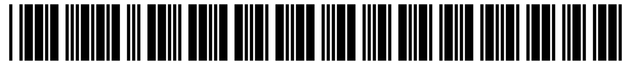

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Palaniappa et al.

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(45) **Date of Patent: Mar. 18, 2003**

(54) **PACKAGED DEVICE ADAPTER ASSEMBLY**

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(73) Assignee: **Ironwood Electronics, Inc.**, Eagan, MN (US)

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(22) Filed: **Oct. 14, 1999**

(51) **Int. Cl.**[7] **H01R 9/01**
(52) **U.S. Cl.** **439/71**; 439/331
(58) **Field of Search** .... 439/71, 72, 73, 439/74, 630, 68, 331; 174/117 A

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Primary Examiner—Lynn D. Feild
Assistant Examiner—Phuong Dinh
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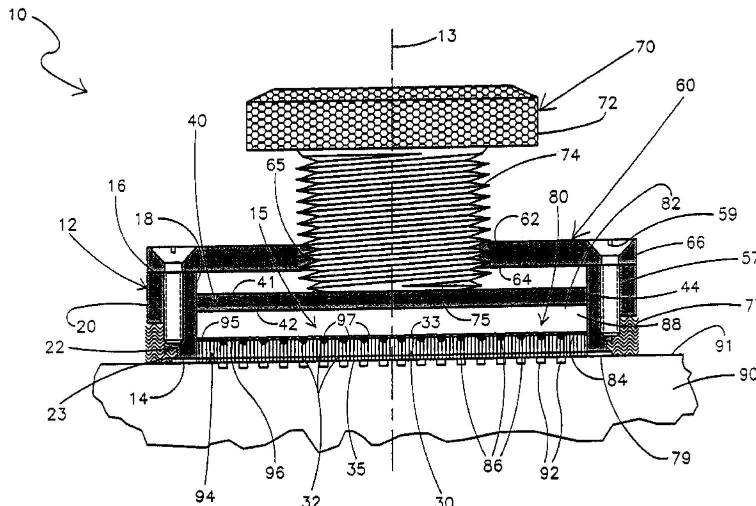
(57) **ABSTRACT**

An adapter apparatus is provided for receiving a packaged device having a plurality of contact elements disposed on a surface thereof. The adapter apparatus includes a perimeter wall member having a length along an adapter axis between a first end of the wall member and a second end of the wall member. A conductive element layer including arranged contact elements is positioned at the first end of the perimeter wall member orthogonal to the adapter axis. The perimeter wall member and the conductive element layer define a socket cavity to receive the packaged device with the contact elements thereof adjacent the arranged conductive elements of the conductive element layer. A cover member is positioned at the second end of the perimeter wall member to close the socket cavity. The cover member is movable to allow the packaged device to be removed from the socket cavity. The adapter apparatus may include a floating member moveable in the socket cavity and an actuator element operable to provide a force on the floating member such that a corresponding force is distributed to the packaged device when received in the socket cavity to provide effective electrical coupling between the contact elements of the packaged device and the arranged conductive elements of the conductive element layer, e.g., a conductive elastomer layer. Further, the perimeter wall member may include an inner surface facing towards the adapter axis and an outer surface facing in an opposing direction. The outer surface of the perimeter wall member may include an adhesive retaining surface adjacent the first end thereof, e.g., channels adjacent the first end, for use in receiving an adhesive to mount the assembly to a target board. Yet further, the adapter apparatus may include an alignment structure positioned in the socket cavity adjacent the conductive element layer and adjacent the surface of the packaged device on which the contact elements are disposed to align the contact elements of the packaged device with contact pads on a target board when the adapter apparatus is mounted relative thereto.

31 Claims, 9 Drawing Sheets



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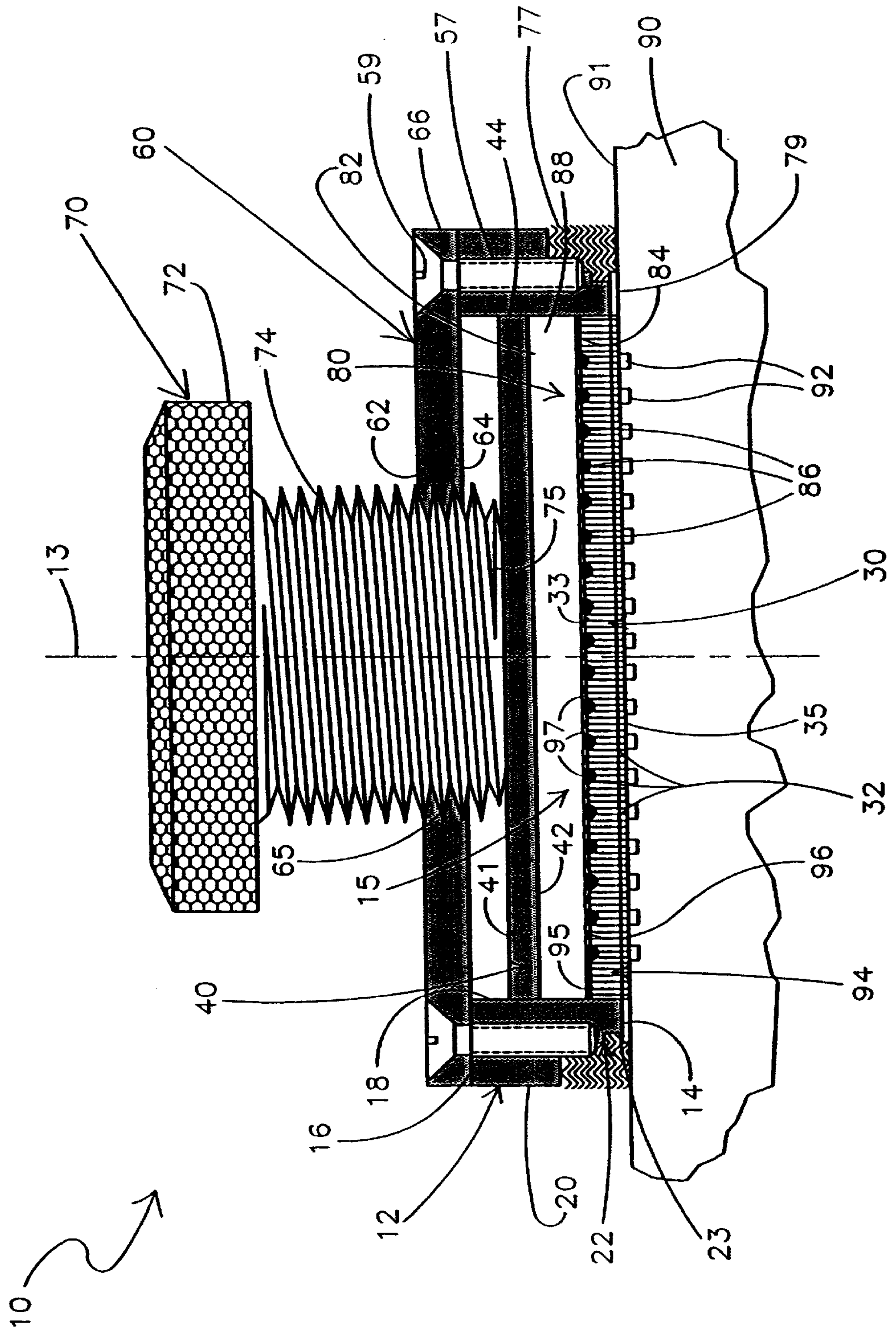
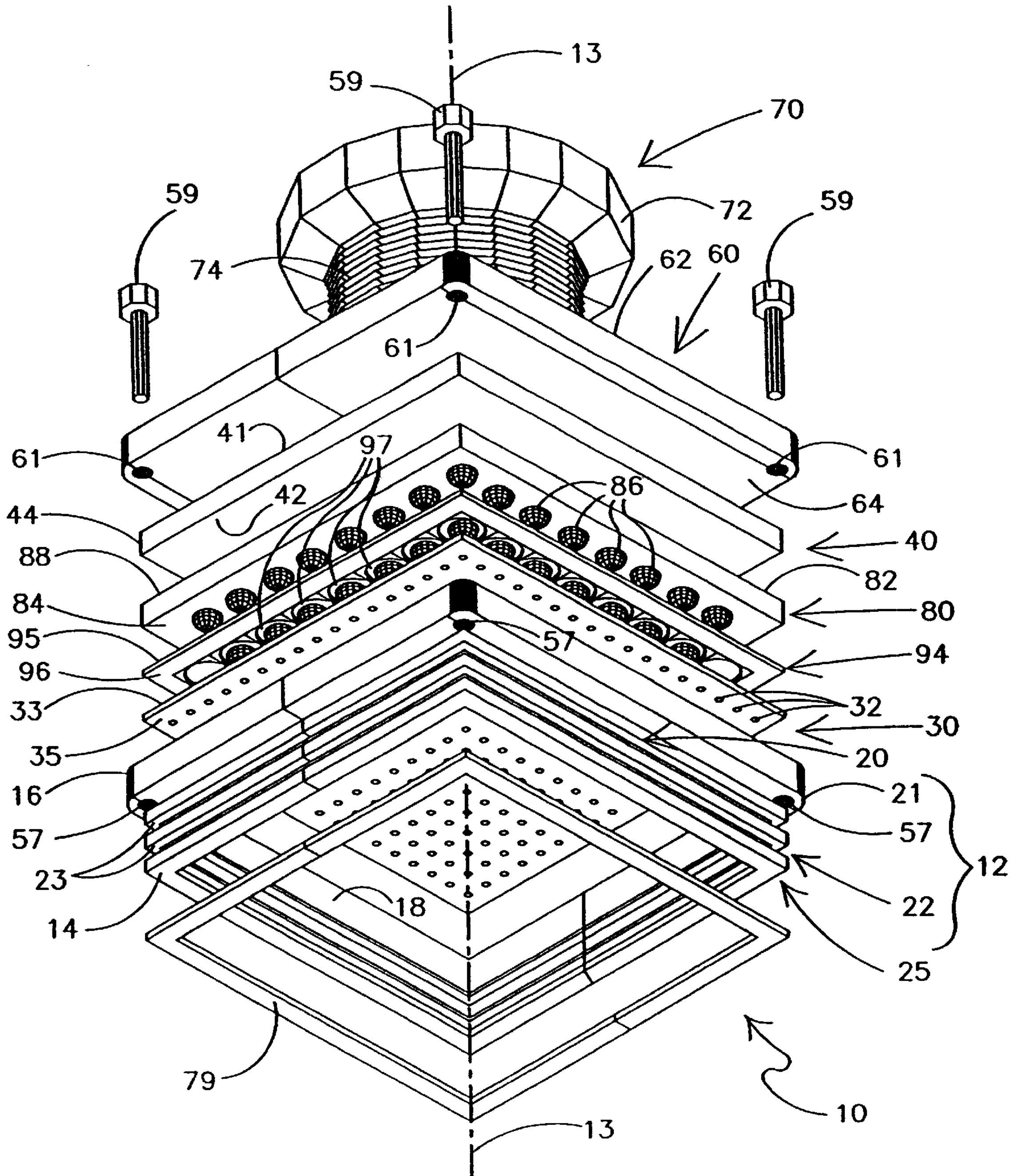


