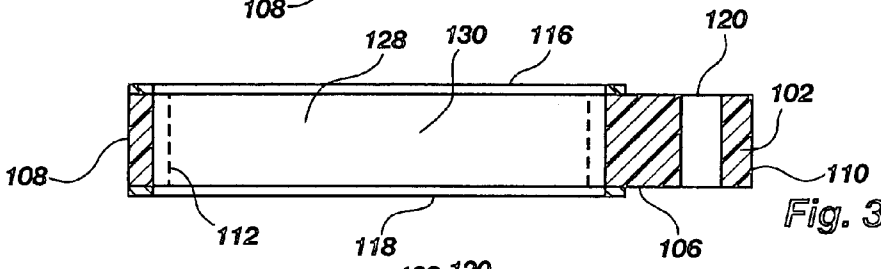


Fig. 3B

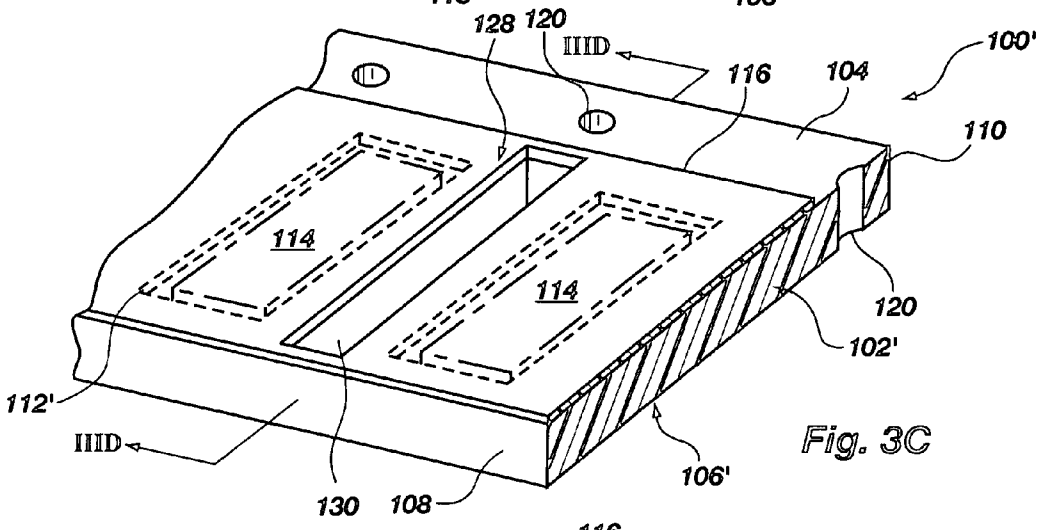


Fig. 3C

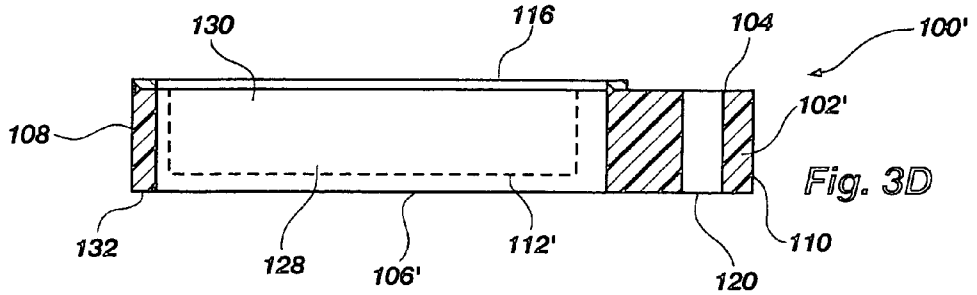


Fig. 3D

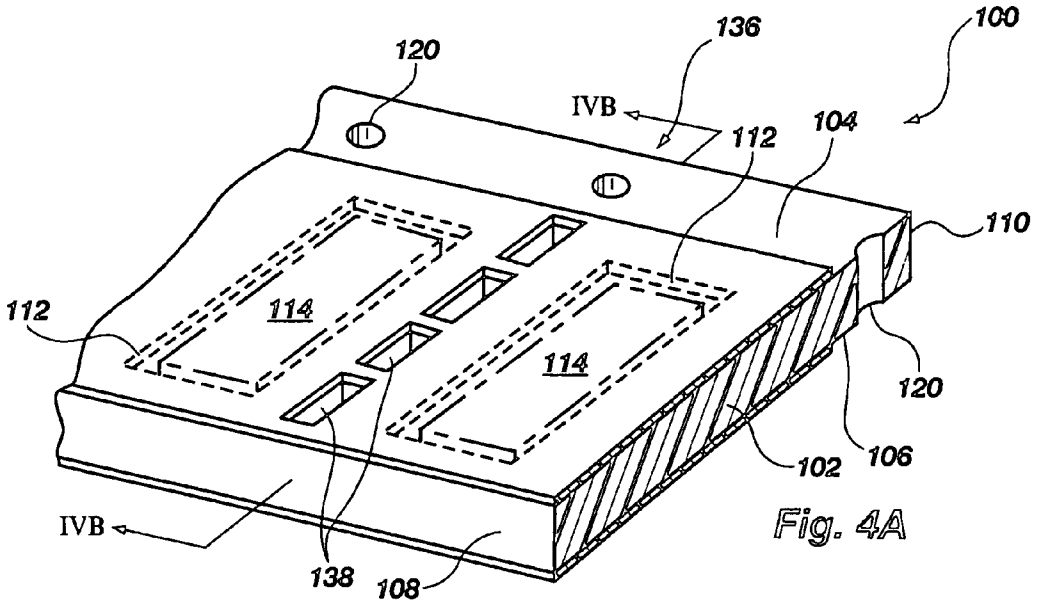


Fig. 4A

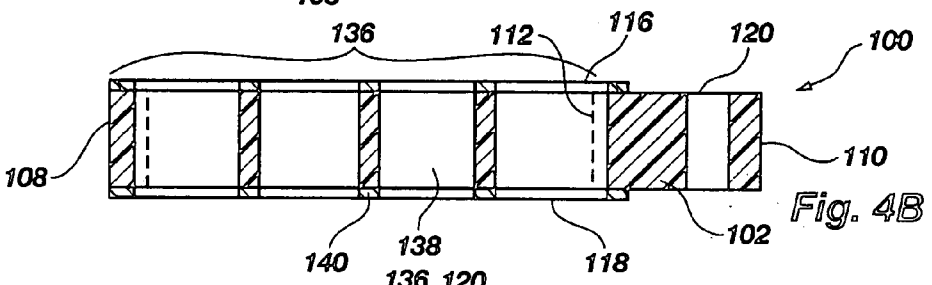


Fig. 4B

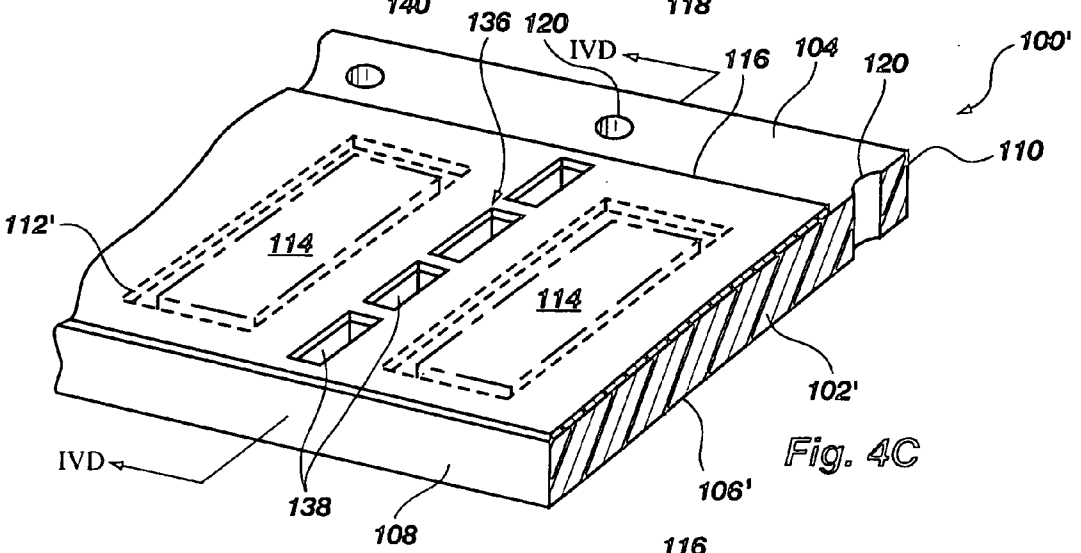


Fig. 4C

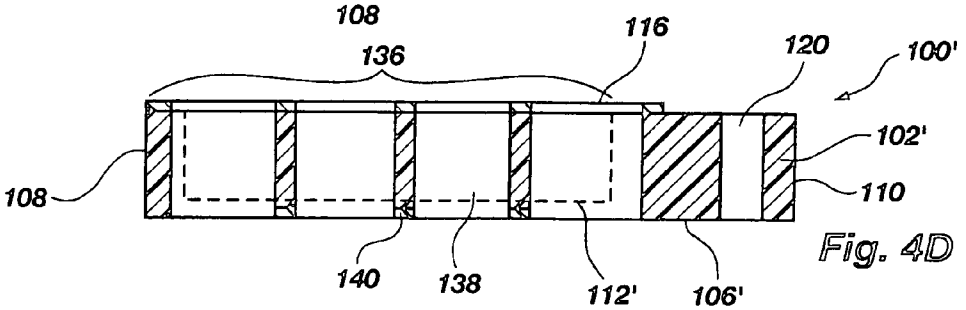


Fig. 4D

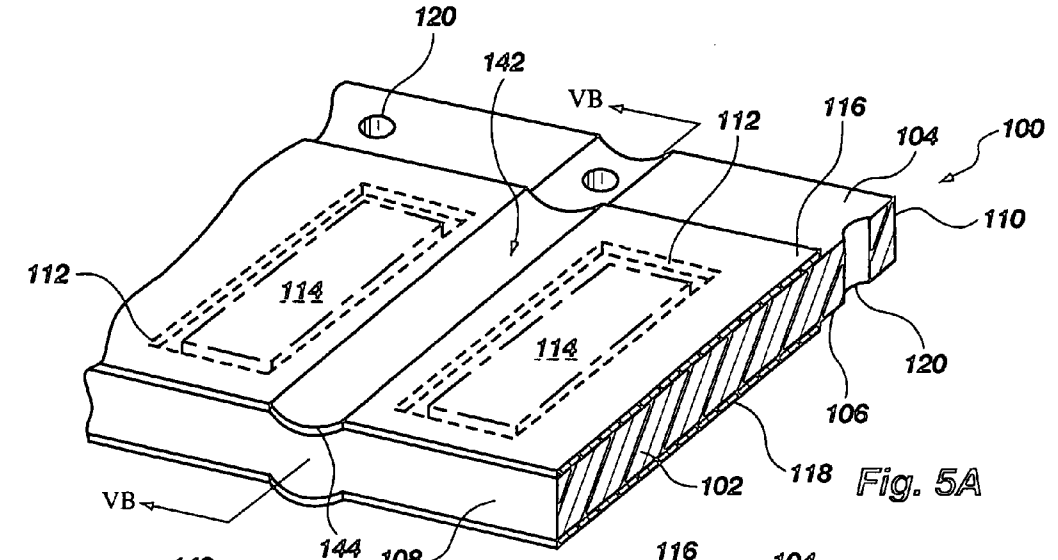


Fig. 5A

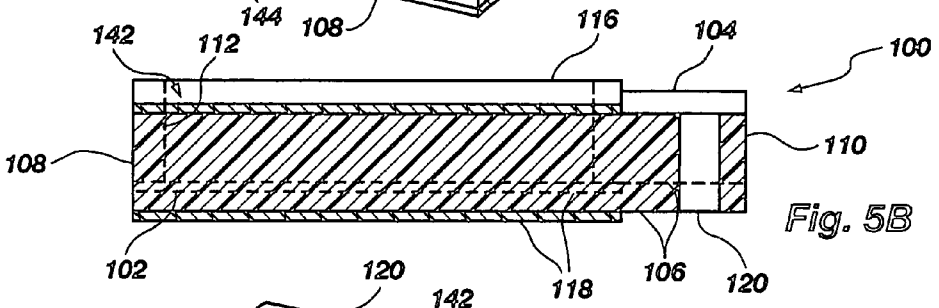


Fig. 5B

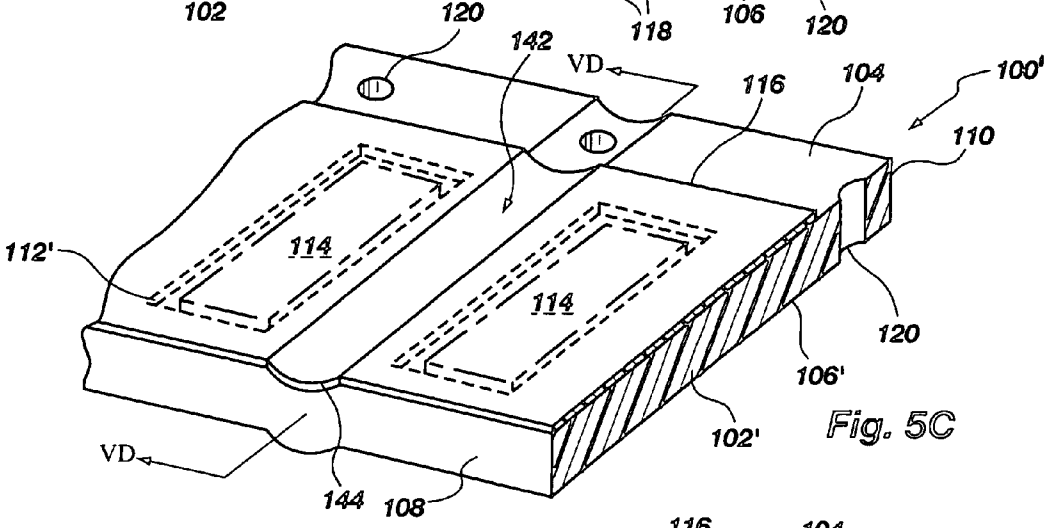


Fig. 5C

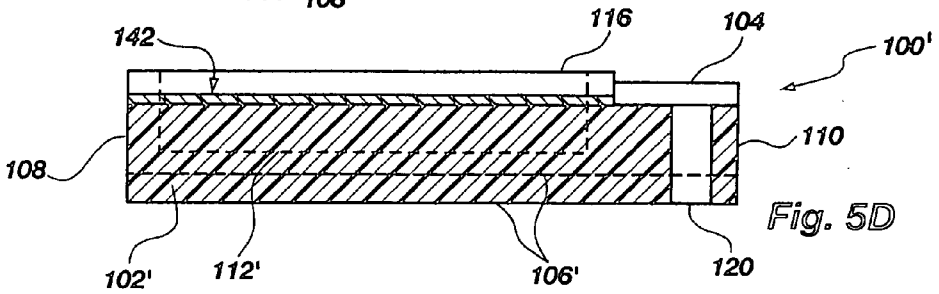


Fig. 5D

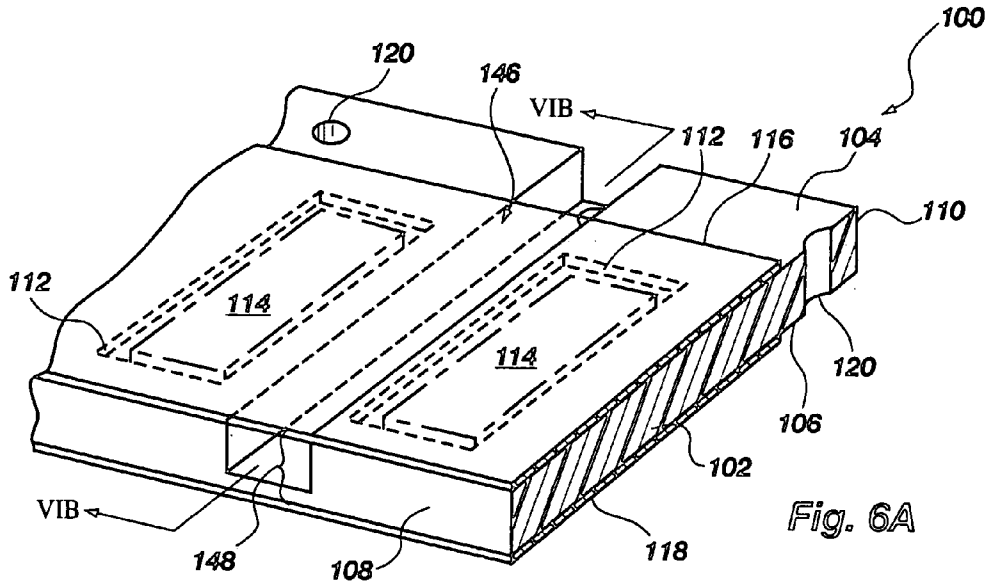


Fig. 6A

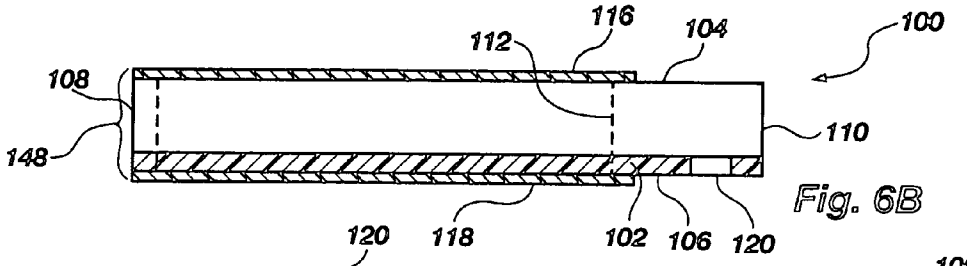


Fig. 6B

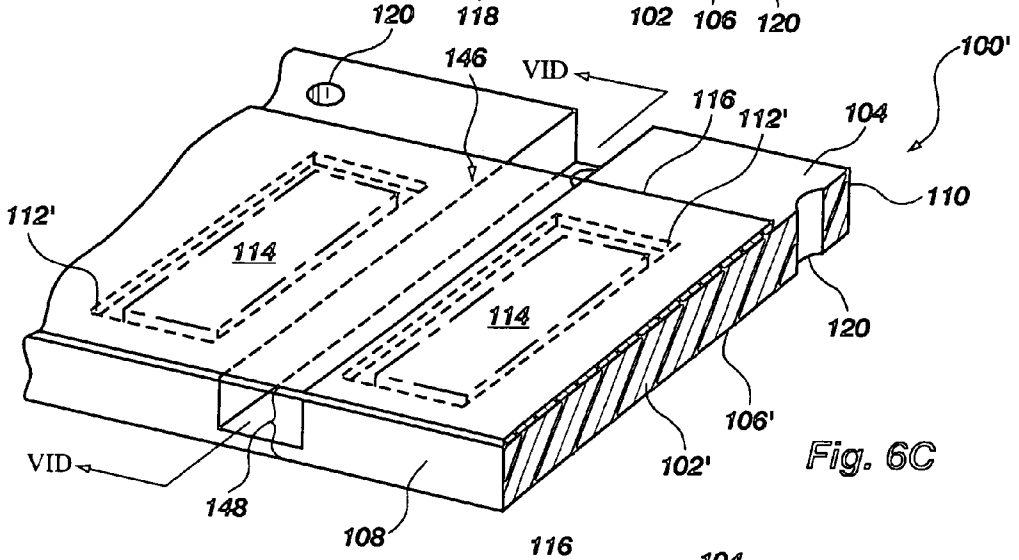


Fig. 6C

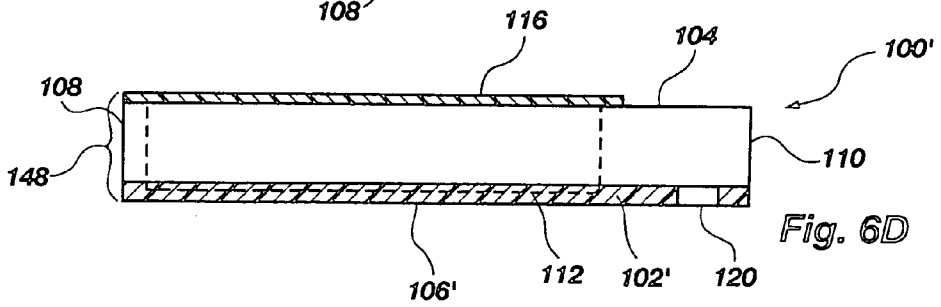


Fig. 6D

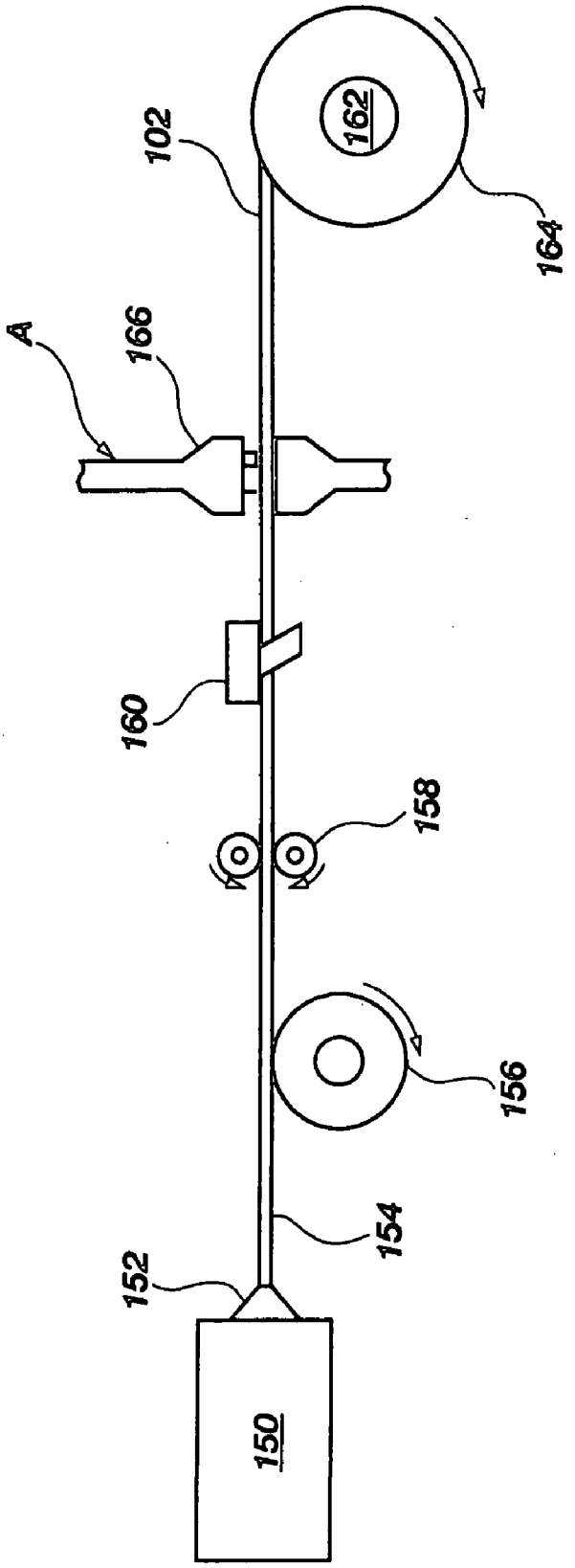


Fig. 7

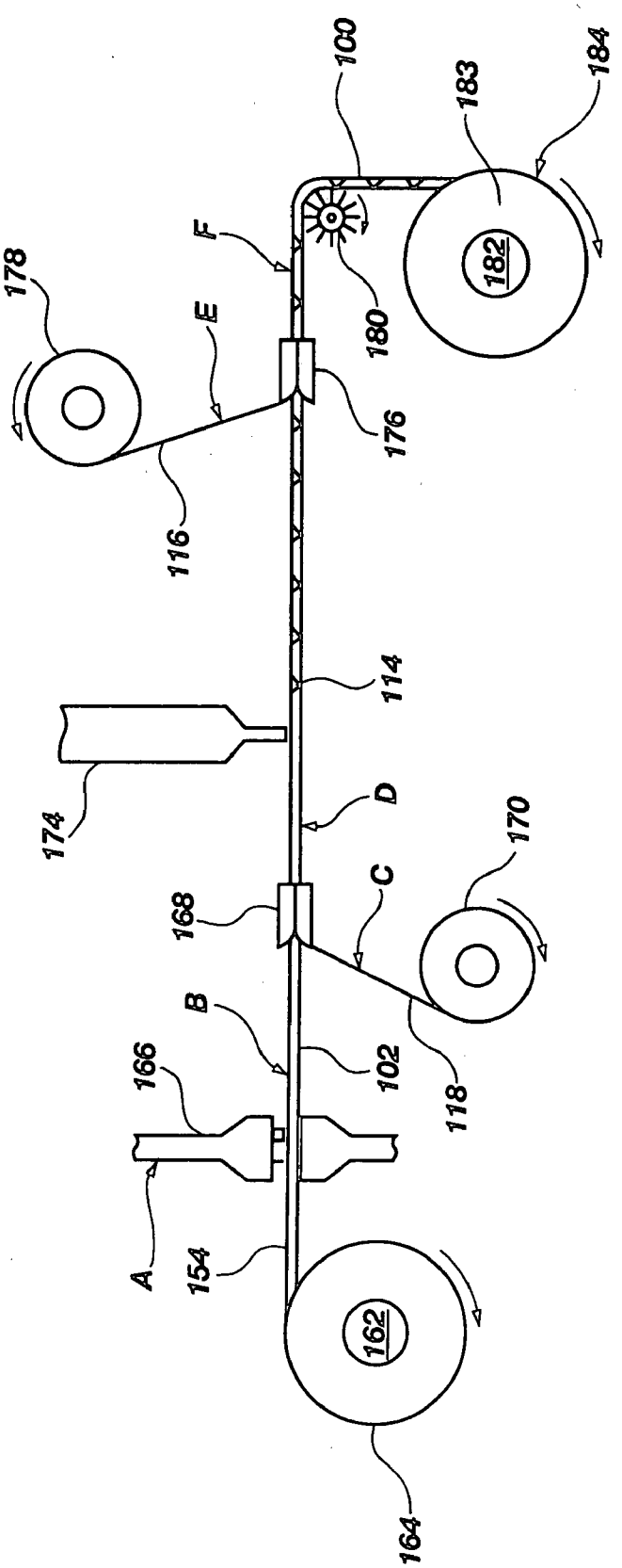

100
183
184
182
F
178
E
180
176
116
114
174
D
170
C
168
B
166
102
118
A
154
162
164

Fig. 8

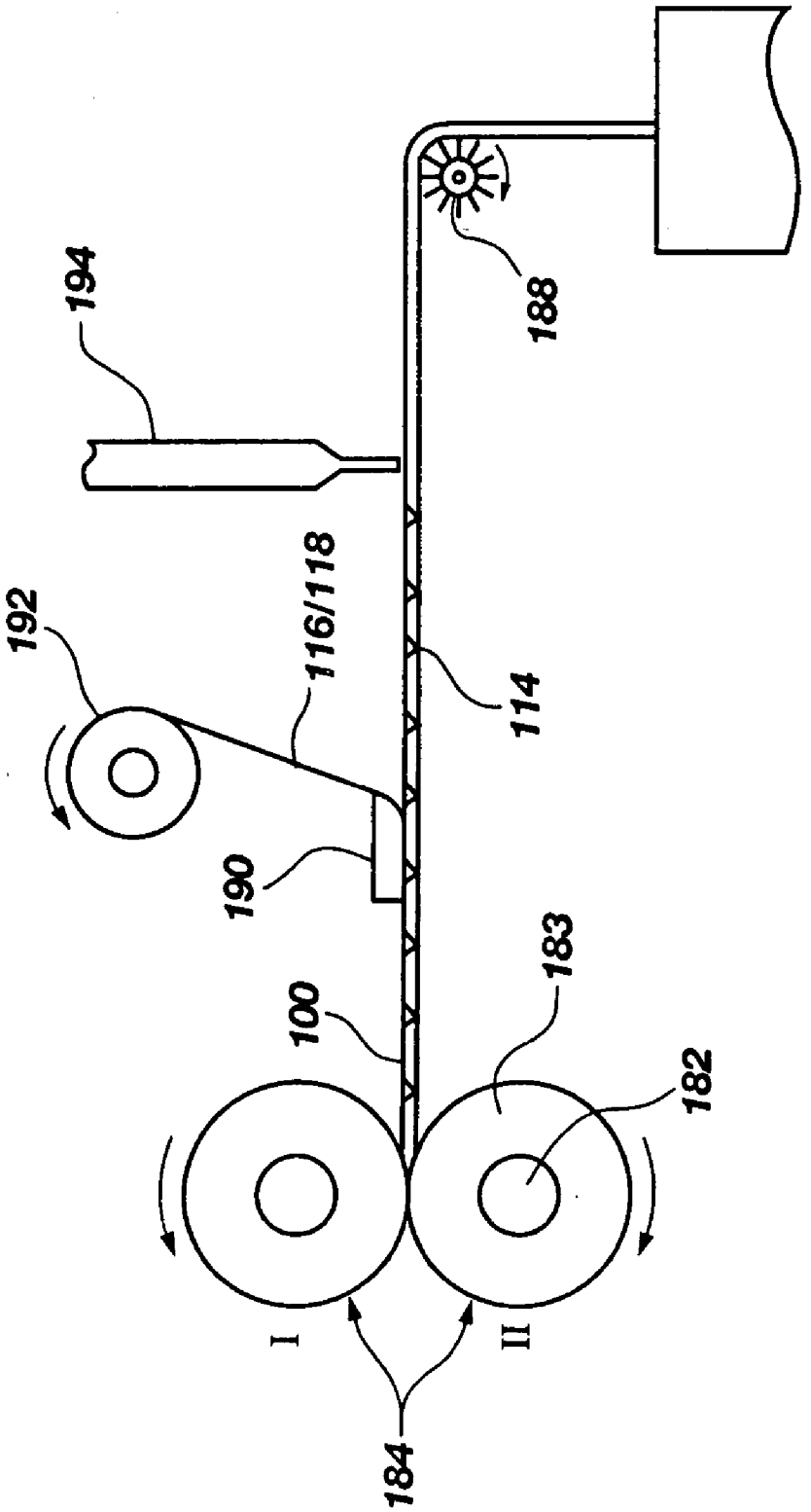


Fig. 9

METHODS FOR MAKING TEMPORARY ELECTRONIC COMPONENT-CARRYING TAPES WITH WEAKENED AREAS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of application Ser. No. 10/225,829, filed Aug. 21, 2002, pending, the disclosure of which is hereby incorporated herein, in its entirety, by this reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to tapes for temporarily carrying electronic components for storage or transportation, as well as to methods for designing, forming, and introducing electronic components into pockets and removal of electronic components from the pockets of such tapes. More specifically, the present invention relates to temporary component-carrier tapes that include weakened areas between locations for receiving electronic components and associated methods.

[0004] 2. Background of the Related Art

