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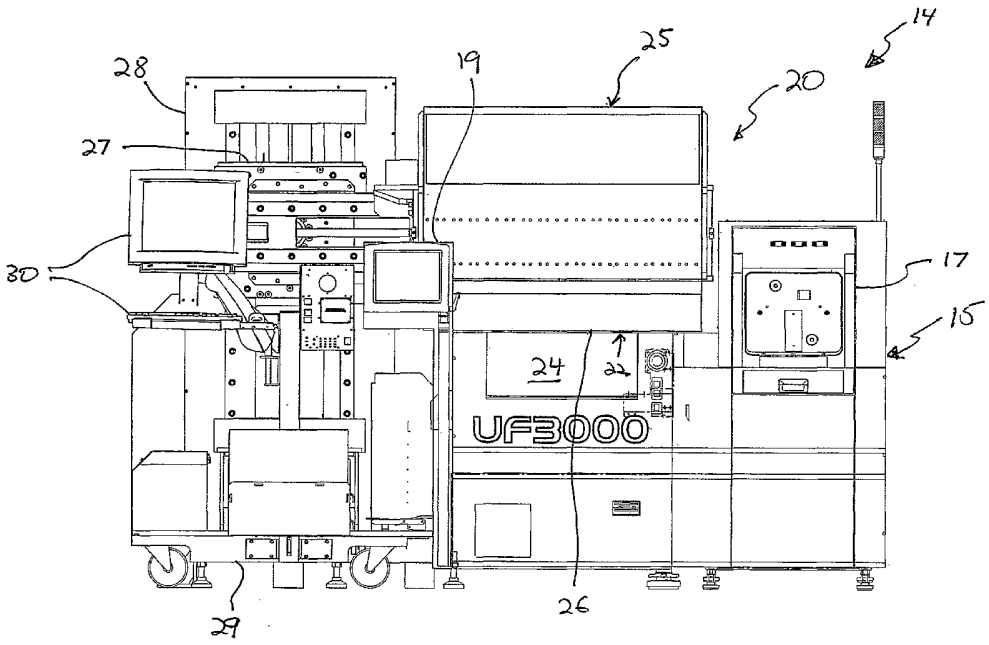
[Continued on next page]

(54) Title: APPARATUS FOR PLANARIZING A PROBE CARD AND METHOD USING SAME



(57) Abstract: An apparatus (69) for use with a wafer prober (15) and a probe card (34) comprising a stiffening member (60) having a feature (68) defining a first plane. The stiffening member is mountable atop the central portion (56) of the probe card. A reference member (42) is provided to mount to the wafer prober and has an underside with a feature (44) defining a second plane. When the feature of the stiffening member defining the first plane is urged against the feature of the reference member defining a second plane the probe elements (59) of the probe card are substantially planarized relative to the wafer prober.

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APPARATUS FOR PLANARIZING A PROBE CARD AND METHOD USING SAME

The present invention relates generally to systems for testing integrated circuits in wafer form and, more particularly, to apparatus for planarizing probe cards for use therewith.

Manufacturers in the electronics industry use automatic test systems or testers to test various electronic components, integrated circuits (ICs) and other devices under test (DUTs) to cull out defective devices. For example, data patterns are delivered to an integrated circuit with specific timing and voltage settings through timing generators and pin electronic channels to test the functionality of the integrated circuit. Data is then read from the integrated circuit to ensure that the device responds correctly. A variety of parametric timing tests may also be performed to validate correct operation of the integrated circuit as well as adherence to its specifications. Generally, it is desirable to test integrated circuits at several points during the manufacturing process, including while they are still part of a wafer or substrate.

Equipment used in wafer testing can include a wafer prober and an automated test system. A conventional wafer prober has a movable chuck which serves to transport the wafer to a position underlying a probe card mounted to the top deck of the wafer prober by being clamped at its periphery. A probe array is typically provided on the underside of the probe card for engaging the bonding pads of one or more die on the wafer. A plurality of contact elements, electrically coupled with the probe array, are usually provided at the periphery on the top of the probe card. The automated test system includes one or more testers which overlie the top deck of the wafer probe and have an electrical interface for electrically engaging the contact elements of the probe card.

Unfortunately, changes in temperature and mechanical forces experienced by the probe card during testing can result in distortion of the probe card, thus deflecting the generally unsupported central portion of the probe card where the probe array is located. The larger the probe card, the more deflection can occur in the probe card. Such distortion of the probe card can result in undesirable alignment errors between the probe array of the probe card and the chuck, thus compromising the accuracy or completeness of the testing of die carried by the chuck.

In view of the foregoing, it would be desirable to minimize distortion of the probe card, particularly in the vicinity of the probe array mounted to the underside of the probe card.

FIG. 1 is an elevational view of an automatic test system and wafer prober using the apparatus for planarizing a probe card of the present invention.

FIG. 2 is an exploded, schematic side elevational view of a portion of the automatic test system and wafer prober of FIG. 1 showing the apparatus for planarizing a probe card of the present invention.

FIG. 3 is a schematic, perspective view of the wafer prober of FIG. 1 having a top deck with a reference plate thereon.

FIG. 4 is a schematic, top plan view of a probe card for use with the apparatus for planarizing a probe card of FIG. 2.

FIG. 5 is a schematic, side elevational view taken along the line 5-5 of FIG. 4, of the probe card of FIG. 4.