FIGURE 1A

FIGURE 1B



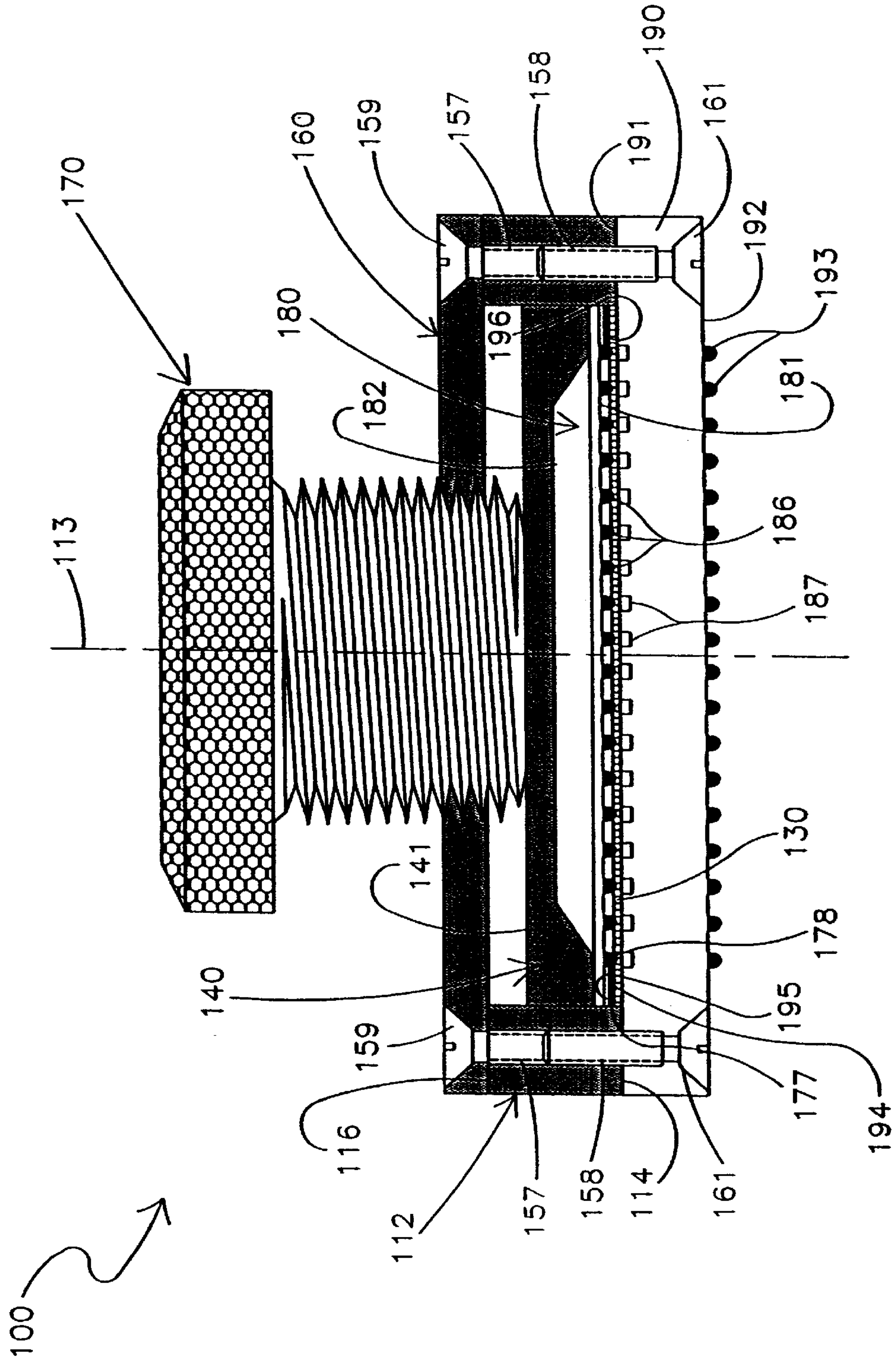
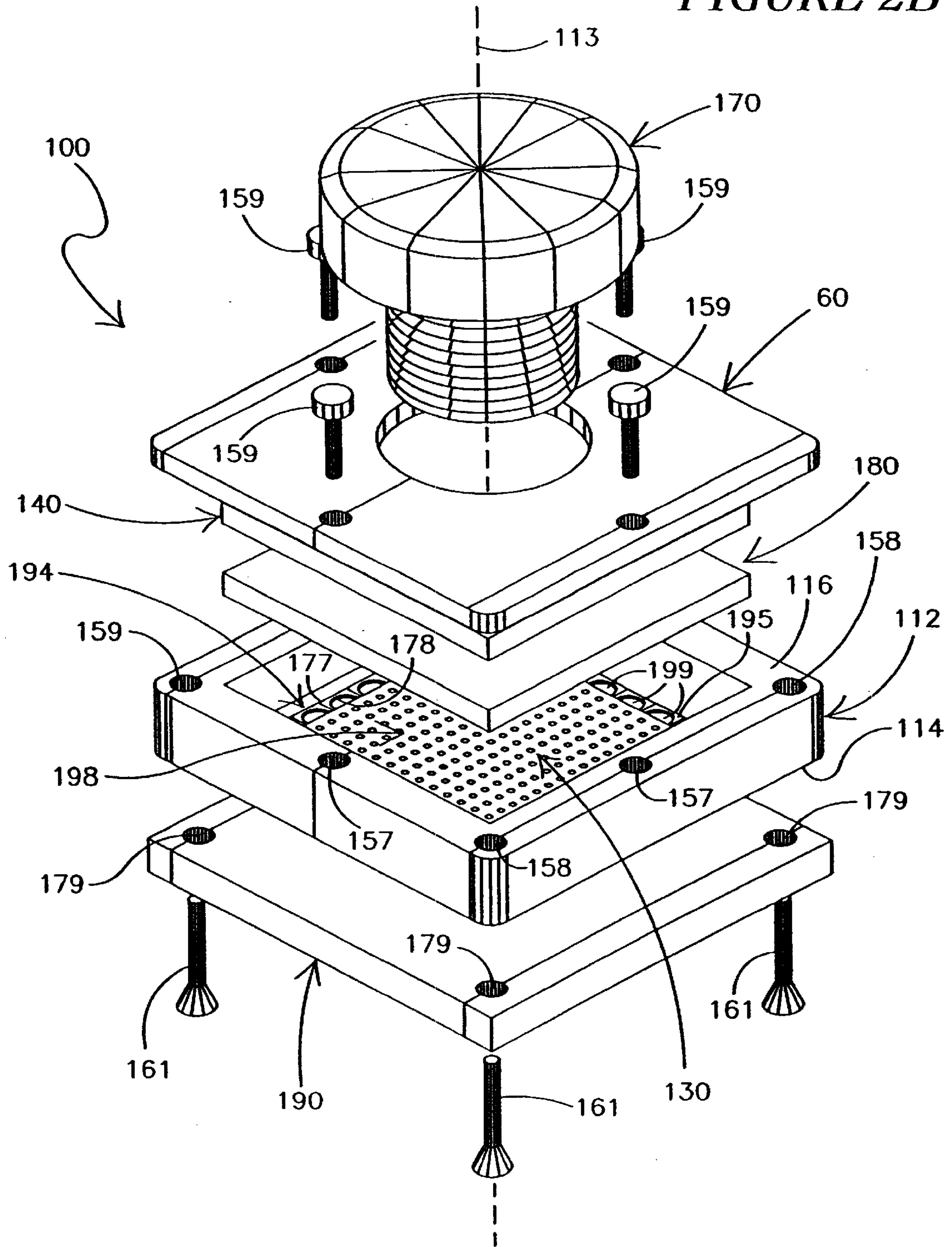


FIGURE 2A

FIGURE 2B



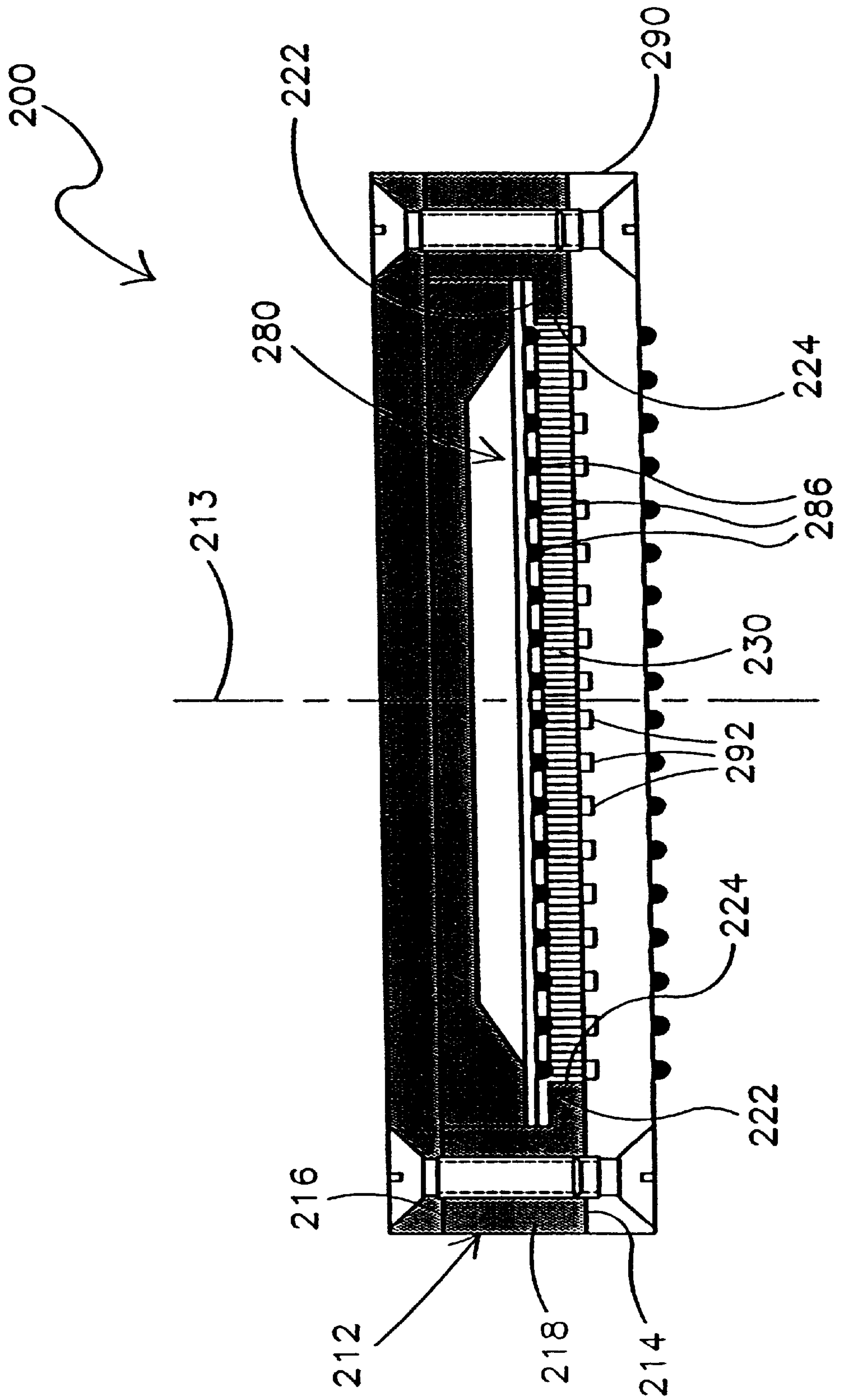


FIGURE 3
200
222
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280
224
213
286
230
292
224
222
216
212
218
214