[0005] Virtually every type of electronic device now incorporates one or more semiconductor devices. Typically, the semiconductor devices are mounted and electrically connected to some sort of carrier substrate, such as a circuit board, to electrically connect the same to input and output devices or exterior components to be monitored and/or controlled by the semiconductor devices. In addition to the semiconductor devices, ancillary electronic components, such as resistors, resistor systems, and capacitors, are typically mounted upon and electrically connected to such carrier substrates.

[0006] Semiconductor devices and the other, ancillary electronic components that are used in electronic devices are often manufactured at different locations. Thus, it is often necessary to transport at least some of these components from one location to another for assembly. As the ancillary electronic components are typically smaller, more robust and less expensive than the semiconductor devices with which they are to be used, it is usually the ancillary electronic components that are transported to the location where the semiconductor devices are fabricated and packaged for assembly therewith in an electronic system.

[0007] Typically, such ancillary electronic components are temporarily packaged in pockets of a tape comprising a plastic-paper-plastic laminate, with the pockets being formed in the center, paper layer of the tape and the plastic layers of the tape holding the ancillary electronic components within their respective pockets. The ancillary electronic components are typically packaged within the pockets of the tape by providing a tape which includes a paper layer with a single plastic layer secured to a bottom surface thereof. Once the ancillary electronic components are introduced into the pockets, such as by pick-and-place equipment, the other, upper plastic layer is secured to the paper layer to completely encase each ancillary electronic component within its respective pocket. One or both of the