FIG. 6 is a perspective view of a latching plate of the apparatus for planarizing a probe card of FIG. 2.

FIG. 6A is an enlarged view of a portion of the latching plate of FIG. 6 indicated by the circle 6A of FIG. 6.

FIG. 7 is a top plan view of the latching plate of FIG. 6.

FIG. 7A is an enlarged view of a portion of the latching plate of FIG. 6 indicated by the circle 7A of FIG. 7.

FIG. 8 is a top plan view of the apparatus for planarizing a probe card of FIG. 2 in a first position.

FIG. 9 is a cross-sectional view of the apparatus for planarizing a probe card of FIG. 2 taken along the line 9-9 of FIG. 8.

FIG. 10 is a top plan view the apparatus for planarizing a probe card of FIG. 2 positioned relative to the reference plate of the wafer prober.

FIG. 11 is a top plan view, similar to FIG. 8, of the apparatus for planarizing a probe card of FIG. 2 in a second position.

FIG. 12 is a cross-sectional view, similar to FIG. 9, of the apparatus for planarizing a probe card of FIG. 2 taken along the line 12-12 of FIG. 11.

FIG. 13 is a top plan view, similar to FIG. 8, of the apparatus for planarizing a probe card of FIG. 2 in a third position.

FIG. 14 is a cross-sectional view, similar to FIG. 9, of the apparatus for planarizing a probe card of FIG. 2 taken along the line 14-14 of FIG. 13.

FIG. 15 is a top plan view, similar to FIG. 8, of the apparatus for planarizing a probe card of FIG. 2 in a fourth position.

FIG. 16 is a cross-sectional view, similar to FIG. 9, of the apparatus for planarizing a probe card of FIG. 2 taken along the line 16-16 of FIG. 15.

FIG. 17 is a schematic, side elevational view of the apparatus for planarizing a probe card of FIG. 2 in an engaged position.

FIG. 18 is a schematic side elevational view, similar to FIG. 2, of a portion of the automatic test system and wafer prober of FIG. 1 showing the apparatus for planarizing a probe card of FIG. 2 in an engaged position.

FIG. 19 is a schematic top plan view of a wafer prober utilizing another embodiment of the apparatus for planarizing a probe card of the present invention.

FIG. 20 is a schematic, cross-sectional view of the wafer prober of FIG. 19 taken along the line 20-20 of FIG. 19.

FIG. 21 is a schematic, top plan view of a circular probe card for use with the apparatus for planarizing a probe card of FIG. 19.

FIG. 1 illustrates the main components of a wafer testing system 14, namely a wafer prober 15 and an automated test system 20. Although any suitable wafer prober can be utilized, a suitable wafer prober is of the type manufactured as model number UF3000 by Accretech located in Tokyo, Japan. Wafer prober 15 generally includes a wafer loader 17, controls 19 and a housing 21 provided with a top deck 22 and an access door 24 (see FIG. 1).

Automated test system 20 can be of any suitable type, such as of the type disclosed in copending U.S. application Serial No. 10/170,916 filed June 12, 2002 [Attorney Docket No. A-71001], the entire content of which is incorporated herein by this reference. The automated test system 20 includes one or more testers and as shown a single tester 25 having

a test head 26. The tester 25 is supported above the wafer prober 15 by a support arm 27 that is vertically adjustable on a post 28 upstanding from a wheelable base 29. The system 20 further includes controls 30. FIG. 2 shows a schematic and enlarged view of portions of the wafer prober 15 and test system 20 and specifically the interface between the test head 26 and the wafer prober 15 for performing automated wafer testing. The wafer prober 15 includes a movable chuck 30, located behind the access door 24 of the wafer prober, having a top substantially planar surface 32 on which a wafer 33 is placed. Typically, top deck 22 of the wafer prober 15 is a reference plane to which probe manufacturers planarize chuck 30 so that the top deck 22 is therefore planar and parallel with respect to the top surface 32 of the chuck 30. A plurality of die (not shown) have been formed on the wafer 33, each have a plurality of bonding pads, contact pads or other contact interconnects formed on its top surface.

Each test head 26 includes an electrical interface 36, for example input/output blocks, for outputting test signals to the die undergoing testing and receiving response signals from the die to be analyzed by the automate test system 20 (see FIG. 2). The electrical interface 36 includes a plurality of test pins 38 for electrically connecting the test head 26 to the probe card 34 and hence to the die electrically connected to the probe card 34. The test pins 38 are arranged to contact a corresponding plurality of contact pads 39 on the probe card 34, which are illustrated in FIG. 4.

The system of the invention further includes a reference member or plate 42 mounted to or integral with the top deck plate 22 of the prober 15 (see FIGS. 2 and 3). The reference plate 42, more clearly illustrated in FIG. 3 which shows a perspective top view of the wafer prober 15 without the test head 26, is supported above the probe card 34 by the top deck 22. Reference plate 42 preferably bridges over the central opening in top deck 22, as shown in FIG. 3, and is more preferably centered over the top deck. The reference or support member 42, which can be a thick, highly planar plate made from any suitable material such as metal or ceramic. Reference member 42 preferably has a feature defining a plane, which is preferably on the underside of the reference member 42. Such feature is planar with the top deck 22, and hence parallel to and planar with respect to the top surface 32 of the chuck 30, and is preferably a planar bottom surface 44. To achieve a high degree of planarity for reference surface 44, the reference plate 42 is preferably made from a rigid material, for example a metal such as steel or aluminum. Access openings 46 are provided between the reference plate 42 and the top deck 22 to permit the electrical interface 36 of the test head 26 to access the underlying probe card 34.