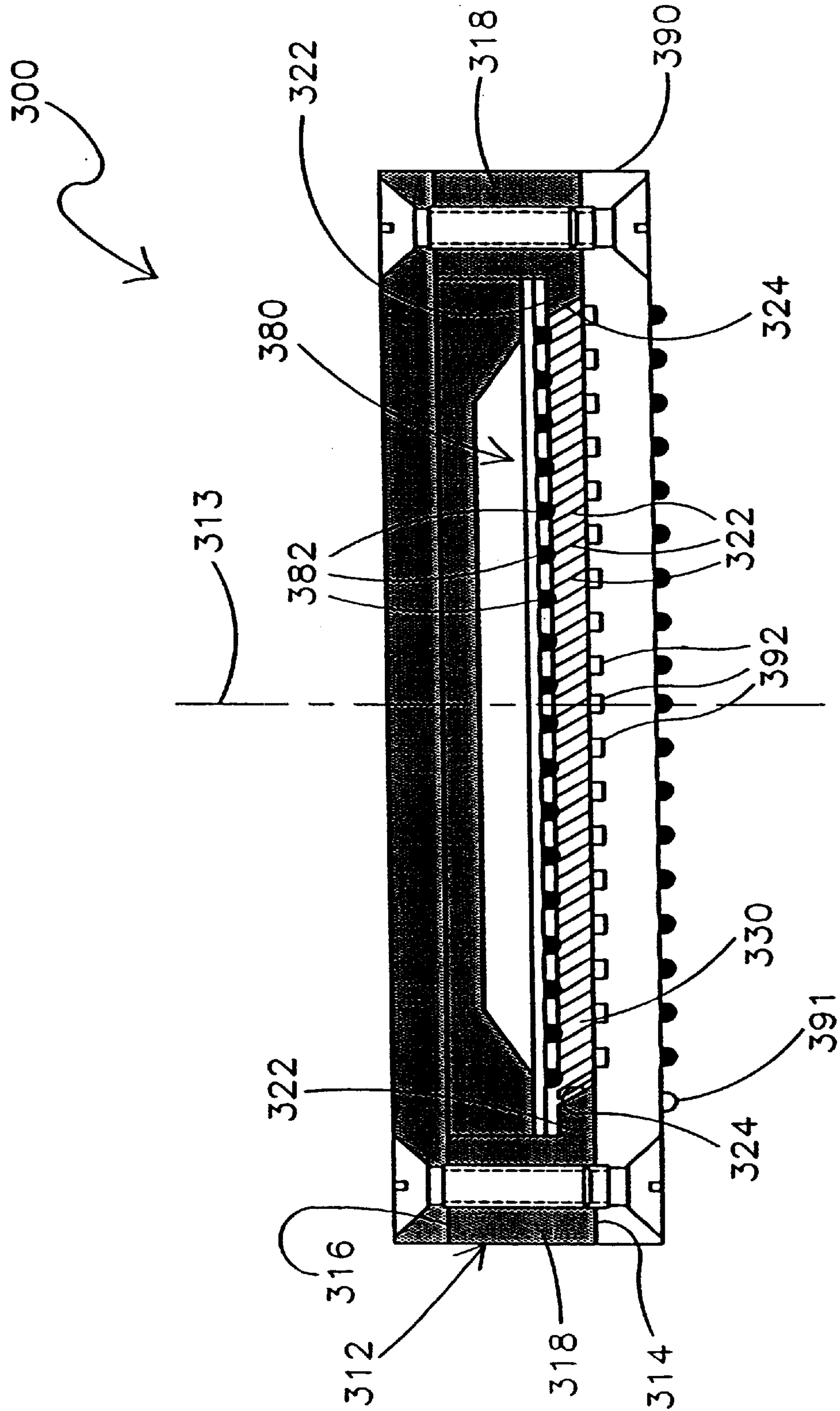


FIGURE 4

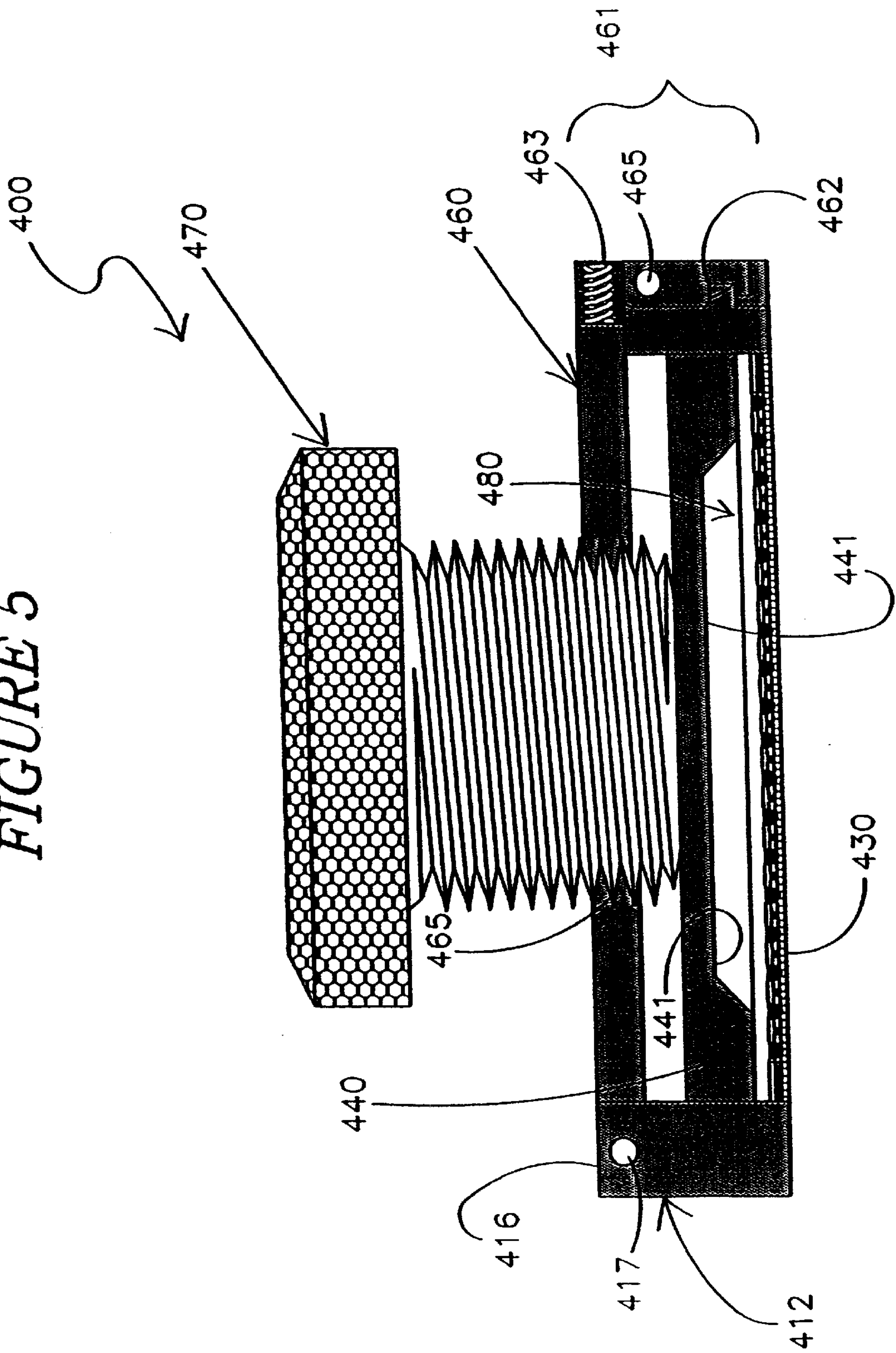


FIGURE 5
400
470
460
463
465
462
461
480
441
430
465
441
440
416
417
412

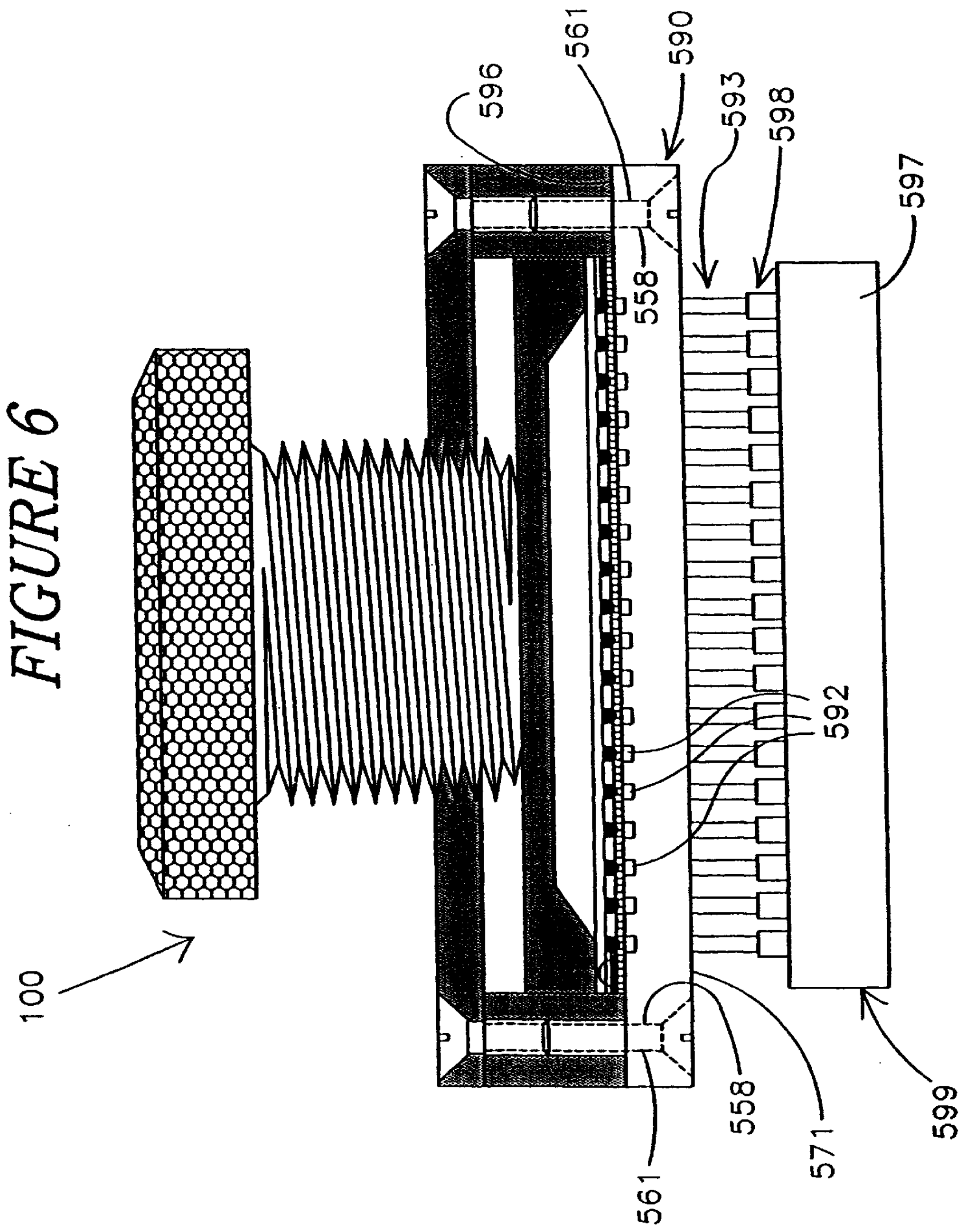


FIGURE 6
100
596
561
590
593
598
597
558
592
558
571
561
599

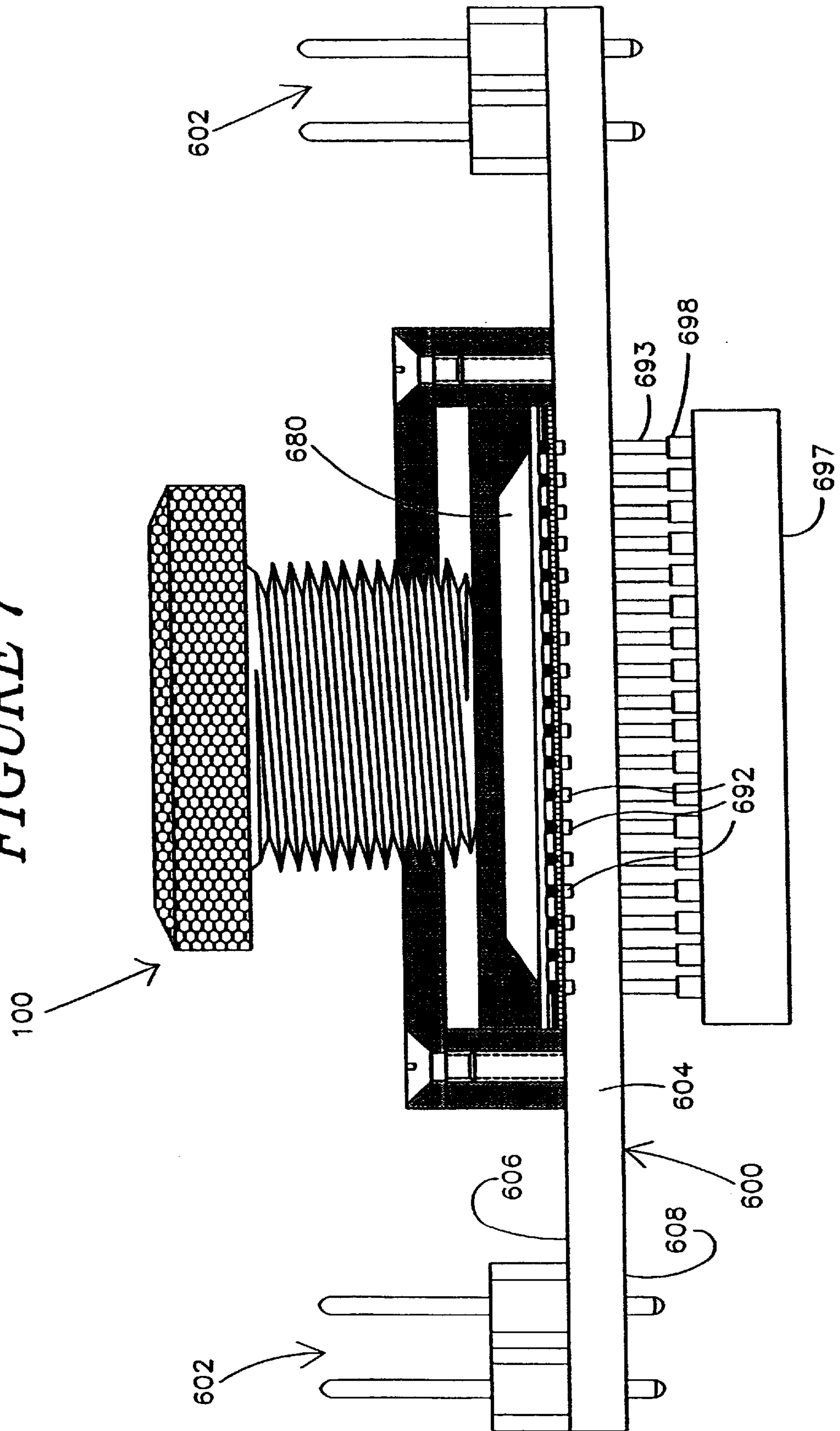


FIGURE 7
602
100
680
693
698
697
692
604
600
606
608
602

PACKAGED DEVICE ADAPTER ASSEMBLY

FIELD OF THE INVENTION

The present invention relates to electrical adapters. More particularly, the present invention pertains to adapters for packaged integrated circuit devices, e.g., ball grid array packages, flip chip packages, etc.

BACKGROUND OF THE INVENTION

Certain types of integrated circuit packages are becoming increasingly popular due to their occupancy area efficiency. In other words, they occupy less area on a target board on which they are mounted while providing a high density of contact terminals. For example, one such high density package type is a ball grid array package. Generally, ball grid array packages contain an integrated circuit having its die bond pads electrically connected to respective conductive solder spheres that are distributed on the bottom surface of the package in an array. A target printed circuit board typically has formed on its surface a corresponding array of conductive pads which are aligned with the array of solder spheres for electrically mounting the ball grid array package on the target board. The target board typically includes other conductive traces and elements which lead from the array of conductive pads used for mounting the ball grid array package to other circuitry on the board for connecting various components mounted thereon. Typically, to mount such a ball grid array package to a target board, the package is positioned with the array of solder spheres corresponding to the array of conductive pads on the target board. The resulting structure is then heated until the solder spheres are melted and fused to the conductive pads of the target board.

Such area efficient packaging, e.g., ball grid array packages, provide a high density of terminals at a very low cost. Also, this packaging provides for limited lead lengths. The limited lead lengths may reduce the risk of damage to such leads of the package, may provide for higher speed product, etc.

Generally, circuit boards and/or components mounted thereon are tested by designers as the circuit boards are being developed. For example, for a designer to test a circuit board and/or a ball grid array package mounted thereon, the designer must first electrically connect the solder balls on the ball grid array package to the target circuit board. As described above, this generally includes mounting the ball grid array package on the target board and heating the solder spheres to fuse the solder spheres to the conductive pads of the target board. Therefore, the package may be prevented from being used again. It is desirable for various reasons to use package adapters for mounting the packages and reuse ball grid array packages after testing. For example, such ball grid array packages may be relatively expensive. Further, for example, once attached, the solder spheres are not accessible for testing. In addition, it is often difficult to rework the circuit board with the packages soldered thereon.

Various adapters for ball grid array packages which electrically connect a ball grid array package to a target printed circuit board without requiring that the solder balls on the ball grid array package be fused to the target board are known. For example, one such adapter is shown in U.S. Pat. No. 5,892,245 to Hilton, issued Apr. 6, 1999 and entitled, "Ball Grid Array Package Emulator." However, the high density of terminals for certain packages, e.g., ball grid array packages, lead to various interconnect problems for adapters being used with such packages. For example, such a high density of terminals, e.g., solder spheres, of such packaged devices may lead to isolation problems between conductive elements of conventional adapters used for connecting the packages to the target board. Further, many adapters require the provision of structure on the target board for mechanically fastening an adapter thereto. For example, in many cases the target board is required to have holes defined therein for receiving fastening devices to mechanically mount the electrical adapter to the target board. Yet further, alignment of the contact terminals of the packaged device, e.g., solder spheres, to the contact pads of the target board may be problematic when an electrical adapter is used.