plastic layers of the tape are secured to the paper layer thereof with an adhesive material that facilitates peeling of the plastic layer or layers from the paper layer and, thus, opens the pockets so that an ancillary electronic component may be removed therefrom. The component-bearing tape is typically rolled and may be stored on a reel until use of the temporarily packaged ancillary electronic components is desired.

[0008] Components may be removed from the tape by introducing the tape into appropriate equipment, which typically includes a conveyor element that is configured to engage indexing holes formed in an edge of the tape, a separation element which is positioned so as to retain the assembled relation of the upper plastic layer with the paper layer until removal of an ancillary electronic component from its corresponding pocket is desired, a first take-up reel located somewhat above or behind the separation element for receiving regions of the upper plastic layer which have been peeled away from the remainder (i.e., paper layer and lower plastic layer) of the tape, and a second take-up reel positioned in front of (i.e., upstream from) the separation element for receiving the remainder of the tape. In addition, such equipment includes a pick-and-place element that removes an ancillary electronic component from its corresponding pocket of the tape and for placing the ancillary electronic component at a desired location, such as upon a carrier substrate.

[0009] When such a component-bearing tape is handled, such as by introducing the tape into equipment for removing the ancillary electronic components therefrom and placing the same on a carrier substrate, the tape may be subjected to stresses which could cause kinking thereof. Typically, such kinking occurs at the weakest regions of the tape, typically those areas at which the pockets are located. When a component-bearing tape becomes kinked at such a location, one or both of the plastic layers at that location may be creased or bowed, which may increase the depth of at least a portion of the pocket and form a "barrel"-shaped pocket.