A probe card 34 is carried by the wafer prober and provides an electrical interface between the one or more test heads 26 of the test system 20 and a die of the wafer 33 undergoing testing (see FIG. 2). Probe card 34 includes a substrate layer which can be made from any suitable dielectric material and is preferably a printed circuit board (PCB) 48 having a first or top surface 49 and an opposite second or bottom surface 50 (see FIGS. 4 and 5). A plurality of contact pads 39 are formed on the top surface 49 of the PCB 48 and are preferably located in a peripheral portion 52 of the probe card 34. The contact pads 39, some of which are shown in FIG. 4, are arranged in one or more patterns and accessible from the top of the probe card 34. The plurality of test pins 38 of the test head 26 are arranged in a corresponding one or more patterns as the pattern of contact pads 39 to permit contact and registration of the test pins 38 with the contact pads 39. Contact pads 39, including pluralities of distinct arrays thereof, can extend partially or completely around the peripheral portion 52 of the probe card 34. Accordingly, it is appreciated that the invention is broad enough to cover cards 34 having contact pads 39 disposed only at portions of the periphery 52, such as along two sides as shown in FIG. 4. The probe card 34 can further include a substrate member, for example block 54 made from ceramic or any other suitable material, secured or rigidly coupled to the bottom surface 50 of the PCB 48 and located within a central portion 56 of the probe card 34. The central portion 56 of the card 34 is preferably that portion of the card 34 interior of contact pads 39 and more preferably that portion of the card 34 beneath the central portion of the reference plate 42.

A probe array or assembly 58 descends or depends from the centrally-disposed block 54, which supports the probe array 58 (see FIG. 5). The probe elements or probes 59 of the probe array 58 are arranged in a pattern corresponding to the pattern of contact bonding pads or balls of the die undergoing testing. Each of the probes 59 has a probe end or tip which registers with and engages a contact pad of the die when the probe array 58 engages the wafer 33. The probe tips of the probe array 58 are aligned in a plane, sometimes referred to herein as the plane of the probe array 58. Electrical leads are provided in the probe card 34, for example conductive traces (not shown) within the PCB 48, for electrically coupling the contact pads 39 on the top surface 49 of the PCB 48 to the probes 59 of the probe array 58 descending from the central portion 56 of the underside of PCB 48.

The probe card 34 preferably further includes a stiffening member or plate 60 attached to the top surface 49 of the PCB 48 within the central portion 56 of the probe card 34 (see FIGS. 4 and 5). The stiffener plate 60 is preferably made from any suitable rigid

material such as metal and may be attached to the PCB 48 by screws (not shown). The stiffener plate 60 adds rigidity to the central portion 56 of the probe card 34. The probe card 34 further includes three or more planarizing adjustment screws 62 for adjusting the plane of the probe array 58, and specifically the plane formed by the tips of the probes 59, with respect to the plane of the stiffener plate 60. More specifically, screws 62 permit the plane of the probe array 58 to be made substantially parallel to the plane of the stiffener plate 60.

The central portion of probe card 34, and preferably stiffener plate 60, includes a feature defining a plane. Such feature is preferably a plurality of at least three alignment elements 65 are attached to the stiffener plate 60 within the central portion 56 of the probe card 34 and extend outwardly, and preferably upwardly, from the probe card 34 (see FIGS. 4 and 5). The alignment elements 65 have top surfaces 68 and are arranged on the stiffener plate 60 such that the top surfaces 68 substantially define a plane. As shown in FIG. 4, the alignment elements 65 are spaced apart so as to form the shape of a triangle, preferably an equilateral triangle, when viewed in plan. The alignment elements 65 are preferably made out of metal that can be machined with a high degree of accuracy. The plane formed by the top surfaces 68 of the alignment elements, that is the feature of the probe card defining a plane, is preferably substantially parallel to the plane of the plane of the probe array 58 and preferably the plane of the stiffener plate 60.

A means or cooperating mechanism is included for urging the feature of the probe card 34 defining a plane against the reference member 42 and preferably the feature of the reference member 42 defining a plane. In the illustrated embodiment, such means or apparatus 69 includes alignment elements 65 and serves to make the plane formed by the tips of probes 59 planar or parallel with the bottom surface 44 of reference plate 42. Apparatus 69 can part of a cooperating mechanism of the invention that is carried by the reference member 42 and the central portion of the probe card 34 for rigidly coupling the central portion of the probe card 34 to the reference member 42. Such cooperating mechanism and apparatus 69 preferably include a latching mechanism 70 mounted to the reference plate 42 for latching the alignment elements 65 of the probe card 34 to the reference plate 42. Preferably, the latching mechanism 70 lifts and urges the top surface 68 of the alignment elements 65 against the bottom, planar surface 44 of the reference plate 42. Latching mechanism 70 is rigidly coupled to wafer prober 15, and preferably to top deck 22 thereof. In one preferred embodiment, illustrated herein, the latching mechanism is bolted or otherwise rigidly secured to reference plate 42.