SUMMARY OF THE INVENTION

The present invention provides a packaged device adapter assembly preferably useable for high density integrated circuit packages, e.g., ball grid array packages, flip-chip packages, chip scale packages, etc. An adapter assembly according to the present invention for receiving a packaged device having a plurality of contact elements disposed on the surface thereof includes a perimeter wall member having a length along an adapter axis between a first end of the wall member and a second end of the wall member. A conductive element layer including arranged contact elements, e.g., a conductive elastomer layer or an array of contact elements isolated by insulative material, is positioned at the first end of the perimeter wall member orthogonal to the adapter axis. The perimeter wall member and the conductive element layer define a socket cavity to receive the packaged device. Generally, the plurality of contact elements of the packaged device are adjacent the conductive element layer. A cover member is positioned at the second end of the perimeter wall to close the socket cavity. The cover member is movable to allow the packaged device to be removed from the socket cavity. The adapter apparatus further includes a floating member that is moveable in the socket cavity and an actuator element operable to provide a force on the floating member such that a corresponding force is distributed to the packaged device when the packaged device is received in the socket cavity such that the plurality of contact elements thereof are in electrical contact with the arranged conductive elements.

In one embodiment of the adapter apparatus, the actuator element is associated with the cover member. For example, the actuator element may be a threaded element moveable in a threaded insert of the cover member. Further, the threaded element may include a heat sink head portion with a threaded portion extending therefrom.

In another embodiment of the apparatus, the floating member is a plate member having a surface configured as a function of a surface of the packaged device. The surface of the plate member is positioned in direct contact with the surface of the packaged device when the packaged device is received in the socket cavity.

In yet another embodiment of the apparatus, the perimeter wall member has an inner surface facing towards the adapter axis and an outer surface facing in an opposing direction. The outer surface of the perimeter wall member includes an adhesive retaining surface adjacent the first end thereof. In various embodiments, the adhesive retaining surface may include one or more channels located adjacent the first end of the perimeter wall, an additional adhesive material (e.g., double-sided tape) may be applied on the first end of the perimeter wall member, and the adhesive material applied to the adhesive retaining surface may also be in contact with a target board.

In another embodiment of the apparatus, the apparatus further includes an alignment structure positioned in the socket cavity adjacent the conductive element layer and adjacent the surface of the packaged device on which the plurality of contact elements are disposed to align the contact elements of the packaged device with contact pads on a target board when the adapter apparatus is mounted relative to the target board. For example, the alignment structure may include an alignment plate positioned orthogonal to the adapter axis and may include at least one opening defined therein to allow the contact elements of the packaged device to be in electrical contact with the arranged conductive elements. Yet further, for example, the alignment plate may include a plurality of openings with each opening corresponding to one of the plurality of contact elements disposed on the surface of the packaged device. Yet further, the alignment plate may include an outer surface positioned adjacent the perimeter wall member and an inner surface facing inward towards the adapter axis with the inner surface formed to include arc surface portions corresponding to certain perimeter solder spheres of a ball grid array package received in the socket cavity. In addition, the alignment structure may include a lip portion of the perimeter wall member extending inward towards the adapter axis at the first end of the perimeter wall member.