[0010] Once the pocket has been opened, a pick-and-place element including, for example, a vacuum quill, is used to remove the ancillary electronic component therefrom and to place the same at an appropriate location on a carrier substrate. If the height of the pocket has been increased by kinking or bowing of the tape, the ancillary electronic component may be located at a distance which precludes removal thereof from the pocket by the quill or other retrieval device, resulting in advancement of the component-bearing tape to the location of the next ancillary electronic component and, thus, waste of the ancillary electronic component that could not be picked from the tape.

[0011] Bowing or kinking of the plastic bottom of the pocket resulting in "barreling" of the pocket may also result in inversion of the ancillary electronic component, which inversion will typically not be recognized by the pick-and-place element. Although state-of-the-art pick-and-place elements may be equipped with machine vision systems that recognize shapes and dimensions, they cannot recognize right-side up or upside-down orientations or color (i.e., the color difference between the labeled top side of an ancillary electronic component and the bottom side of the electronic component). As a result of such inversion, ancillary electronic components may be secured to carrier substrates in improper orientations, which leads to failure of not only the

ancillary electronic components, but also of the carrier substrate and any other components that have already been secured thereto.

[0012] The inventor is not aware of a temporary component-carrier tape that is configured to resist kinking or bowing at the component-carrying pockets thereof.