Gripping or latching mechanism 70 according to one embodiment of the invention includes a latch member or plate 171 having a first or top surface 172 and an opposite second or bottom surface 173 (see FIGS. 6 and 7). A plurality of holes or slots 176 adapted to engage or receive at least a portion of respective alignment elements 65 extend through surfaces 172 and 173 of the latching plate. The alignment elements or latch pins 65 are preferably in the form of mushroom latch pins with indentations such as annular groves177 extending around the cylindrical body of the alignment element for facilitating latching of the element 65 by the plate 171 (see FIGS. 2 and 9). Each keyhole slot 176 includes an enlarged opening 178 large enough for the head 179 of an alignment element 65 to pass therethrough and an inner ledge 180 that slides into the groove 177 of the alignment element 65 to engage the alignment element 65 beneath the head 179 of the element 65.

The gripping or latching assembly or mechanism 170 further includes a lift plate 182 positioned above the latch plate 171, as shown in FIGS. 8 and 9. Side portions 184 of the latch plate 171 extend beyond the lift plate 171, as shown in FIG. 8, and underneath the reference plate 42 of the wafer prober 15, shown in phantom lines in FIG. 8 and solid line in FIG. 9. The keyhole slots 76 are located within the side portions 184 of the latch plate 171 and are therefore not covered by the overlying lift plate 182. The lift plate 182 is mechanically coupled to the underlying latch plate 171 by six mechanical couplers or fasteners 185. The latching mechanism 70 includes an actuator or mechanism 186, shown schematically in FIG. 8, that is mechanically coupled to the lift plate 182 for moving the lift plate 182 and the latch plate 171 mechanically coupled to the lift plate 182 laterally and upwardly. The actuator may be of any suitable type, such as pneumatic, hydraulic, electric, mechanical or any combination of the foregoing.

Each mechanical coupler 185, one of which is illustrated in some detail in FIG. 9, is preferably from an I-shaped body or pin 187 extending through the lift plate 182. The pin 187 has a flanged top end 189 seated against a spring 191 and a flanged bottom end 194 seated in a key shaped slot 195, similar to slot 176, formed in the latch plate 171. The spring 191 is preferably a suitable stack of bellevelle washers extending concentrically around the pin 187 and seated or disposed within a cavity or bore 196 formed in the lift plate 182. The spring 191 biases the pin 187 by having a first or top end rest or push against the top end 189 of the pin 187 and the second or bottom end rest or push against an inner surface of a flange 196 forming the bottom of cavity 192.

FIG. 10 shows a top view of the latching mechanism 70 relative to the reference plate 42 of the wafer prober 15. The lift plate 182 is positioned within an opening 194 of the reference plate 142. The side portions 184 of the latch plate 171 are positioned beneath the reference plate 42, and therefore not visible in FIG. 10, so as to position the keyhole slots 176 located within the side portions 184 beneath the lower planar surface 44 of the reference plate 42. FIG. 9 shows one of the keyhole slots 176 beneath the lower planar surface 44 of the reference plate 42.

In the method of operating and using apparatus 69, latching mechanism 70 engages and lifts the alignment elements 65 upwardly to urge the top surfaces 68 of the alignment elements 65 against the bottom planar surface 44 of the reference plate 42. A latching sequence utilizing apparatus 69 is described with reference to FIGS. 8-17. The operator initially loads probe card 34 into wafer prober 15 by means of access door 24. The probe card 34 is placed onto an internal mechanism of the wafer prober (not shown) which delivers the probe card to a position beneath latching mechanism 70, which position is similar to the position illustrated in FIG. 9 where only a portion of the probe card 34 is shown. Such internal mechanism aligns elements 65 with the large openings 178 of the keyholes slots 176, as illustrated in FIGS. 8 and 9, and then raises the alignment elements 65 to align grooves 177 of the elements 65 with the inner ledges 180 of the keyhole slots 176, as illustrated in FIGS. 11 and 12. The lift plate 171 is then slid laterally by the actuator 186 referred to above, thereby sliding the latch plate 171 coupled to the lift plate 182 laterally. This causes the inner ledges 80 of the keyhole slots 176 to engage the annular grooves 177 of the alignment elements 65 (see FIGS. 13 and 14). The lift plate 182 is then raised upwardly by the actuator, thereby lifting the latch plate 147 upwardly until all of the top surfaces 68 on the heads 179 of the alignment elements 65 engage the bottom planar surface 44 of the reference plate 42 (see FIGS. 15 and 16). The probe card 34 is electrically connected to the die by having the chuck 30 mechanically position the wafer 33 so that bonding pads of the die contact respective probe elements or probes 59 of the probe card 34.

The nonrigid attachment of the latch plate 171 to the lift plate 182, by means of couplers 185, permits the latch plate to separate from the lift plate as necessary to accommodate any misalignment between the plates 171 and 182, such as the top surface of the latch plate 171 not being parallel to the bottom surface 44 of the reference plate 42 when all of the top surfaces 68 of the alignment elements 65 have engaged the reference plate 42. More specifically, each of the couplers 185 can float within its respective cavity 192 to

permit such movement between plates 171 and 182. Springs 191 serve to urge or push against the flanged top ends 189 of couplers 185 so as to continually urge top surfaces 168 of the alignment elements 65 against the planar surface 44 of the reference plate 42 regardless of any such movement of latch plate 171 relative to lift plate 182. The amount of each such spring force can be predetermined by adjustment of the amount that the spring 191 is initially compressed within the lift plate 182. Preferably, the alignment elements 65 are urged against the planar surface 44 with sufficient force to prevent translation and rotation of the alignment elements 65, and the probe card 34 attached thereto, relative to the reference plate 22 during the operation of system 14.