Another adapter apparatus according to the present invention for receiving a packaged device having a plurality of contact elements disposed on a surface thereof includes a perimeter wall member having a length along an adapter axis between a first end of the wall member and a second end of the wall member. The perimeter wall member has an inner surface facing towards the adapter axis and an outer surface facing in an opposing direction. The outer surface of the perimeter wall member includes an adhesive retaining surface adjacent to the first end thereof. The adapter apparatus further includes a conductive element layer including a plurality of arranged conductive elements positioned at the first end of the perimeter wall member orthogonal to the adapter axis. The perimeter wall member and the conductive element layer define a socket cavity to receive the packaged device with the plurality of contact elements of the packaged device in electrical contact with the arranged conductive elements. A cover member is positioned at the second end of the perimeter wall to close the socket cavity. The cover member is moveable to allow the packaged device to be removed from the socket cavity.

In one embodiment of the adapter apparatus, the adhesive retaining surface includes one or more channels located adjacent the first end of the perimeter wall. In yet another embodiment of the apparatus, an additional adhesive material is applied on the first end of the perimeter wall member, e.g., double-sided tape.

In yet another embodiment of the adapter apparatus, an adhesive material is applied to the adhesive retaining surface such that the adhesive material is also in contact with the target board. For example, the adhesive material may be an epoxy material.

Yet another adapter apparatus is described according to the present invention for receiving a packaged device having a plurality of contact elements disposed on a surface thereof. This adapter apparatus includes a perimeter wall member having a length along an adapter axis between a first end of the wall member and a second end of the wall member. A conductive element layer including arranged conductive elements is positioned at the first end of the perimeter wall member orthogonal to the adapter axis. The perimeter wall member and the conductive element layer define a socket cavity to receive the packaged device with the plurality of contact elements thereof in electrical contact with the arranged conductive elements. A cover member is positioned at the second end of the perimeter wall to close the socket cavity. The cover member is movable to allow the packaged device to be removed from the socket cavity. An alignment structure is further positioned in the socket cavity adjacent the conductive element layer and adjacent the surface of the packaged device on which the plurality of contact elements are disposed. The alignment structure aligns the contact elements of the packaged device with contact pads on a target board when the adapter apparatus is mounted relative to the target board.

In various embodiments of this adapter apparatus, the alignment structure may be an alignment plate positioned orthogonal to the adapter axis between the layer of arranged conductive elements and the surface of the packaged device in which the plurality of contact elements are disposed, the alignment plate may include at least one opening defined therein to allow the contact elements of the packaged device to be in electrical contact with the arranged conductive elements, the alignment plate may include a plurality of openings defined therein with each opening corresponding to one of a plurality of contact elements disposed on the surface of the packaged device, the alignment plate may include an outer surface positioned adjacent the perimeter wall member and an inner surface facing inward towards the adapter axis with the inner surface formed to include arc surface portions corresponding to certain perimeter solder spheres of a ball grid array package mounted in the socket cavity, or the alignment structure may include a lip portion of the perimeter wall member extending inward towards the adapter axis at the first end of the perimeter wall member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a cross-section side view of a packaged device adapter assembly according to the present invention mounted on a target board.

FIG. **1**B is a bottom exploded perspective view of the packaged device adapter assembly of FIG. **1**A.

FIG. **2**A is a cross-section side view of an alternate packaged device adapter assembly according to the present invention mounted on a target board.

FIG. **2**B is a top exploded perspective view of the packaged device adapter assembly shown in FIG. **2**A.

FIG. **3** is another alternate embodiment of a packaged device adapter assembly showing a particular alignment structure according to the present invention.

FIG. **4** is yet another alternate embodiment of a packaged device adapter assembly showing another alternate alignment structure according to the present invention.

FIG. **5** is yet another alternate embodiment of a packaged device adapter assembly including a particular cover structure according to the present invention.

FIG. **6** shows a packaged device adapter assembly similar to that shown in FIG. **2**A and further including a particular embodiment of a target board useable with the adapter assembly according to the present invention.

FIG. **7** also shows a packaged device adapter assembly similar to that shown in FIG. **2**A in addition to yet another alternate embodiment of a target board useable with the adapter assembly according to the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Generally, packaged device adapter assemblies for use with packaged devices, e.g., high density devices, shall be

described herein. Generally, a first illustrative packaged device adapter assembly **10** according to the present invention shall be described with reference to illustrative FIGS. **1**A and **1**B. Various other illustrative embodiments of packaged device adapter assemblies according to the present invention including features which may be included in combination with features or structure of the other assemblies as described herein shall be described with reference to FIGS. **2**–**7**. One skilled in the art will recognize from the description herein, that the various illustrative embodiments described include some features or elements included in other illustrative embodiments and/or exclude other features.

However, a packaged device adapter assembly according to the present invention may include any combination of elements selected from one or more of the various embodiments as described herein with reference to FIGS. **1**–**7**. For example, as will be readily apparent from the description below, an adhesive retaining surface described with reference to FIGS. **1**A and **1**B may be used with the alignment structure described with reference to FIGS. **2**A and **2**B. Further, for example, the cover member **460** described with reference to FIG. **5** may be used with one or more of the various adapter assembly embodiments described with reference to FIGS. **1**A–**1**B, **2**A–**2**B, **3** or **4**.

FIGS. **1**A and **1**B show a cross-section side view and a bottom exploded perspective view, respectively, of an illustrative packaged device adapter assembly **10** for use with a packaged device **80** according to the present invention. Generally, the packaged device adapter assembly **10** is for mounting on a target board **90**. The packaged device adapter assembly **10** includes a perimeter wall member **12** having a length along an adapter axis **13**. Generally, the length of the perimeter wall member **12** extends between a first end **14** of the perimeter wall member **12** and a second end **16** of the perimeter wall member **12** and includes an inner surface **18** facing towards the adapter axis **13** and an opposing outer surface **20** facing away from the adapter axis **13**.

The packaged device adapter assembly **10** further includes a conductive element layer **30** including a plurality of arranged conductive elements **32** therein, e.g., a conductive elastomer layer. The perimeter wall member **12** and the conductive element layer **30** including the plurality of arranged conductive elements **32** generally define a socket cavity **15** sized for receiving a packaged device **80** therein.

Generally, the packaged device **80** includes an upper surface **82** and a lower surface **84** in addition to an edge surface **88** extending therebetween at the perimeter of the packaged device **80**. A plurality of contact elements **86** are disposed on the lower surface **84**. Preferably, the contact elements **86** are distributed in an array along x and y axes orthogonal to the adapter axis **13**. However, any arrangement of contact elements **86** may be accommodated according to the present invention.

The packaged device **80** may be any packaged device having a plurality of contact elements **86** disposed on a surface thereof. Preferably, the packaged device is a device having a high density of contact terminals, e.g., solder spheres, bumps, contact pads, leads, etc., disposed on a surface thereof For example, the high density packaged device may be a ball grid array package as shown in FIG. **1**A and in the various other illustrative embodiments shown in the other figures described herein. However, the packaged device **80** may also be, for example, a chip scale package, a flip chip package, a flat package, a quad flat package, a small outline package, a micro ball grid array package, or any other package having contact elements disposed on a surface thereof. Although the present invention is described herein with reference to a ball grid array package as illustrated in the figures, the present invention is in no manner limited to use of the illustrative adapter apparatus embodiments described herein with only ball grid array packages. Rather, the adapter assemblies and adapter concepts described herein may be used with any packaged device having contact elements disposed on a surface thereof.

Further, the packaged device adapter assembly **10** includes a cover member **60** positioned at the second end **16** of the perimeter wall member **12** to close the socket cavity **15**. The cover member **60** is generally movable, e.g., removable via fastening devices **59** as shown in FIG. **1**A, moveable about a hinge axis **417** as shown in FIG. **5**, etc. This allows the packaged device **80** to be removed from the socket cavity **15** and another packaged device placed therein. The packaged device adapter assembly **10** is generally used to provide electrical contact between the contact elements **86** of the packaged device **80** and contact pads **92** of the target board **90** via the arranged conductive elements **32** of conductive element layer **30**, when the packaged device **80** is positioned in the socket cavity **15**.

The packaged device adapter assembly **10** further includes a floating member **40** as shown in FIGS. **1**A and **1**B. The floating member **40** is used in combination with an actuator element **70** to provide a distributed force on the packaged device **80** when received in the socket cavity **15** such that the contact elements **86** disposed on the lower surface **84** of the packaged device **80** are in effective electrical contact with the arranged conductive elements **32** of the conductive element layer **30**. The floating member **40** preferably includes an upper surface **41** that is generally planer and orthogonal to the adapter axis **13** when the floating member **40** is positioned in the socket cavity **15**. Further, the floating member **40** preferably includes a lower surface **42** that is configured as a function of the upper surface **82** of the packaged device **80**. For example, as shown in FIG. **1**A, lower surface **42** of the floating member **40** is generally planer and in direct contact with the planar upper surface **82** of a packaged device **80**. However, as shown in FIG. **2**A, the lower surface **142** of the floating member **140** is configured according to the upper surface **182** of the packaged device **180** and is not planer. However, in both cases, the lower surface **42**, **142** of the floating member **40**, **140** is in direct contact with the upper surface **82**, **182** of the packaged device **80**, **180**. Further, as shown in FIG. **1**A, the floating member **40** preferably includes an edge surface **44** extending between the upper surface **41** and the lower surface **42** at the perimeter of the floating member **40**. The edge surface **44** lies adjacent, and may even be in contact with, the perimeter member wall **12** and is moveable relative thereto within the socket cavity **15**.

The actuator element **70** may be any actuator element operable to apply a force on the upper surface **41** of the floating member **40**. As a force is applied by the actuator element **70** to the upper surface **41** of the floating member **40**, the force is distributed generally equally along the upper surface **82** of the packaged device **80**. As such, an equivalent force is provided at each contact element **86**, e.g., solder ball, for effective contact between each contact element **86** and one or more conductive elements **32**, e.g., conductive strands of a conductive elastomer layer. Such a distributed force across the entire packaged device **80** reduces the potential application of excessive force on one part of the packaged device **80** versus another part thereof, e.g., the center versus the perimeter.

Preferably, the actuator element **70** is an element associated with the cover member **60**. For example, the actuator element may be a spring element, a leaf spring, or any other flexible element capable of applying a force to the floating member **40** via the association with the cover member **70**. Further, although not preferred, the cover member **70** itself may be used to apply a force to the floating member **40** such as by tightening the cover member directly down on the floating member **40** by fastening elements, e.g., screws **59**.

Preferably, the actuator element **70** is a threaded element that includes a head portion **72** with a threaded portion **74** extending therefrom. Further, preferably, the cover member **60** includes a threaded insert **65** positionable along the axis **13** of the adapter assembly **10** for mating with the threaded portion **74** of the actuator element **70**. The threaded portion **74** terminates in a generally planer surface **75**. With the packaged device **80** in the socket cavity **15**, the planer surface **75** is placed in direct contact with the upper surface **41** of the floating member **40** by turning the head portion **72** of the actuator element **70**. As such, the actuator element **70** is adjustable to provide an effective force to the upper surface **41** of floating member **40** such that the distributed force is applied for effective electrical coupling of the contact elements **86** to the arranged conductive elements **32** of conductive element layer **30**. With use of the actuator element **70** and the floating member **40**, a suitable distributed force on the packaged device **80** can be achieved. The minimized load applied to the packaged device **80** and thus to the conductive elements **32** of the conductive element layer **30** allows for operation of the adapter assembly **10** over many insertion cycles as the conductive element layer **30** is not unnecessarily damaged by the force applied to the packaged device **80** in order to achieve contact between all of the contact elements **86** and the arranged conductive elements **32**.