BRIEF SUMMARY OF THE INVENTION

[0013] The present invention includes a temporary component-carrier tape with component-carrying locations along the length thereof and a weakened region located between each adjacent pair of component-carrying locations. In addition, methods for designing, forming, and introducing electronic components into and removing electronic components from the temporary component-carrier tape of the present invention are within the scope of the present invention.

[0014] An exemplary embodiment of a temporary component-carrier tape according to the present invention includes a bottom layer and a device-retaining layer that are secured to one another. The device-retaining layer may include a series of apertures, or "pockets," at device-retaining areas along the length thereof. The device-retaining layer has a thickness or depth that is about equal to or greater than the electronic devices that are to be received within the apertures thereof. The bottom layer forms a bottom of each of the apertures. In addition, the temporary component-carrier tape may include an upper layer, which is securable to an opposite surface of the device-retaining layer from that to which the bottom layer is secured. At least one of the top and bottom layers of the temporary component-carrier tape is readily removable, by peeling thereof, from the device-retaining layer so as to facilitate removal of electronic components from their corresponding apertures.

[0015] A temporary component-carrier tape that incorporates teachings of the present invention may also include a weakened region between each pair of adjacent device-retaining areas. Each weakened region may extend at least partially across the temporary component-carrier tape in a direction substantially perpendicular to a length thereof. The weakened regions may be located in one or more of the bottom layer, device-retaining layer, and top layer of the temporary component-carrier tape. Each weakened region is configured to absorb stress (e.g., compressional stress, bending stress, torsional stress, elongation stress, etc.) exerted on the temporary component-carrier tape, at least partially removing such stress from an adjacent device-retaining area of the tape. By way of example only, each weakened region may comprise a creased area or an elongate slot or series of linearly arranged perforations formed through one or more of the layers of the temporary component-carrier tape. Alternatively, a weakened region may comprise a discontinuity in one or two, but fewer than all, of the layers of the temporary component-carrier tape.

[0016] A method for designing a temporary component-carrier tape that incorporates teachings of the present invention includes configuring a plurality of device-retaining areas along the length of an elongate element and at least one weakened region between each adjacent pair of device-retaining areas. By way of example only, the device-retaining areas may be configured by configuring a device-retaining layer to have a thickness that is substantially equal to or greater than a height of an electronic device to be carried by the temporary component-carrier tape and to include a plurality of apertures, each of which has dimensions that facilitate the positioning of an electronic component therein. In addition, top and bottom layers of the device-retaining layer may be configured in such a way as to facilitate securing of the top and bottom layers to opposite surfaces of the device-retaining layer. Each weakened region of the temporary component-carrier tape may be configured to absorb stress (e.g., compressional stress, bending stress, torsional stress, tensile stress, etc.) exerted along the tape, at least partially removing such stress from an adjacent device-retaining area of the tape. Each weakened region may be configured so as to extend at least partially across the tape, in a direction substantially perpendicular to a length thereof. By way of example only, each weakened region may be configured as one or more thinned areas of the tape or one or more apertures through the tape. Alternatively, a weakened region may be configured as a crease extending across at least a portion of the tape.

[0017] A temporary component-carrier tape incorporating teachings of the present invention may be formed by providing at least one device-retaining layer and at least one cover layer. As described, an exemplary temporary component-carrier tape of the present invention includes a device-retaining layer sandwiched between two outer, cover layers, which hold electronic components within apertures of the device-retaining layer. Prior to assembly of the layers, weakened regions may be formed in one or more of the layers, such as by cutting (e.g., die cutting, slicing with a knife or blade, etc.), etching, creasing, or the like, or, alternatively, weakened regions may be formed after the layers are assembled. Next, at least one outer layer of tape, which includes spaced-apart device-retaining areas thereon, may be provided. Apertures of a device-retaining layer of the tape may be aligned with corresponding device-retaining areas of the outer layer. The device-retaining and outer layers of the tape may then be secured to one another. Electronic components are positioned at device-retaining areas such that, when the device-retaining and outer layers of the tape are secured to one another, the apertures of the device-retaining layer and the device-retaining areas of the outer layer form receptacles, each of which is configured to substantially enclose an electronic component. The device-retaining layer of the tape may be secured to the outer layer either before or after electronic components are positioned at device-retaining areas of the outer layer. Once a receptacle has an electronic component therein, another outer layer may be secured to the opposite surface of the device-retaining layer so as to substantially enclose the electronic component within its corresponding receptacle. The layers may be secured to one another by way of an adhesive material, such as a pressure-sensitive adhesive, placed therebetween or by application of heat.

[0018] Another exemplary embodiment of the temporary component-carrier tape may comprise a device-retaining layer and an outer cover layer. Receptacles are formed in the device-retaining layer, such as by molding the device-retaining layer, at device-retaining areas thereof so as to not extend completely through the device-retaining layer, thereby obviating the need for a second outer layer. Weakened regions may be formed in either or both layers and the receptacles of the device-retaining layer may be aligned with device-retaining areas of the outer layer. Electronic compo-

nents are placed in the apertures of the device-retaining layer and enclosed in a receptacle formed by securing the outer layer to the device-retaining layer. The two layers may be secured by application of a pressure-sensitive or other adhesive placed therebetween, by application of heat, or otherwise, as known in the art.

[0019] In use, the temporary component-carrier tape includes electronic components that are substantially contained within the apertures thereof and may be stored, transported, and supplied in a rolled configuration (e.g., upon a hub, reel, or the like). When removal of one or more electronic components from the temporary component-carrier tape is desired, an end of the temporary component-carrier tape may be introduced into appropriate assembly equipment, as known in the art. At least an outer layer (i.e., the top layer or bottom layer) of the temporary component-carrier tape is removed from the device-retaining layer of the tape at a particular device-retaining area of the tape to provide access to an electronic component carried at that device-retaining area. If any stress is applied along the length of or otherwise to the temporary component-carrier tape, weakened regions thereof absorb such stress, preventing kinking or bowing of any of the layers of the tape at a device-retaining area thereof.

[0020] Other features and advantages of the present invention will be apparent to those of skill in the art through consideration of the ensuing description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0021] In the drawings, which depict various aspects of exemplary embodiments of the present invention:

[0022] FIG. **1** is a perspective view of an exemplary embodiment of a temporary component-carrier tape, which includes a device-retaining layer, a bottom cover layer, a top cover layer, and a weakened region, with an end portion of the tape separated to show details thereof.

[0023] FIG. **2** is a perspective view of another exemplary embodiment of a temporary component-carrier tape, which includes a device-retaining layer, a top cover layer, and a weakened region, with the layers at an end portion of the tape separated to show details thereof.

[0024] FIG. **3**A is a perspective view of the temporary component-carrier tape in FIG. **1** that includes a weakened area comprising an elongated slot between two apertures.

[0025] FIG. **3**B is a cross-sectional view of the elongated slot depicted in FIG. **3**A, taken along line IIIB-IIIB of FIG. **3**A.

[0026] FIG. **3**C is a perspective view of the temporary component-carrier tape in FIG. **2** that includes a weakened area comprising an elongated slot between two receptacles.

[0027] FIG. **3**D is a cross-sectional view of the elongated slot depicted in FIG. **3**C, taken along line IIID-IIID of FIG. **3**C.

[0028] FIG. **4**A is a perspective view of the temporary component-carrier tape in FIG. **1** that includes a weakened area comprising a perforation between two apertures.

[0029] FIG. **4**B is a cross-sectional view of the perforation depicted in FIG. **4**A, taken along line IVB-IVB of FIG. **4**A.

[0030] FIG. **4**C is a perspective view of the temporary component-carrier tape in FIG. **2** that includes a weakened area comprising a perforation between two receptacles.

[0031] FIG. **4**D is a cross-sectional view of the perforation depicted in FIG. **4**C, taken along line IVD-IVD of FIG. **4**C.

[0032] FIG. **5**A is a perspective view of the temporary component-carrier tape in FIG. **1** that includes a weakened area comprising a crease between two apertures.

[0033] FIG. **5**B is a cross-sectional view of the crease depicted in FIG. **5**A, taken along line VB-VB of FIG. **5**A.

[0034] FIG. **5**C is a perspective view of the temporary component-carrier tape in FIG. **2** that includes a weakened area comprising a crease between two receptacles.

[0035] FIG. **5**D is a cross-sectional view of the crease depicted in FIG. **5**C, taken along line VD-VD of FIG. **5**C.

[0036] FIG. **6**A is a perspective view of the temporary component-carrier tape in FIG. **1** that includes a weakened area comprising a thinned area between two apertures.

[0037] FIG. **6**B is a cross-sectional view of the thinned area depicted in FIG. **6**A, taken along line VIB-VIB of FIG. **6**A.

[0038] FIG. **6**C is a perspective view of the temporary component-carrier tape in FIG. **2** that includes a weakened area comprising a thinned area between two receptacles.

[0039] FIG. **6**D is a cross-sectional view of the thinned area depicted in FIG. **6**C, taken along line VID-VID of FIG. **6**C.

[0040] FIG. **7** is a schematic representation of an exemplary system and method for making the device-retaining layer of a temporary component-carrier tape according to the present invention.