FIG. 17 shows the probe card 34 attached to the reference plate 22 and thus wafer prober 15 by means of apparatus 69 and latching mechanism 70 thereof. As shown therein, as well as in FIG. 16, a gap 196 exists between the bottom surface of latch plate 171 and the top surface of stiffener plate 60 when the probe card 34 has been referenced and affixed to the reference plate as described above. Gap 196 desirably accommodates any irregularities, misalignments or lack of planarity between the stiffener plate 60 and the reference plate 22 which may exist prior to the operation of system 14 or which may come about as a result of changes in temperature or mechanical forces experienced by the probe card 34, during the operation of the system 14.

As can be seen, apparatus 69 and the method of the present invention serve to planarize the top surfaces 68 of the alignment elements 65 with the bottom planar surface 44 of the reference plate 42 and hence the top surface 32 of the chuck 30. Because the plane of the probe array 58 is planar with the plane of the top surfaces 68 of the alignment elements 65 and the plane of such top surfaces 68 is planar with the plane of the chuck 30 when urged against the planar surface 44 of the reference plate 42, the plane of the probe array 58 is planar with the plane of the chuck 30 so as to facilitate proper engagement of the probe array 58 with die on the wafer 33 and thus accurate testing of such die. In the latched state, the latching mechanism 70 thus firmly holds the central portion 56 of the probe card 58 planar with the chuck 30.

The system of the invention offers advantages over the prior art. One advantage is that distortions of the probe card 34 outside the central portion 56 of the probe card 34 have minimal effect on planarization of the probe array 58 because the central portion 56 is held planar by the reference plate 42. FIG. 18 illustrates how distortions of the PCB 48 of the probe card 34 do not affect the planarization of the probe array 58. Apparatus 69 can thus

reduce the need to provide a stiffener plate extending beyond the central portion 56 of the probe card 34 to maintain planarity of the probe array 58, thereby reducing the weight of the probe card 34.

Another advantage is that the reference plate 42 adds rigidity to the central portion 56 of the probe card 34 by holding the central portion 56 planar to the reference plate 42. In addition, the reference plate 42 does not increase the thermal mass of the probe card 34 because the reference plate 42 is thermally isolated from the probe card 34 by a gap 96, assuming negligible thermal conduction through the alignment elements 65. As a result, the reference plate 42 is subject to significantly less thermal distortion during temperature testing of the wafer. Low thermal mass is important because it reduces the time required for the temperature of the probe card 34 to stabilize during temperature testing of the wafer.

Apparatus 69, and the method of the present invention, serve to rigidly couple or secure the central portion 56 of the probe card 34 to the bridging support member 42 and thus to wafer prober 15. In the preferred embodiment, the peripheral portion 52 of the probe card 34 is free of the reference plate 42, that is not supported by the reference plate 42 or the wafer prober 15. Nothwithstanding the foregoing, the invention is broad enough to cover methods and apparatus where some small portion or percentage of the peripheral portion 52 of the probe card 34 is contacted by the wafer prober, for example for purposes other than supporting the probe card 34. The invention is also broad enough to cover methods and apparatus where some small portion or percentage of the peripheral portion 52 of the prober card 34 is supported by the wafer prober, such as by the reference plate 42 or top probe deck 22, so long as the main or significant proportion or majority of the weight of the probe card 34 is supported by the central portion 56 of the card 34.

Supporting probe card 34 substantially or preferably solely by the central portion 56 advantageously serves to free the peripheral portion 52 of the probe card 34 for other purposes. For example, freeing the peripheral portion 52 of the probe card from support pins or other support elements can expand the methods and means by which test head 36 can engage the probe card 34.

The invention can be used to planarize the probe arrays of various types of probe cards, including circular and other nonrectangular-shaped probe cards. In another embodiment of the apparatus for planarizing a probe card of the present invention, a reference plate 242 for use with a circular probe card 234 is provided. The reference plate

242, shown on a circular top deck 222 of a wafer prober 215 in FIGS. 19 and 20, has a central portion 245 with spokes 247 extending therefrom and attaching to or integral with the circular top deck 222. The spokes 247 rigidly support the reference plate 242 above the circular probe card 234, a peripheral portion 252 of which is shown in FIG. 19 underlying the reference plates 242. Contact pads 239 are provided on the upper surface of the substrate layer or printed circuit board 248 of the card 234. For simplicity, only a single array of the contact pads 239 are shown in FIG. 19. Spokes 247 are arranged to provide access openings 249 therebetween so that an appropriately configured test head 36 can access the underlying probe card 234, and specifically contact pads 239 thereon. The latching mechanism and reference planar surface (not shown), similar to latching mechanism 70 and reference planar surface 44 described above, are located in the central portion 245 of the reference plate 142.

The circular probe card 234, shown in plan in FIG. 21, includes a stiffener plate 260 within a central portion 256 of the probe card 234 and exemplary arrays 240 of contact pads 239 arranged in a ring along a periphery 252 of the probe card 234. A probe array, not shown but similar to probe array 58 described above, descends from a bottom of the probe card 234 within the central portion 256. Three or more alignment elements 265, which can be substantially similar to alignment elements 65 described above, are attached to the stiffener plate 270 within central portion 156 and extend upwardly from the probe card 234. The alignment elements 256 cooperate with reference plate 234 in the manner described above to planarize or make parallel the probe array with respect to the top surface of the chuck (not shown) of the wafer prober 215. More specifically, the top surfaces of the alignment elements 265 are urged against the bottom planar surface of the reference plate 242.