Preferably, the floating member **40** is formed of a heat conductive material, e.g., aluminum, to provide heat sinking capability. Further, actuator element **70** and the perimeter wall member **12** and cover **60** are formed of such heat sinking material. In such a manner, the elements that form the socket cavity **15** which provide electrical coupling of the packaged device **80** to a target board **90** also function to dissipate heat away from the packaged device **80** when the packaged device **80** is operable. This is particularly important for high density packaged devices such as ball grid array packages, chip scale packages, flip-chip packages, etc., in that the packaged device **80** tends to operate with greater heat output.

As can be readily seen from FIG. **1A**, the floating member **40** is sized and configured such that edge **44** thereof is in moveable contact with inner surface **18** of the perimeter wall member **12** which allows heat conduction therethrough and away from the packaged device **80**. Likewise, the contact between the actuator element **70**, such as a screw formed of aluminum, provides for heat conduction from the threaded portion **74** (which is in direct contact with the floating member **40**) to the head portion **72** of the actuator element **70**. The head portion **72** is sized and configured to provide a large surface area for heat dissipation therefrom.

The perimeter wall member **12** includes an inner surface **18** facing inward towards the adapter axis **13** and an outer surface **20** facing in an opposing direction generally away from the adapter axis **13**. The outer surface **20** includes an adhesive retaining surface **22** adjacent the first end **14** of the perimeter wall member **12**. Generally, any adhesive retaining surface **22** which provides for mounting the adapter assembly **10** to the target board **90** without the use of any particular adaptation of the target board, e.g., the drilling of holes therein, the attachment of structure thereto, etc., may be used according to the present invention.

Preferably, the adhesive retaining surface **22** includes a plurality of grooves or channels **23** for receiving adhesive material **77**, e.g., an epoxy, and is retained therein and which is also positioned adjacent to target board **90** such that the adapter assembly **10** is affixed to the target board **90** when the adhesive material is set or cured. The channels may be configured and sized in various manners, e.g., vertical channels parallel to the adapter axis **13**, horizontal channels, angled channels, curved channels, etc. However, any adhesive retaining surface **22** may be used according to the present invention. For example, the adhesive retaining surface **22** may be an abrasive surface capable of retaining an adhesive material thereon, may be a ribbed surface, or may be any other surface for retaining an adhesive material thereon.

The adhesive material **77** may be any adhesive material that is suitable for being received by the adhesive retaining surface **22**, such as in grooves **23**, and which is suitable for attaching or mounting the adapter assembly **10** to the target board **90** by contact with the adhesive retaining surface **22** and the target board surface **91**. For example, the adhesive material **77** may be an epoxy, may be a tape product, or may be any other adhesive material suitable for performing such retention or fixation.

As shown in FIG. 1B, the perimeter wall member **12** generally includes a wall member base **21** and an adhesive retaining portion **25**. As such, this wall member **12** may be formed of two separate pieces or it may be formed as a single piece element. It will be recognized that other elements formed herein made also be made of a single or multiple layer structure. For example, the floating member **40** may be formed of one or more layers.

The adapter assembly **10**, as more clearly shown in FIG. 1B, is formed in a substantially square configuration. However, one skilled in the art will recognize that the elements used in forming the packaged device adapter assembly **10** may include elements for forming an adapter assembly configured as a rectangle, a circle, or any other configuration sized to accommodate a packaged device received in a socket cavity therein. As such, one skilled in the art will recognize that the present invention is not limited to any particular shape of adapter assembly but is limited only as described in the appended claims.

The perimeter wall member **12** further has affixed thereto an additional adhesive material **79** to temporarily position an adapter assembly **10** on a target board **90** as will be described further below prior to affixing the adapter assembly **10** to the target board **90** using the adhesive material **77** on the adhesive retaining surface **22** and the target board **90**. For example, the additional adhesive material **79** may include double-sided tape or any other like adhesive.

The cover member **60** of the packaged device adapter assembly **10** may be configured in various manners. The cover member **60** is used to close the socket cavity **15** and includes various other elements associated therewith for facilitating other functionality. For example, as previously described herein, cover member **60** is integrated with a threaded insert **65** for receiving the threaded portion **74** of the actuator element **70** used in applying a direct force to floating member **40**. Further, cover member **60** as shown in FIG. 1A includes openings **61** for receiving corresponding fastening elements **59**, e.g., screws, to affix cover member **60** to the perimeter wall member **12**. In such an embodiment,

the perimeter wall member **12** includes inserts **57** for retaining the fastening elements **59** therein. For example, as shown in FIG. **1**A, inserts **57** may be threaded inserts for retaining threaded screw portions of screws **59** to attach cover member **60** to the perimeter wall member **12**.

However, the cover member **60** may also be configured as a latchable hinge cover **460** as shown in FIG. **5**, e.g., a ZIF type or clam-type lid. FIG. **5** is a cross-section side view of a packaged device adapter assembly **400** which includes a perimeter wall member **412** and a conductive element layer **430** to form a socket cavity for receiving a packaged device **480** in a manner similar to that as shown in FIG. **1**A. However, instead of a screw down cover member **60** as shown in FIG. **1**A, a latchable hinge cover member **460** is shown in FIG. **5**. The latchable hinge cover member **460** is attached at the upper end **416** of the perimeter wall member **412** by hinge mechanism **417**. The latchable hinge cover **460** further includes a latchable closure mechanism **461** to provide for latching of the cover member **460** to the perimeter wall member **412**. For example, as shown in FIG. **5**, the latchable closure mechanism **461** includes a spring **463** coupled to a latch member **462** which is coupled at hinge **465** for operation with spring **463**. One skilled in the art will recognize that this is just one embodiment of a latchable closure mechanism **461** useable in accordance with the present invention and that any closure mechanism for a cover member that is not entirely removed to allow removal of a packaged device from socket cavity **15** may be used according to the present invention.

Also as shown in FIG. **5**, the hinged latchable cover **460** includes a threaded insert **465** for receiving the heat sink screw actuator **470**. Further, also as shown in FIG. **5**, the lower surface **441** of floating member **440** used therein is sized in accordance with the packaged device **480** such that the distributed force from the actuator element **470** is effectively provided to the packaged device **480**.

Further with reference to FIGS. **1**A and **1**B, the conductive element layer **30** includes an upper surface **33** and a lower surface **35**. The arranged conductive elements **32** extend from the upper surface **33** to the lower surface **35** through insulative material to provide isolated conductive paths therethrough. The upper surface **33** is configured to allow contact between the contact elements **86** of the packaged device **80** and the conductive elements **32** arranged therein and the lower surface **35** is configured to allow contact between the conductive elements **32** and the contact pads **92** of the target board **90**.

The conductive element layer **30** including the arranged conductive elements **32** is preferably a conductive elastomer layer. For example, the conductive elastomer layer may be formed of a z-axis elastomer material or a slanted axis conductive elastomer material. For example, such material may be that as described in U.S. Pat. No. 4,923,739 to Jin et al., issued May 8, 1990 and entitled "Composite Electrical Interconnection Medium Comprising a Conductive Network, And Article, Assembly, and Method;" that as described in U.S. Pat. No. 4,754,546 to Lee et al., issued Jul. 5, 1988 and entitled "Electrical Connector for Surface Mounting and Method of Making Thereof;" that as described in U.S. Pat. No. 4,729,166 to Lee et al., issued Mar. 8, 1988 and entitled "Method of Fabricating Electrical Connector for Surface Mounting;" that as described in U.S. Pat. No. 4,668,957 to Spohr, issued May 26, 1987 and entitled "Amorphous Glass Matrix Containing Aligned Microscopically Thin Metal Conductors;" or may be any other conductive elastomer material such as that available from Shin-Etsu Polymer America Inc. (Union City, Calif.) under the trade designation GB-Matrix.

Although the conductive element layer **30** is preferably a conductive elastomer material having conductive elements or material arranged therein, various other layers which include arranged conductive elements **32** therein may also be used according to the present invention. For example, the arranged conductive elements **32** may include formed conductive element structures, stamped conductive elements structures, or any other conductive material for connecting contact elements **86** to contact pads **92** on target board **90**, e.g., pins, springs, pogo pins, or fizz buttons.

As shown in FIG. **1**A, the sizing of various elements therein are used to align the contact elements **86**, e.g., solder spheres, of packaged device **80** with the contact pads **92** of the target board **90**. For example, the inner surface **18** of perimeter wall member **12** may be configured to set edge **88** of the packaged device **80** in contact therewith to assist in alignment of the contact elements **86** with the contact pads **92**. However, preferably, the adapter assemblies described herein include additional alignment structure to precisely position the packaged device **80** over the contact pads **92** of target board **90** in addition to the various alignment functionality already provided by the perimeter wall member **12**. The alignment structure, such as a precise spacer structure, allows for easy and reliable connection of the contact elements **86** of packaged device **80** to the contact pads **92** via the conductive element layer **30** including the arranged conductive elements **32**. Various alignment structures shall be described with reference to FIGS. **1**A–**1**B, **2**A–**2**B, **3**, and **4**.

As shown in FIG. **1**A with regard to the packaged device adapter assembly **10**, the alignment structure is provided by an alignment plate **94** positioned orthogonal to the adapter axis **13** between the upper surface **33** of the conductive element layer **30** and the lower surface **84** of the packaged device **80** on which the plurality of contact elements **86** are disposed. Preferably, the alignment plate **94** includes a planar upper surface **95** adjacent to lower surface **84** of the packaged device **80** and a planar lower surface **96** adjacent to upper surface **33** of conductive element layer **30**. The alignment plate **94** may or may not be in direct contact with adjacent surfaces.

The alignment plate **94** is a planer plate structure having a plurality of openings **97** defined therein. Each opening **97** corresponds to one of the contact elements **86** disposed on the lower surface **84** of the packaged device **80**. For example, when the packaged device **80** is a ball grid array having a plurality of solder spheres disposed on a surface thereof, each opening **97** as shown in FIG. **1**A corresponds to one of the solder spheres. In this manner, when the packaged device **80** is positioned in the socket cavity **15**, the contact elements **86** are precisely positioned on the target board **90** as the openings **97** defined in the alignment plate **94** are sized and configured to directly align the contact elements **86** with the contact pads **92**.