[0041] FIG. **8** is a schematic representation of exemplary systems and methods for making temporary component-carrier tapes according to the present invention.

[0042] FIG. **9** is a schematic representation of an exemplary system and method of removing components from a temporary component-carrier tape according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0043] Turning to the drawing figures, the temporary component-carrier tapes **100** and **100'**, illustrated in FIGS. **1** and **2**, respectively, are useful for storing and transporting components (e.g., electronic components) from a component manufacturer to a different location where the components will be removed from the temporary component-carrier tape **100** or **100'** and assembled with other elements (e.g., circuit boards, semiconductor devices, etc.). An exemplary tape width may be about 8 mm.

[0044] As shown in FIG. **1**, the temporary component-carrier tape **100** has three layers, a device-retaining layer **102**, a top cover layer **116** and a bottom cover layer **118**, where the top cover layer **116** and the bottom cover layer **118** are depicted as partially removed from the device-retaining

layer **102** to expose features of the device-retaining layer **102**. A row of apertures **112** that may extend through the device-retaining layer **102** open to both the top surface **104** and the bottom surface **106** of the device-retaining layer **102**. The thickness of the device-retaining layer **102** is substantially equal to or greater than the height of the component **114** to be laterally surrounded by the device-retaining layer **102**. Also shown are sides **108** and **110** of the device-retainer layer **102** and a row of advancement wheel or indexing holes **120** spanning the thickness of at least the device-retaining layer **102** and located along at least one edge **122** of the device-retaining layer **102**. The row of advancement wheel or indexing holes **120** is not limited to a single row along one edge of the device-retaining layer **102**, as shown in FIG. **1**. A second row of advancement wheel holes may optionally be included substantially along the edge opposite edge **122** of the device-retaining layer **102**.

[**0045**] The temporary component-carrier tape **100'** shown in FIG. **2** represents a variation of the device-retaining layer **102**, which includes receptacles **112'** that do not open to the bottom surface **106'** of the device-retaining layer **102'**. The depths of the receptacles **112'** are substantially equal to or greater than the height of component **114** enclosed therein. The temporary component-carrier tape **100'** differs from the temporary component-carrier tape **100** depicted in FIG. **1** by obviating the need to include a bottom cover layer **118**.

[**0046**] The apertures **112** and receptacles **112'** are not limited to the size or shape depicted in the figures. Although specifically illustrated, the apertures **112** and receptacles **112'** may be designed to accommodate components of various sizes. Also, the apertures **112** and receptacles **112'** may be circular, elliptical, triangular, pentagonal, or any of a number of other shapes. In addition, the apertures **112** and receptacles **112'** may include ribs, ledges and other similar structures to better accommodate and support particular component features. In general, apertures **112** and receptacles **112'** open to the top surface **104** of the device-retaining layer **102**, **102'** and may extend either partially or completely therethrough. For components **114** enclosed in closed apertures **112** and receptacles **112'** extending completely through the device-retaining layer **102**, as shown in FIG. **1**, the top cover layer **116** and the bottom cover layer **118** are respectively secured to the top surface **104** and the bottom surface **106** thereof. Where the receptacles **112'** do extend proximate to the bottom surface **106'**, as shown in FIG. **2**, components **114** are enclosed in the temporary component-carrier tape **100'** when the top cover layer **116** is secured to the top surface **104** of the device-retaining layer **102'**.

[**0047**] Since material has been removed from the device-retaining layer **102**, **102'** to form apertures **112** and receptacles **112'**, the apertures **112** and receptacles **112'** are vulnerable to bowing or kinking as a result of stresses applied to the temporary component-carrier tape **100** or **100'**, such as stresses caused by forces communicated to the temporary component-carrier tape **100** or **100'**, such as along the length thereof or transverse to the length thereof, when the temporary component carrier-tape **100** or **100'** is being fed into component removal equipment or when the components are removed from the temporary component-carrier tape **100** or **100'**. Stresses may likewise be applied to a temporary component-carrier tape **100** or **100'** as it is wound around a hub or hub of a reel. Weakened regions **124** that are located between two adjacent apertures **112** or receptacles **112'**, as shown in FIGS. **1** through **6**, are more susceptible to deformation under stress than are apertures **112** and receptacles **112'** and, thus, may more readily absorb stresses that are applied to the temporary component-carrier tapes **100** and **100'** than the apertures **112** and receptacles **112'** thereof. Weakened regions **124** may be formed by eliminating material from one or more of the device-retaining layer **102**, apertures **112** or receptacles **112'**, the top cover layer **116**, and the bottom cover layer **118** or by placing a crease in one or more of these layers between adjacent apertures **112** or receptacles **112'** of the temporary component-carrier tapes **100** and **100'**, respectively.

[**0048**] FIGS. **3**A through **3**D depict a first exemplary type of weakened region of temporary component-carrier tapes **100** and **100'** according to the present invention. Illustrated in FIG. **3**A is a perspective view of the weakened region **128** of temporary component-carrier tape **100**. FIG. **3**B is a cross-sectional view of the weakened region **128** shown in FIG. **3**A along section line IIIB-IIIB. The weakened region **128**, shown in FIGS. **3**A and **3**B, is an elongated slot **130** positioned between two closed apertures **112** and extending substantially through the top cover layer **116**, the device-retaining layer **102** and the bottom cover layer **118**. The two-layer temporary component-carrier tape **100'** illustrated in the perspective view of FIG. **3**C also includes weakened regions **128** between each adjacent pair of closed receptacles **112'**. FIG. **3**D is the cross-sectional view along section lines IIID-IIID shown in FIG. **3**C. The weakened region **128** shown in FIGS. **3**C and **3**D includes an elongated slot **130** extending substantially through the top cover layer **116** and the device-retaining layer **102'**. In general, the present invention is not limited to the rectangularly shaped slot illustrated. It may include nonsquare (e.g., rounded) ends or have another shape, such as elliptical, circular, square, or any shape that provides an open space between two apertures **112** or receptacles **112'**. Also, an elongated slot may be much thinner than illustrated.

[**0049**] FIGS. **4**A through **4**D illustrate a second exemplary type of weakened region of temporary component-carrier tapes **100** and **100'** of the present invention. FIG. **4**A is a perspective view of the weakened region **136** located between closed apertures **112** in the three-layer temporary component-carrier tape **100**. FIG. **4**B is a cross-sectional view of the weakened region **136** along the section lines IVB-IVB shown in FIG. **4**A. The weakened region **136** shown in FIGS. **4**A and **4**B includes a substantially linearly arranged series of perforation holes **138** extending substantially through the top cover layer **116**, the device-retaining layer **102**, and the bottom cover layer **118**, where each perforation hole **138** is laterally separated from adjacent perforation holes **138** by walls **140** located therebetween. Illustrated in FIG. **4**C is a perspective view of the two-layer temporary component-carrier tape **100'** with the weakened region **136** located between two closed receptacles **112'**. Shown in FIG. **4**D is a cross-sectional view of weakened region **136** along section lines IVD-IVD depicted in FIG. **4**C. Both figures illustrate the weakened region **136** as a series of substantially linear perforation holes **138** extending substantially through top cover layer **116** and device-retaining layer **102'** and separated by walls **140**. The perforation holes **138** are not limited to a rectangular configuration, as illustrated. The perforation holes **138** illustrated in FIGS. **4**A through **4**D may alternatively be elliptical, circular, trian-

gular, square, diamond shaped or any shape that provides a hole extending through one or more of the top cover layer **116**, the device-retaining layer **102**, **102'** and the bottom cover layer **118**. In addition, the number of perforation holes **138** is not limited to the number or relative size shown in FIGS. **4**A through **4**D.

[**0050**] A third exemplary type of weakened region of temporary component-carrier tapes **100** and **100'** according to the present invention is illustrated in FIGS. **5**A through **5**D. A perspective view of temporary component-carrier tape **100** depicts the weakened region **142**, in this case a crease **144**, positioned between two closed apertures **112**, as shown in FIG. **5**A. FIG. **5**B shows a cross-sectional view of the weakened region **142** along section lines VB-VB in FIG. **5**A. The crease **144** in FIGS. **5**A and **5**B is depicted as a concave-up impression in the top cover layer **116**, the device-retaining layer **102** and the bottom cover layer **118** substantially perpendicular to the length of the temporary component-carrier tape **100**. FIG. **5**C is a perspective view of the weakened region **142** located between two closed receptacles **112'** in the two-layer temporary component-carrier tape **100'**. A cross-sectional view of the weakened region **142** along section lines VD-VD in FIG. **5**C is shown in FIG. **5**D. The weakened region **142** is a crease **144** illustrated as a concave-up impression substantially including the top cover layer **116** and the device-retaining layer **102'** and substantially perpendicular to the length of the temporary component-carrier tape **100'**. In general, the crease **144** is not restricted to the embodiment shown in FIGS. **5**A through **5**D. The crease **144** may be concave-down and may be located in one or more of the top cover layer **116**, the device-retaining layer **102**, **102'** and the bottom cover layer **118**.