It should be appreciated from the foregoing that the reference member or plate of the present invention can be configured and shaped to accommodate any sized and shaped probe card. As discussed above, for example, the reference plate can be rectangular or circular in plan. Openings or apertures can be provided in the reference plate, in any suitable configuration, for permitting access to the contact pads of a probe card positioned beneath the reference plate. For example, round reference plate 242 is provided with spokes which define openings therebetween for accessing arrays of contact pads 239 provided on a circular probe card 234.

It is appreciated that the feature of the reference member defining a plane referenced above is not limited to a planar surface but can be of any suitable configuration. For

example, such feature can be a plurality of spaced-apart, outwardly-extending alignment elements like elements 65 above. Similarly, the feature of the probe card defining a plane is not limited to the spaced-apart outwardly-extending alignment elements 65 discussed above, but can be of any suitable configuration. Thus, for example, outwardly-extending alignment elements, such as alignment elements 65 above, can be provided on reference member or plate 42 or elsewhere on the wafer prober, instead of on stiffening plate 60 as discussed above. Where, for example, the alignment elements depend from the reference plate 42 and have end surfaces defining a plane that is parallel to the upper surface 32 of the chuck 30, a planar reference surface is provided on the probe card, for example as the upper surface of stiffening plate 60, which is parallel to the plane of the probe array 58. A latching assembly or mechanism, for example similar to latching mechanism 70, can be mounted on the top of the central portion of the probe card for gripping the alignment elements of the reference member in the manner described above with respect to mechanism 70. Alternatively, when the alignment elements are provided on the reference member or elsewhere on the wafer prober the latching assembly or mechanism can be rigidly coupled to the wafer prober, such as to reference member 42 as described above, for gripping a set of coupling elements extending upwardly from the stiffening plate 60 or elsewhere on the central portion of the probe card. Such an embodiment could thus have alignment elements depending from the reference member and coupling elements, for example similar to alignment elements 65, upstanding from the stiffening plate 60. It is further appreciated that any reference plane of the invention can be formed from a single surface or a set of distinct surfaces that extend in a single plane.

Although a latching mechanism was employed in the preferred embodiment, other means may be employed to urge the top surfaces of the alignment elements of the apparatus of the present invention against the bottom planar surface of the reference plate. For example, the entire probe card may be raised toward the reference plate so that the top surfaces of the alignment element abut against the bottom planar surface of the reference plate. This may be done, for example, by securing the probe card to a movable plate capable of raising and lowering the probe card. The probe card may be grasped, clamped or otherwise moved at its peripheral portion or any other portion.

In one aspect of the invention, an apparatus for use with a wafer prober and with a probe card having a substrate layer provided with central and peripheral portions and a depending probe assembly mounted to the central portion of the substrate layer and having a

plurality of probe elements provided with respective probe tips extending substantially in a first plane and an array of contact elements accessible from above the substrate layer and electrically coupled with respective probe elements for permitting electrical communication with the probe elements is provided. The apparatus can comprise a stiffening member having a feature defining a second plane, the stiffening member being adapted to mount atop the central portion of the substrate layer so that the second plane is substantially parallel to the first plane, and a reference member adapted for mounting to the wafer prober and having an underside with a feature defining a third plane whereby when the feature of the stiffening member defining the second plane is urged against the feature of the reference member defining a third plane the first plane extends substantially parallel to the third plane so that the probe tips are substantially planarized relative to the wafer prober.

Such apparatus can be for use with a wafer prober having a top deck and the reference member can be configured to bridge over the top deck. The feature of the reference member defining a third plane can be a bottom surface extending substantially in the third plane, or the feature of the reference member defining a third plane can be a plurality of at least three spaced-apart, downwardly-extending alignment elements having respective end surfaces substantially defining the third plane. The feature of stiffening member defining a second plane can be a plurality of at least three spaced-apart, upwardly-extending alignment elements having respective end surfaces substantially defining the second plane, and such apparatus can further comprise a gripping assembly carried by the reference member for engaging the alignment elements and moving the alignment elements so that the end surfaces engage the feature of the reference member defining a third plane and for retaining the end surfaces of the alignment elements against such feature of the reference member. Such apparatus can comprise means for urging the feature of the stiffening member defining a second plane against the feature of the reference member defining a third plane, and the urging means can be carried by the reference member. The substrate layer can be a printed circuit board.

In another aspect of the invention, a probe card for use with a wafer prober having a top deck provided with a reference member and a tester to test an integrated circuit on a wafer is provided. The probe card can comprise a substrate layer having central and peripheral portions and top and bottom surfaces, a probe assembly depending from the central portion of the substrate layer and having a plurality of probe elements adapted to engage the integrated circuit, the probe elements provided with respective probe tips extending

substantially in a first plane, an array of contact elements on the top surface of the peripheral portion of the substrate layer and electrically coupled with respective probe elements for permitting electrical communication with the probe elements, a stiffening member mounted on the central portion of the substrate layer and having a feature defining a second plane that is substantially parallel to the first plane whereby when the feature of the stiffening member defining the second plane is urged against the reference member the first plane of the probe tips is substantially planarized relative to the wafer prober.