In an alternate embodiment, adapter assembly **100** shown in FIG. **2**A includes perimeter wall member **112** and conductive element layer **130**, e.g., a conductive elastomer layer, which define a socket cavity wherein packaged device **180** is received in a manner like that as described with reference to FIG. **1**A. The alignment structure for providing precise alignment of contact elements **186** with contact pads **187** of target board **190** is provided by alignment plate **194**. Alignment plate **194** includes an upper surface **195** adjacent the lower surface **181** of packaged device **180** and a lower surface **196** adjacent to the conductive element layer **130**. As shown in FIGS. **2**A and **2**B, the alignment plate **194** includes a single opening **198** defined therein for precisely position-

ing contact elements **186** of the packaged device **180** relative to the contact pads **187** of target board **190**. The alignment plate **194** includes an outer surface **177** about the outer perimeter of the alignment plate **194** which is adjacent, and preferably in contact with the perimeter wall **112**, and includes an inner surface **178** about the inner perimeter of the alignment plate **194** defining opening **198**. The inner surface **178** of the alignment plate **194** includes arc portions **199** extending about the inner perimeter. The arc portions **199** correspond to certain perimeter contact elements **186** (e.g., solder spheres of a ball grid array package). With use of alignment plate **194**, by aligning the outer perimeter solder balls of contact elements **186** as shown in FIG. **2**A, the remainder of the solder balls are aligned with the contact pads **187** of the target board **190**.

Alignment structures for precise positioning of contact elements of a packaged device may also be provided by extensions from the perimeter wall member of the adapter assembly as shown in the adapter assembly embodiments of FIGS. **3** and **4**. For example, as shown in FIG. **3**, adapter assembly **200** includes a perimeter wall member **212** having a length along adapter axis **213** between a first end **214** and second end **216** of the perimeter wall member **212**. Generally, the perimeter wall member **212** forms a socket cavity with a conductive element layer **230** for receiving a packaged device **280** therein. The adapter assembly **200** is substantially like the assembly shown in FIG. **2** except without the actuator element.

The perimeter wall member **212** includes a first wall portion **218** which lies generally parallel to the adapter axis **213**. A second wall portion **222** extends adjacent the lower end **214** of the perimeter wall member **212** inward toward adapter axis **213**. Preferably, the second wall portion **222** extends inward generally orthogonal to the adapter axis **213**. This second wall portion **222** forms a lip for providing alignment of the contact elements **286** of packaged device **280** with contact pads **292** of target board **290**. The second wall portion **222** terminates at end surface **224** which is adjacent the conductive element layer **230**, e.g., a conductive elastomer layer, and generally parallel to the adapter axis **213** to accommodate a conductive elastomer layer that has z-axis conductive elements therein. In such a manner, the solder balls **286** of packaged device **280** are aligned to contact pads **292** of target board **290** through a desired number of z-axis conductive elements embedded in conductive elastomer layer **230**.

The alignment structure shown in adapter assembly **300** of FIG. **4** is provided in a manner similar to that shown and described with reference to FIG. **3**. However, the extension of the perimeter wall member **312** accommodates the use of a conductive elastomer layer **330** having slanted conductive elements **322** embedded therein. As shown in FIG. **4**, adapter assembly **300** includes perimeter wall member **312** having a length along adapter axis **313** between a first end **314** and a second end **316**. The perimeter wall member **312** and a conductive elastomer layer **330** form a socket cavity for receiving a packaged device **380** therein. Generally, the perimeter wall member **312** includes a first wall portion **318** which lies generally parallel to adapter axis **313**. Further, the perimeter wall member **312** includes a second wall portion **322** extending generally orthogonal to adapter axis **313** and first wall portion **318** and which extends therefrom towards the axis **313**. The second wall portion **322** terminates at a surface end **324** that is adjacent the conductive elastomer layer **330** and at an angle relative to the adapter axis **313**. The angle is determined at least in part by the angle of the slanted conductive elements embedded in the conductive elastomer layer **330**. In such a manner, the contact elements **382** disposed on a surface of packaged device **380** can be aligned with contact pads **392** of target board **390** through a desired number of angled conductive elements **322** embedded in conductive elastomer **330**. As shown in this particular embodiment, with the adapter assembly **300** mounted to target board **390**, dummy spheres **391** may be used to balance the target board **390** relative to the adapter assembly **300**. In other words, the number of solder spheres on the lower surface of target board **390** are made symmetrical about adapter axis **313**.

The adapter assemblies as described herein may be mounted relative to various target boards as illustrated generally in FIG. **1**A by target board **90**. The target board **90** may be any substrate including contact pads arranged thereon for electrical connection with the adapter assembly **10**. For example, the target board may be a printed circuit board including various other components mounted thereon or may be a surface mountable substrate as shown and described with reference to FIG. **2**A.

As shown in FIG. **2**A, the target board **190** includes an upper surface **191** having a plurality of contact pads **187** disposed thereon for electrical contact with conductive elastomer layer **130**. A plurality of surface mountable solder spheres **193** are disposed on lower surface **192**, e.g., arranged in an array like solder balls **186**. The contact pads **187** are electrically coupled to solder spheres **193** through use of conductive traces or any other. conductive elements generally used to provide electrical contact between conductive elements disposed on opposing surfaces of a substrate. Further, for example, the target board **190** may be formed of FR4 material and printed with conductive traces as performed using conventional printed circuit board fabrication techniques.

As shown in FIG. **2**A, the adapter assembly **100** is mounted to target board **190** in a manner unlike that shown in FIG. **1**A. As shown in FIG. **2**A, target board **190** includes a plurality of openings **179** defined therein for receiving fastening devices **161**, e.g., screws. The perimeter wall member **112** of adapter assembly **100** includes inserts **158**, e.g., threaded inserts, for mating with fastening devices **161**. As such, the target board **190** is mounted adjacent the first end **114** of perimeter wall member **112** by insertion of fastening elements **161** through openings **179** defined in target board **190** and coupled with threaded inserts **158** within perimeter wall member **112**.

The target board upon which the adapter assemblies are mounted may further include other types of target boards such as that shown in FIGS. **6** and **7**. The adapter assemblies shown in FIGS. **6** and **7** are substantially identical to the adapter assembly **100** as shown in FIG. **2**A except that the alignment plate used in FIGS. **6** and **7** is an alignment plate like that shown in FIG. **1**A.

As shown in FIG. **6**, the adapter assembly **100** is mounted relative to target board **590**. Target board **590** includes openings **558** defined therein for attachment of the target board **590** to the adapter assembly **100** using fastening devices **561** in a manner similar to that shown in FIGS. **2**A–**2**B. The target board **590** further includes male pins **593** extending beyond the lower surface **571** and electrically connected to the contact pads **592** disposed on the upper surface **596** thereof. As such, the male pin elements **593** may be used with female socket elements **598** extending from a substrate body **597** of an additional adapter apparatus **599**.

As shown in FIG. **7**, the adapter assembly **100** is mounted relative to target board **600**. Target board **600** includes male

pin elements **693** electrically connected to contact elements **692** disposed on upper surface **606** of target board **600**. Male pin elements **693** extend beyond lower surface **608** of the target board **600** for mating with female socket elements **698** of another adapter apparatus or device **697**. Further, the target board **600** includes conductive traces from contact pads **692** to test probes **602** for use in providing testing of packaged device **680** or a circuit board having other functionality (not shown) mounted relative to the adapter assembly, e.g., via the adapter apparatus **697**.

As such, and as described in FIGS. **6** and **7**, the target board may include a male or female pin interface at the lower surface thereof, the target board may be surface mountable such as when solder balls are mounted at a lower surface thereof, test probes may be integrated with the target board, or any other target board may be mounted relative to the adapter assemblies as described herein.

The adapter assemblies described herein are preferably very small, e.g., 0.2 inches larger than the actual packaged device mounted in the socket cavity thereof. Further, the elements of the adapter assembly are preferably formed of heat conductive material such that heat can be dissipated away from the packaged device mounted in the socket cavities thereof. By providing conductive elements that have a relatively short length along the axis of the adapter assembly to connect the contact elements of the packaged device to a target board, very high speed applications can be performed. The adapter assembly is generally very robust in that it does not lose connections very easily because of the distributed force applied on the packaged device mounted within the adapter assembly. Further, very high density packaged devices can be accommodated, particularly with use of a conductive elastomer layer, and yet further, unlimited number of insertion cycles may be accomplished with replacement of the conductive elastomer as needed.

A method of assembling the adapter assembly **10** shall be further described with reference to FIGS. **1A** and **1B**. Such techniques may be utilized with any of the other adapter assemblies described herein and it will be recognized that any number of various methods of assembly may be used and that the present invention is not limited to the method described herein. Preferably, adapter assembly **10** is assembled in the following manner. First, the alignment plate **94** is positioned on target board **90** with the openings defined in the alignment plate **94** aligned with the contact pads **92** of the target board **90**. The double-sided tape **79** is then positioned about the perimeter of the alignment plate **94**. The alignment plate **94** is then removed for later use.

Thereafter, perimeter wall member **12** is positioned on the double-sided tape **79** to initially fasten at least a portion of the adapter assembly **10** to the target board **90**. The conductive element layer **30**, e.g., a conductive elastomer layer, is then positioned within the perimeter wall member **12** and adjacent the double-sided tape **79** to form cavity **15** in which the packaged device **80** may be placed. Alignment plate **94** is then positioned over conductive element layer **30** and thereafter packaged device **80** is positioned within socket cavity **15**. Floating member **40** is then positioned within socket cavity **15** adjacent to upper surface **82** of packaged device **80** and cover member **60** is mechanically coupled to perimeter wall member **12** via suitable fastening elements **59**. Thereafter, actuator element **70** is threaded into threaded insert **65** of cover member **60** and a force is applied via the actuator element **70** to the upper surface **41** of floating member **40** such that contact elements **86** of packaged device **80** are in effective contact with conductive elements **32** of the conductive element layer **30**. In such a manner, precise alignment of the contact elements **86** with the contact pads **92** is accomplished. It will be recognized that adhesive material **77** may be used to mount the assembly **10** to the target board at any time after the perimeter wall member **12** is positioned on the additional adhesive material **79**. Preferably, the adhesive material **77** is placed in contact with the adhesive retaining surface **22** and an area of the target board **90**.

All patents and references cited herein are incorporated in their entirety as if each were incorporated separately. This invention has been described with reference to illustrative embodiments and is not meant to be construed in a limiting sense. As described previously, one skilled in the art will recognize that various other illustrative adapter assembly embodiments may be provided which utilize various combinations of the elements described herein. Various modifications of the illustrative embodiments, as well as additional embodiments of the invention and combinations of various elements herein, will be apparent to persons skilled in the art upon reference to this description. It is therefore contemplated that the patented claims will cover any such modifications or embodiments that may fall within the scope of the present invention as defined by the accompanying claims.