[**0051**] Shown in FIGS. **6**A through **6**D is a fourth exemplary type of weakened region of temporary component-carrier tapes **100** and **100'** of the present invention. FIG. **6**A shows a perspective view of the weakened region **146**, which comprises a thinned region **148** located in at least one layer of the three-layer temporary component-carrier tape **100**. As shown in FIG. **6**A, the thinned region **148** is located in the device-retaining layer **102** between two closed apertures **112** and substantially perpendicular to the length of the component-carrier tape **100**. FIG. **6**B is a cross-sectional view of the illustration in FIG. **6**A along section lines VIB-VIB showing the thinned region **148** positioned in the device-retaining layer **102**. A perspective of a weakened region **146** comprising a thinned region **148** in the two-layer temporary component-carrier tape **100'** is provided in FIG. **6**C. FIG. **6**D is an illustration of the cross-section of the weakened region **146** in FIG. **6**C along section lines VID-VID. The thinned region **148** is located between two closed receptacles **112'** and substantially perpendicular to the length of the temporary component-carrier tape **100'** as illustrated in FIG. **6**C. FIG. **6**D shows the thinned region **148** as a thin layer along the bottom of the device-retaining layer **102'**. The thinned region **148** is not limited to the rectangular cross-section illustrated. The cross-section may alternatively be concave-up at the sides, elliptical, circular, square, triangular or any shape. The thinned region **148** may include openings or thinning in one or more of the top cover layer **116** and the bottom cover layer **118**. Moreover, the thinned region **148** could be nonlinear or any other suitable configuration that is substantially perpendicular to the length of temporary component-carrier tapes **100** and **100'**. Also, the thinned region **148** is not limited to the location illustrated and may be placed anywhere between the top surface **104** and the bottom surface **106**, **106'** of the device-retaining layer **102**, **102'**.

[**0052**] The device-retaining layers **102**, **102'** of the present invention may comprise a layer of paper, cardboard, polymer (e.g., thermoplastic polymeric foam) or the like that is sufficiently flexible to allow the temporary component-carrier tapes **100** and **100'** to be wound around a hub or the hub of a reel and flexible enough to deform in the weakened regions. It may also be sufficiently strong enough to carry and provide, along the top and bottom cover layers **116** and **118**, some structural support for components **114** that are temporarily carried by temporary component-carrier tapes **100** and **100'**. Thermoplastic polymeric foams, which may be used as device-retaining layer **102**, **102'** do not create dust particles or loose fibers during the slitting and punching process, may be used as device-retaining layer **102**, **102'**. If the device-retaining layer **102**, **102'** is formed from a thermoplastic polymer foam, the thermoplastic polymer foam material should not tear during punching and should have a low elongation to minimize stretching. The polymeric materials that may be used to produce thermoplastic polymeric foam includes, without limitation, polyethylene terephthalate and ethylene glycol-modified polyethylene terephthalate, polyolefins, polystyrene, polycarbonate, nylon, acrylics, acrylonitrile-butadiene-styrene, and copolymers. In addition to its physical properties, it is also desirable that the thermoplastic polymer foam material be electrically dissipative. This may be accomplished by including an electrically conductive material, such as carbon black, which is coated on the surface or interspersed within the material during manufacturing. The electrically conductive material allows an electric charge to be dissipated throughout the material, thereby preventing damage to the components. The thermoplastic polymeric foam may also include other materials to vary the properties of the foamed sheet.

[**0053**] The device-retaining layer may be formed by known processes, such as those that are used to form paper and wax- or plastic-coated paper tapes.

[**0054**] Another exemplary method for making the device-retaining layer **102** according to the present invention is depicted in FIG. **7**. In general, the process of foaming polymeric materials is familiar to those of ordinary skill in the art and is described in various references such as *Handbook of Polymeric Foams and Foam Technology* (Daniel Klemper and Kurt C. Frisch eds., Hanser Publishers 1991). Many of the methods described in this reference may be used to manufacture polymeric materials. The device-retaining layer **102** may be manufactured using a known extrusion process. Basically, the polymeric materials are placed in an extruder **150** where they are melted, mixed, and forced through a die **152** under pressure to form film product. FIG. **7** shows a film **154** formed by extruding the polymeric materials through a die **152**. The film **154** then passes over a cooling cylinder **156** and is reheated as it passes between a pair of temperature-controlled cylindrical rollers **158** to form and further shape the film **154**. A cutter **160** is employed to cut the width of the film **154** before it is wound around a hub **162** or hub **162** of a reel to produce a supply roll **164**. As illustrated in FIG. **7**, the apertures **112** and the advancement wheel holes **120** may be punched into

film **154** by a punch press **166** to form device-retaining layer **102** prior to winding the film **154** into supply roll **164**.

[**0055**] A method of making the temporary component-carrier tape **100**, **100'** according to the present invention is depicted in FIGS. **1** and **8**. The film **154** is unwound from the supply roll **164** and fed through a punch press **166**. The punch press **166** may be employed at this point if the apertures **112** and the advancement wheel holes **120** have not already been punched into the film **154** prior to rolling the film **154** onto the supply roll **164** as illustrated in FIG. **7**. As the film **154** passes through the punch press **166**, the device-retaining layer **102** emerges having apertures **112** and the advancement wheel holes **120** therein. The device-retaining layer **102** then passes between platens **168**, where the bottom cover layer **118**, supplied by the supply roll **170**, is connected to the bottom surface **106** of device-retaining layer **102**. The platens **168** may be heated to cause the bottom cover layer **118** and the bottom surface **106** to adhere to one another. Alternatively, a pressure-sensitive adhesive may be applied to either the bottom cover layer **118** or the bottom surface **106** of the device-retaining layer **102** and the platens **168** may be replaced by laminator rollers (not shown) to apply sufficient pressure to secure the bottom cover layer **118** to the bottom surface **106**. One end of each of the apertures **112** is closed as the bottom cover layer **118** is connected to the bottom surface **106** of the device-retaining layer **102**. Components **114** may be placed in the open apertures **112** as they pass under the component loader **174**. Next, the device-retaining layer **102**, with the attached bottom cover layer **118**, passes through a second set of platens **176** where the top cover layer **116**, supplied by supply roll **178**, is connected to the top surface **104**. Like the platens **168** used to connect the bottom cover layer **118** to the bottom surface **106**, platens **176** may be heated to allow the top cover layer **116** to adhere to the top surface **104**. Alternatively, laminated rollers may be used to apply pressure where a pressure-sensitive adhesive is applied between the top cover layer **116** and the top surface **104**. Emerging from the platens **176** is the temporary component-carrier tape **100**, with the apertures **112** being closed by the top cover layer **116**, thereby providing an enclosure for components **114**. Advancement of the temporary component-carrier tape **100** may be controlled by a sprocketed advancement wheel **180** which engages the advancement wheel or indexing holes **120** in the device-retaining layer **102**. The temporary component-carrier tape **100** is ready to be stored and transported after it is wound around a hub **182** or hub **182** of a reel **183** to produce the loaded roll **184**.

[**0056**] Referring again to FIGS. **2** and **7**, a method for fabricating temporary component-carrier tape **100'** may include the film **154** passing between the temperature-controlled cylinder rollers **158**, where the top roller may include at least one protrusion that presses receptacles **112'** not completely through the softened film **154**. Next, if the film **154** is not extruded to the desired width, the film **154** may proceed to the cutter **160**, where the film **154** is cut to a predetermined width. The advancement wheel holes **120** may be punched into the film **154** by punch press **166**, producing the device-retaining layer **102'** which may then be rolled onto supply roll **164**. Alternatively, the advancement wheel holes **120** may not be punched prior to winding onto the supply roll **164** as shown in FIG. **8**. Instead, the advancement wheel holes **120** may be punched as the film **154** is unwound from supply roll **164**, as illustrated in FIG. **7**. Since the receptacles **112'** do not penetrate far enough into the device-retaining layer **102** to include openings in the bottom surface **106'**, the device-retaining layer **102'** may proceed to the component loader **174** where components **114** are placed in the receptacles **112'**, thereby omitting the first set of platens **168**, the bottom cover layer **118** and supply roll **170**. After the components **114** have been loaded, the device-retaining layer **102'** passes between platens **176** where the top cover layer **116**, supplied by supply roll **178**, is secured to the top surface **104** of the device-retaining layer **102'**, thereby encasing components **114** within receptacles **112'**. The platens **176** may be heated to allow the top cover layer **116** to adhere to the top surface **104**, or, alternatively, the platens may be replaced with laminated rollers which may be used to apply pressure to adhere the top cover layer **116** to the top surface **104** where pressure-sensitive adhesive has been applied therebetween. Advancement of the temporary component-carrier tape **100'** may be controlled by a sprocketed advancement wheel **180** which engages the advancement wheel holes **120** in the device-retaining layer **102'**. The temporary component-carrier tape **100'** may then be wound around a hub **182** or hub **182** of a reel **183** to produce loaded roll **184**.