The feature of the stiffening member defining a second plane can be a plurality of at least three spaced-apart upwardly extending alignment elements having respective end surfaces substantially defining the second plane, and the alignment elements can be pins. The alignment elements can be spaced apart so as to form the shape of a triangle when viewed in plan.

In another aspect of the invention, a wafer prober for use with a tester to test an integrated circuit on a wafer is provided. The wafer probe can comprise a housing provided with a chuck therein having an upper planar surface adapted for carrying the wafer, the housing having a top deck provided with a reference member, the reference member having a first plane defined by at least one surface of the reference member and substantially parallel to the upper surface of the chuck, a probe card overlying the chuck and having a substrate layer formed from a nonconductive material, the substrate layer having central and peripheral portions and top and bottom surfaces, a probe assembly mounted on the bottom surface of the central portion of the substrate layer and having a plurality of probe elements adapted to engage the integrated circuit, the probe elements provided with respective probe tips extending substantially in a second plane, and a stiffening plate mounted on the central portion of the substrate layer and having a third plane defined by at least one surface of the stiffening plate and substantially parallel to the second plane, one of the at least one surface of the reference member and the at least one surface of the stiffening plate being end surfaces of a plurality of at least three spaced-apart, outwardly-extending alignment elements and the other of the at least one surface of the reference member and the at least one surface of the stiffening plate being a surface extending in a plane whereby when the stiffening plate is urged against the reference plate the end surfaces of the alignment elements engage the surface extending in a plane so that the second plane of the probe tips is substantially parallel to the upper surface of the chuck.

Such wafer prober can comprise a gripping assembly carried one of the reference member and the stiffening plate for gripping and urging the alignment elements against the surface extending in a plane. The gripping assembly can be carried by the reference member and can include a mechanism configured to capture and grip the alignment elements. The reference member of such wafer prober can have the plurality of at least three spaced-apart, outwardly-extending alignment elements, or the stiffening plate of such wafer prober can have the plurality of at least three spaced-apart, outwardly-extending alignment elements.

In another aspect of the invention, a method for use with a probe card having a central portion with a depending probe assembly and a feature defining a plane and for use with a wafer prober provided with a top deck having a reference member is provided. The method can comprise urging the feature in the central portion of the probe card defining a plane against the reference member to align the probe assembly relative to the wafer prober.

Such method can comprise securing the central portion of the probe card to the wafer prober. The feature of the probe card defining a plane can be a plurality of at least three spaced-apart, upwardly-extending alignment elements having respective end surfaces substantially defining the plane. The reference member can have a bottom surface extending substantially in a plane, and the urging step can include urging the feature of the probe card defining a plane against the bottom surface of the reference member. The feature of the probe card defining a plane can be a planar surface.

In another aspect of the invention, an apparatus for use with a wafer prober having a top deck is provided. The apparatus can comprise a support member adapted to mount on the top deck in a position bridging the top deck, a probe card having central and peripheral portions, the probe card having a probe assembly depending from the central portion of the probe card, and a cooperating mechanism carried by the support member and the central portion of the probe card for rigidly coupling the probe card to the support member.

The probe card can have a substrate layer, and the cooperating mechanism can include a stiffening member mounted atop the substrate layer. The cooperating mechanism can include a latching mechanism rigidly coupled to the support member.

In a further aspect of the invention, a method for securing a probe card having central and peripheral portions to a wafer prober is provided. The method can comprise securing the central portion of the probe card to the wafer prober, the peripheral portion of the probe card being free of the wafer prober.

Such method can be for use with a wafer prober having a top probe deck provided with a reference member, and the securing step can include securing the central portion of the probe card to the reference member.

As can be seen from the foregoing, an apparatus for planarizing a probe card has been provided which minimizes distortion of the probe card, particularly in the vicinity of the probe array mounted to the underside of the probe card. The apparatus can include a plurality, preferably a plurality of at least three, alignment elements disposed in the central portion of the probe card for aligning the planarity of the probe array provided on the underside of the probe card with a reference plate of a wafer prober. The alignment elements can be urged against a reference plane of the reference plate by being grasped by a latching mechanism or by engaging any other portion of the probe card so as to urge the alignments elements secured thereto against the reference plate.

CLAIMS

We claim:

1. An apparatus for use with a wafer prober and with a probe card having a substrate layer provided with central and peripheral portions and a depending probe assembly mounted to the central portion of the substrate layer and having a plurality of probe elements provided with respective probe tips extending substantially in a first plane and an array of contact elements accessible from above the substrate layer and electrically coupled with respective probe elements for permitting electrical communication with the probe elements comprising a stiffening member having a feature defining a second plane, the stiffening member being adapted to mount atop the central portion of the substrate layer so that the second plane is substantially parallel to the first plane, and a reference member adapted for mounting to the wafer prober and having an underside with a feature defining a third plane whereby when the feature of the stiffening member defining the second plane is urged against the feature of the reference member defining a third plane the first plane extends substantially parallel to the third plane so that the probe tips are substantially planarized relative to the wafer prober.

2. The apparatus of Claim 1 for use with a wafer prober having a top deck wherein the reference member is configured to bridge over the top deck.

3. The apparatus of Claim 1 wherein the feature of the reference member defining a third plane is a bottom surface extending substantially in the third plane.

4. The apparatus of Claim 1 wherein the feature of the reference member defining a third plane is a plurality of at least three spaced-apart, downwardly-extending alignment elements having respective end surfaces substantially defining the third plane.