What is claimed is:

1. An adapter apparatus for receiving a packaged device having a plurality of contact elements disposed on a surface thereof, the apparatus comprising:

a perimeter wall member having a length along an adapter axis between a first end of the wall member and a second end of the wall member;

a conductive element layer including a plurality of arranged conductive elements, the conductive element layer positioned at the first end of the perimeter wall member orthogonal to the adapter axis, wherein the perimeter wall member and the conductive element layer define a socket cavity to receive the packaged device with the plurality of contact elements thereof adjacent the conductive element layer, wherein the conductive element layer is a conductive elastomer layer;

a cover member positioned at the second end of the perimeter wall member to close the socket cavity, wherein the cover member is movable to allow the packaged device to be removed from the socket cavity;

a floating member movable in the socket cavity;

an alignment structure positioned in the socket cavity adjacent the conductive element layer and adjacent the surface of the packaged device on which the plurality of contact elements are disposed to align the contact elements of the packaged device with contact pads on a target board when the adapter apparatus is mounted relative to the target board, wherein the alignment structure comprises:

an alignment plate positioned ortbogonal to the adapter axis between the conductive element layer and the surface of the packaged device on which the plurality of contact elements are disposed, wherein the alignment plate comprises at least one opening defined therein to allow the contact elements of the packaged device to be in electrical contact with the arranged conductive elements of the conductive element layer; and

a lip portion of the perimeter wall member extending inward towards the adapter axis at the first end of the perimeter wall member terminating in a surface used for positioning the conductive elastomer layer; and

an actuator element operable to provide a force on the floating member such that a corresponding force is distributed to the packaged device when received in the socket cavity such that the plurality of contact elements are in electrical contact with the arranged conductive elements of the conductive element layer.

2. The apparatus of claim **1**, wherein the actuator element is associated with the cover member.

3. The apparatus of claim **2**, wherein the actuator element is a threaded element movable in a threaded insert of the cover member.

4. The apparatus of claim **3**, wherein the threaded element includes a heat sink head portion with a threaded portion extending therefrom.

5. The apparatus of claim **1**, wherein the floating member is a plate member having a surface configured as a function of a surface of the packaged device, wherein the surface of the plate member is positioned in direct contact with the surface of the packaged device when the packaged device is received in the socket cavity.

6. The apparatus of claim **1**, wherein the packaged device is one of a ball grid array package, a chip scale package, a flip chip package, a flat package, a quad flat package, and a small outline package.

7. The apparatus of claim **1**, wherein the perimeter wall member has an inner surface facing towards the adapter axis and an outer surface facing in an opposing direction, wherein the outer surface of the perimeter wall member includes an adhesive retaining surface adjacent the first end thereof.

8. The apparatus of claim **7**, wherein the adhesive retaining surface is one or more channels located adjacent the first end of the perimeter wall.

9. The apparatus of claim **7**, wherein the apparatus further includes an additional adhesive material applied on the first end of the perimeter wall.

10. The apparatus of claim **7**, wherein the apparatus further includes an adhesive material applied to the adhesive retaining surface such that the adhesive material is also in contact with a target board.

11. The apparatus of claim **10**, wherein the target board is one of a target board having male pins extending therefrom, a target board including female socket elements, a target board having test points associated therewith, a printed circuit board, and a target board having solder spheres on one side thereof.

12. The apparatus of claim **1**, wherein the perimeter wall member includes one or more openings therein for accepting one or more corresponding fastening devices, wherein the fastening devices extend from a target board such that the target board can be mounted adjacent the conductive element layer with contact pads on the target board in electrical contact with the arranged conductive elements thereof.

13. The apparatus of claim **12**, wherein the target board is one of a target board having male pins extending therefrom, a target board including female socket elements, a target board having test points associated therewith, a printed circuit board, and a target board having solder spheres on one side thereof.

14. The apparatus of claim **1**, wherein the cover member includes a hinged member and a closure structure operable to latch the hinged member in a desired position relative to the perimeter wall member.

15. The apparatus of claim **1**, wherein the alignment plate includes a plurality of openings defined therein, wherein each opening corresponds to one of the plurality of the contact elements disposed on the surface of the packaged device.

16. The apparatus of claim **15**, wherein the packaged device is a ball grid array package having a plurality of solder spheres disposed on a surface thereof, and wherein each opening defined in the alignment plate corresponds to one of the plurality of solder spheres.

17. The apparatus of claim **1**, wherein the packaged device is a ball grid array package having a plurality of solder spheres disposed on a surface thereof, and further wherein the alignment plate includes a single opening defined therein sized to allow solder spheres of the ball grid array package to be in electrical contact with the arranged conductive elements of the conductive element layer.

18. The apparatus of claim **17**, wherein the alignment plate includes an outer surface positioned adjacent the perimeter wall member and an inner surface facing inward towards the adapter axis, wherein the inner surface is formed to include arc surface portions corresponding to certain perimeter solder spheres of the ball grid array package.

19. The apparatus of claim **1**, wherein the lip portion of the perimeter wall member extending inward towards the adapter axis at the first end of the perimeter wall member terminates in a surface generally parallel to the adapter axis.

20. The apparatus of claim **1**, wherein the conductive element layer includes conductive elements therein that are at an angle relative to the adapter axis, and further wherein the lip portion of the perimeter wall member extending inward towards the adapter axis at the first end of the perimeter wall member terminates in a surface positioned at an angle relative to the adapter axis for use in positioning solder spheres adjacent the conductive element layer having angled conductive elements.

21. An adapter apparatus for receiving a packaged device having a plurality of contact elements disposed on a surface thereof, the apparatus comprising:

a perimeter wall member having a length along an adapter axis between a first end of the wall member and a second end of the wall member, wherein the perimeter wall member has an inner surface facing towards the adapter axis and an outer surface facing in an opposing direction, wherein the outer surface of the perimeter wall member includes an adhesive retaining surface adjacent the first end thereof, wherein the adhesive retaining surface includes one or more channels located adjacent the first end of the perimeter wall member such that when an adhesive material is applied to the adhesive retaining surface the adhesive material is also in contact with a target board;

a conductive element layer including arranged conductive elements, wherein the conductive element layer is positioned at the first end of the perimeter wall member orthogonal to the adapter axis, and further wherein the perimeter wall member and the conductive element layer define a socket cavity to receive the packaged device with the plurality of contact elements thereof in electrical contact with the arranged conductive elements of the conductive element layer; and

a cover member positioned at the second end of the perimeter wall to close the socket cavity, wherein the cover member is movable to allow the packaged device to be removed from the socket cavity.

22. The apparatus of claim **21**, wherein the apparatus further includes an additional adhesive material applied on the first end of the perimeter wall member.

23. The apparatus of claim **22**, wherein the additional adhesive material is double-sided tape.

24. The apparatus of claim **21**, wherein the target board is one of a target board having male pins extending therefrom,

a target board including female socket elements, a target board having test points assocated therewith, a printed circuit board, and a target board having solder spheres on one side thereof.

25. The apparatus of claim **21**, wherein the conductive element layer is a conductive elastomer layer.

26. An adapter apparatus for receiving a packaged device having a plurality of contact elements disposed on a surface thereof, the apparatus comprising:

a perimeter wall member having a length along an adapter axis between a first end of the wall member and a second end of the wall member;

a conductive element layer including arranged conductive elements, wherein the conductive element layer is positioned at the first end of the perimeter wall member orthogonal to the adapter axis, and further wherein the perimeter wall member and the conductive element layer define a socket cavity to receive the packaged device with the plurality of contact elements thereof in electrical contact with arranged conductive elements of the conductive element layer, wherein the conductive element layer is a conductive elastomer layer,

a cover member positioned at the second end of the perimeter wall to close the socket cavity, wherein the cover member is movable to allow the packaged device to be removed from the socket cavity;

an alignment structure positioned in the socket cavity adjacent the conductive element layer and adjacent the surface of the packaged device on which the plurality of contact elements are disposed to align the contact elements of the packaged device with contact pads on a target board when the adapter apparatus is mounted relative to the target board, wherein the alignment structure comprises an alignment plate positioned orthogonal to the adapter axis between the conductive element layer and the surface of the packaged device on which the plurality of contact elements are disposed, and further wherein the alignment plate comprises a plurality of openings defined therein, wherein each opening corresponds to one of the plurality of the contact elements disposed on the surface of the packaged device to allow each of the contact elements of the packaged device to be in electrical contact with the arranged conductive elements of the conductive element layer; and

27. The apparatus of claim **26**, wherein the packaged device is a ball grid array package having a plurality of solder spheres disposed on a surface thereof, and wherein each opening defined in the alignment plate corresponds to one of the plurality of solder spheres.

28. The apparatus of claim **26**, wherein the alignment structure includes a lip portion of the perimeter wall member extending inward towards the adapter axis at the first end of the perimeter wall member.

29. The apparatus of claim **28**, wherein the lip portion of the perimeter wall member extending inward towards the adapter axis at the first end of the perimeter wall member terminates in a surface generally parallel to the adapter axis.

30. The apparatus of claim **28**, wherein the conductive element layer includes conductive elements therein that are at an angle relative to the adapter axis, and further wherein the lip portion of the perimeter wall member extending inward towards the adapter axis at the first end of the perimeter wall member terminates in a surface positioned at an angle relative to the adapter axis for use in positioning solder spheres adjacent the conductive element layer having angled conductive elements therein.

31. An adapter apparatus for receiving a packaged device having a plurality of contact elements disposed on a surface thereof, the apparatus comprising:

a perimeter wall member having a length along an adapter axis between a first end of the wall member and a second end of the wall member;

a conductive element layer including arranged conductive elements, wherein the conductive element layer is positioned at the first end of the perimeter wall member orthogonal to the adapter axis, and further wherein the perimeter wall member and the conductive element layer define a socket cavity to receive the packaged device with the plurality of contact elements thereof in electrical contact with arranged conductive elements of the conductive element layer, wherein the conductive element layer is a conductive elastomer layer;

a cover member positioned at the second end of the perimeter wall to close the socket cavity, wherein the cover member is movable to allow the packaged device to be removed from the socket cavity;

an alignment structure positioned in the socket cavity adjacent the conductive element layer and adjacent the surface of the packaged device on which the plurality of contact elements are disposed to align the contact elements of the packaged device with contact pads on a target board when the adapter apparatus is mounted relative to the target board, wherein the alignment structure is an alignment plate positioned orthogonal to the adapter axis between the conductive element layer and the surface of the packaged device on which the plurality of contact elements are disposed, and further wherein the alignment plate includes at least one opening defined therein to allow the contact elements of the packaged device to be in electrical contact with the arranged conductive elements of the conductive element layer, wherein the packaged device is a ball grid array package having a plurality of solder spheres disposed on a surface thereof, and wherein the alignment plate comprises a single opening defined therein sized to allow the solder spheres of the ball grid array package to be in electrical contact with the arranged coductive elements of the conductive element layer, and further wherein the alignment plate comprises an outer surface postioned adjacent the perimeter wall member and an inner surface facing inward towards the adapter axis, wherein the inner surface is formed to include are surface portions corresponding to certain perimeter solder spheres of the ball grid array package; and

an actuator element operable to provide a force on the packaged device in the socket cavity such that the plurality of contact elements are in electrical contact with the arranged conductive elements of the conductive element layer.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

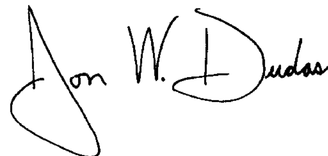
PATENT NO. : 6,533,589 B1
DATED : March 18, 2003
INVENTOR(S) : Palaniappa et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 17,
Line 45, insert -- an actuator element operable to provide a force on the packaged device in the socket cavity such that the plurality of contact elements are in electrical contact with the arranged conductive elements of the conductive element layer. --

Signed and Sealed this

Second Day of March, 2004



JON W. DUDAS
Acting Director of the United States Patent and Trademark Office