[**0057**] The weakened regions **124**, **128**, **136**, **142**, **146** (FIGS. **1-6**), located between adjacent pairs of apertures **112** and receptacles **112'**, may be formed at a number of places in the process of making temporary component-carrier tapes **100** and **100'**. The weakened regions **124**, **128**, **136**, **142**, **146** may be formed by cutting (e.g., with a saw or blade), etching, punching, or creasing one or more of the top cover layer **116**, the device-retaining layer **102**, **102'** and the bottom cover layer **118**. Location A in FIGS. **7** and **8** illustrates that a weakened region **124** may be punched in the device-retaining layer **102**, **102'** at the point where the punch press **166** punches apertures **112** and the advancement wheel holes **120**. Other ways to form the weakened region **124** at location A include cutting or creasing. Location B in FIG. **8** illustrates that the weakened regions **124** may be formed in the device-retaining layer **102**, **102'** just after the device-retaining layer **102**, **102'** emerges from the punch press **166**. A variety of techniques may be used to form the weakened region **124** at location B, including punching, cutting, creasing and other suitable techniques. Since the weakened region **124** may also be formed in the bottom cover layer **118**, location C indicates a point where a weakened region **124** may be generated in the bottom cover layer **118** before it is connected to the bottom surface **106** and may be aligned with the weakened region in the device-retaining layer **102**, **102'**. A weakened region **124** that includes both the device-retaining layer **102**, **102'** and the bottom cover layer **118** may also be generated just after the bottom cover layer **118** has been attached to the bottom surface **106** at location D. Location E, like location C for the bottom cover layer **118**, illustrates that the weakened region **124** may be formed in the top cover layer **116** prior to attaching this layer to the top surface **104** of the device-retaining layer **102**, **102'**. Again, any suitable process may be used at locations C, D, and E to form weakened region **124**. Weakened regions **124** may be formed in either the top cover layer **116** or the bottom cover layer **118** at the time of assembly or subsequent thereto, prior to winding of the temporary component-carrier tapes **100** and **100'** onto the hub **182** or reel **183**. For both the top cover layer **116** and the bottom cover layer **118**, weakened regions in both of these layers may be formed at the time of

manufacturing or elsewhere prior to being wound around the supply rolls **178** and **170**, respectively. They may then be included in the process depicted in FIG. **8** by aligning the weakened regions in the layers so that they overlap when the surfaces are connected. Location F shows that the weakened region **124** may be formed in completed temporary component-carrier tapes **100** and **100'** prior to winding them onto loaded roll **184**.

[**0058**] Extracting components from the temporary component-carrier tapes **100** and **100'** may include transporting the loaded roll **184** to a location where the components **114** may be removed by automated assembly equipment having a sprocketed advancement mechanism that engages the advancement wheel or indexing holes **120** of a temporary component-carrier tape **100**, **100'** and advances it for manual removal or automated removal, such as by pick-and-place robotic equipment, of the components. FIG. **9** illustrates that loaded roll **184** may be placed in position I or II to remove either the top cover layer **116** or the bottom cover layer **118** of the temporary component-carrier tapes **100**. The temporary component-carrier tape **100**, **100'** is unwound from the loaded roll **184** by engaging the advancement wheel holes **120** of the device-retainer tape **102**, **102'** with a sprocketed advancement wheel **188** of an advancement mechanism. The temporary component-carrier tape **100**, **100'** may then be advanced to the stripper assembly **190** where the cover layer **116** or **118** is removed from the device-retaining layer **102**, opening the closed apertures **112** or receptacles **112'**, and the cover layer **116** or **118** is wound around the hub of a take-up reel **192**. The open apertures **112** or receptacles **112'** approach the pick-and-place robotic equipment where a vacuum pick-up quill **194** removes the components from the open apertures **112** or receptacles **112'** and places them at a particular place on a carrier substrate or other electronic device component.

[**0059**] It will be evident to those in the art that various changes and modifications may be made in the apparatus, methods, design and use as disclosed herein without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A method for making a temporary component-carrying tape comprising:

forming a device-retaining layer;

forming a plurality of apertures in the device-retaining layer;

securing a top cover layer to a surface of the device-retaining layer so as to cover at least a portion of each of the plurality of apertures;

securing a bottom cover layer to another surface of the device-retaining layer so as to cover at least a portion of each of the plurality of apertures;

forming at least one weakened feature in the bottom cover layer after securing the bottom cover layer to another surface of the device-retaining layer; and

forming at least one weakened feature in at least one of the device-retaining layer and the top cover layer between adjacent apertures of the plurality of apertures.

2. The method of claim 1, wherein forming the device-retaining layer comprises forming the device-retaining layer from paper, cardboard, or a thermoplastic polymer.

3. The method of claim 1, wherein forming the device-retaining layer comprises forming the device-retaining layer from a thermoplastic polymer foam.

4. The method of claim 1, wherein forming the device-retaining layer comprises extruding a polymeric material through a die.

5. The method of claim 1, wherein forming the device-retaining layer comprises forming at least one series of advancement wheel holes adjacent to an edge of the device-retaining layer.

6. The method of claim 5, wherein forming the plurality of apertures comprises punching the plurality of apertures into the device-retaining layer.

7. The method of claim 1, wherein securing the top cover layer to the surface of the device-retaining layer comprises using a pressure-sensitive adhesive therebetween.

8. The method of claim 1, wherein securing the top cover layer to the surface of the device-retaining layer further comprises applying heat to at least one of the top cover layer and the device-retaining layer.

9. The method of claim 1, wherein securing the bottom cover layer to another surface of the device-retaining layer is effected with a pressure-sensitive adhesive.

10. The method of claim 1, wherein securing the bottom cover layer to the another surface of the device-retaining layer comprises applying heat to at least one of the bottom cover layer and the device-retaining layer.

11. The method of claim 1, wherein forming the at least one weakened feature comprises at least one of punching, cutting, etching, and creasing.

12. The method of claim 1, wherein forming the at least one weakened feature in at least the bottom cover layer comprises at least one of punching, cutting, etching, and creasing.

13. The method of claim 1, wherein forming the at least one weakened feature comprises forming the at least one weakened feature substantially simultaneously with forming the plurality of apertures.

14. The method of claim 1, wherein forming the at least one weakened feature in the bottom cover layer is effected before securing the bottom cover layer to the another surface of the device-retaining layer.

15. The method of claim 1, wherein forming the at least one weakened feature is effected prior to securing the top cover layer to the device-retaining layer.

16. The method of claim 1, wherein forming the at least one weakened feature is effected after securing the top cover layer to the device-retaining layer.

17. A method for making a temporary component-carrying tape comprising:

forming a device-retaining layer;

forming a plurality of apertures in the device-retaining layer;

securing a top cover layer to a surface of the device-retaining layer so as to cover at least a portion of each of the plurality of apertures; and

after securing the top cover layer to the device-retaining layer, forming at least one weakened feature in at least

one of the device-retaining layer and the top cover layer between adjacent apertures of the plurality of apertures.

18. The method of claim 17, wherein forming the device-retaining layer comprises forming the device-retaining layer from paper, cardboard, or a thermoplastic polymer.

19. The method of claim 17, wherein forming the device-retaining layer comprises forming the device-retaining layer from a thermoplastic polymer foam.

20. The method of claim 17, wherein forming the device-retaining layer comprises extruding a polymeric material through a die.

21. The method of claim 17, wherein forming the device-retaining layer comprises forming at least one series of advancement wheel holes adjacent to an edge of the device-retaining layer.

22. The method of claim 21, wherein forming the plurality of apertures comprises punching the plurality of apertures into the device-retaining layer.

23. The method of claim 17, wherein securing the top cover layer to the surface of the device-retaining layer comprises using a pressure-sensitive adhesive therebetween.

24. The method of claim 17, wherein securing the top cover layer to the surface of the device-retaining layer further comprises applying heat to at least one of the top cover layer and the device-retaining layer.

25. The method of claim 17, further comprising securing a bottom cover layer to another surface of the device-retaining layer so as to cover at least a portion of each of the plurality of apertures.

26. The method of claim 25, wherein securing the bottom cover layer to another surface of the device-retaining layer is effected with a pressure-sensitive adhesive.

27. The method of claim 25, wherein securing the bottom cover layer to the another surface of the device-retaining layer comprises applying heat to at least one of the bottom cover layer and the device-retaining layer.

28. The method of claim 17, wherein forming the at least one weakened feature comprises at least one of punching, cutting, etching, and creasing.

29. The method of claim 25, further comprising forming at least one weakened feature in at least the bottom cover layer.

30. The method of claim 29, wherein forming the at least one weakened feature in at least the bottom cover layer comprises at least one of punching, cutting, etching, and creasing.

31. The method of claim 17, wherein forming the at least one weakened feature comprises forming the at least one weakened feature substantially simultaneously with forming the plurality of apertures.

32. The method of claim 29, wherein forming the at least one weakened feature in the bottom cover layer is effected before securing the bottom cover layer to the another surface of the device-retaining layer.

33. The method of claim 17, wherein forming the at least one weakened feature is effected prior to securing the top cover layer to the device-retaining layer.

* * * * *