5. The apparatus of Claim 1 wherein the feature of stiffening member defining a second plane is a plurality of at least three spaced-apart, upwardly-extending alignment elements having respective end surfaces substantially defining the second plane.

6. The apparatus of Claim 5 further comprising a gripping assembly carried by the reference member for engaging the alignment elements and moving the alignment elements so that the end surfaces engage the feature of the reference member defining a third plane and for retaining the end surfaces of the alignment elements against such feature of the reference member.

7. The apparatus of Claim 1 further comprising means for urging the feature of the stiffening member defining a second plane against the feature of the reference member defining a third plane.

8. The apparatus of Claim 7 wherein the urging means is carried by the reference member.

9. The apparatus of Claim 1 wherein the substrate layer is a printed circuit board.

10. A probe card for use with a wafer prober having a top deck provided with a reference member and a tester to test an integrated circuit on a wafer comprising a substrate layer having central and peripheral portions and top and bottom surfaces, a probe assembly depending from the central portion of the substrate layer and having a plurality of probe elements adapted to engage the integrated circuit, the probe elements provided with respective probe tips extending substantially in a first plane, an array of contact elements on the top surface of the peripheral portion of the substrate layer and electrically coupled with respective probe elements for permitting electrical communication with the probe elements, a stiffening member mounted on the central portion of the substrate layer and having a feature defining a second plane that is substantially parallel to the first plane whereby when the feature of the stiffening member defining the second plane is urged against the reference member the first plane of the probe tips is substantially planarized relative to the wafer prober.

11. The probe card of Claim 10 wherein the feature of the stiffening member defining a second plane is a plurality of at least three spaced-apart upwardly extending alignment elements having respective end surfaces substantially defining the second plane.

12. The probe card of Claim 11 wherein the alignment elements are pins.

13. The probe card of Claim 11 wherein the alignment elements are spaced apart so as to form the shape of a triangle when viewed in plan.

14. A wafer prober for use with a tester to test an integrated circuit on a wafer comprising a housing provided with a chuck therein having an upper planar surface adapted for carrying the wafer, the housing having a top deck provided with a reference member, the reference member having a first plane defined by at least one surface of the reference member and substantially parallel to the upper surface of the chuck, a probe card overlying the chuck and having a substrate layer formed from a nonconductive material, the substrate layer having central and peripheral portions and top and bottom surfaces, a probe assembly mounted on

the bottom surface of the central portion of the substrate layer and having a plurality of probe elements adapted to engage the integrated circuit, the probe elements provided with respective probe tips extending substantially in a second plane, and a stiffening plate mounted on the central portion of the substrate layer and having a third plane defined by at least one surface of the stiffening plate and substantially parallel to the second plane, one of the at least one surface of the reference member and the at least one surface of the stiffening plate being end surfaces of a plurality of at least three spaced-apart, outwardly-extending alignment elements and the other of the at least one surface of the reference member and the at least one surface of the stiffening plate being a surface extending in a plane whereby when the stiffening plate is urged against the reference plate the end surfaces of the alignment elements engage the surface extending in a plane so that the second plane of the probe tips is substantially parallel to the upper surface of the chuck.

15. The wafer prober of Claim 14 further comprising a gripping assembly carried one of the reference member and the stiffening plate for gripping and urging the alignment elements against the surface extending in a plane.

16. The wafer prober of Claim 15 wherein the gripping assembly is carried by the reference member.

17. The wafer prober of Claim 15 wherein the gripping assembly includes a mechanism configured to capture and grip the alignment elements.

18. The wafer prober of Claim 14 wherein the reference member has the plurality of at least three spaced-apart, outwardly-extending alignment elements.

19. The wafer prober of Claim 14 wherein the stiffening plate has the plurality of at least three spaced-apart, outwardly-extending alignment elements.

20. A method for use with a probe card having a central portion with a depending probe assembly and a feature defining a plane and for use with a wafer prober provided with a top deck having a reference member comprising urging the feature in the central portion of the probe card defining a plane against the reference member to align the probe assembly relative to the wafer prober.

21. The method of Claim 20 further comprising securing the central portion of the probe card to the wafer prober.

22. The method of Claim 20 wherein the feature of the probe card defining a plane is a plurality of at least three spaced-apart, upwardly-extending alignment elements having respective end surfaces substantially defining the plane.

23. The method of Claim 22 wherein the reference member has a bottom surface extending substantially in a plane and wherein the urging step includes urging the feature of the probe card defining a plane against the bottom surface of the reference member.

24. The method of Claim 20 wherein the feature of the probe card defining a plane is a planar surface.

25. An apparatus for use with a wafer prober having a top deck comprising a support member adapted to mount on the top deck in a position bridging the top deck, a probe card having central and peripheral portions, the probe card having a probe assembly depending from the central portion of the probe card, and a cooperating mechanism carried by the support member and the central portion of the probe card for rigidly coupling the probe card to the support member.

26. The apparatus of Claim 25 wherein the probe card has a substrate layer, the cooperating mechanism including a stiffening member mounted atop the substrate layer.

27. The apparatus of Claim 25 wherein the cooperating mechanism includes a latching mechanism rigidly coupled to the support member.

28. A method for securing a probe card having central and peripheral portions to a wafer prober comprising securing the central portion of the probe card to the wafer prober, the peripheral portion of the probe card being free of the wafer prober.

29. The method of Claim 28 for use with a wafer prober having a top probe deck provided with a reference member wherein the securing step includes securing the central portion of the probe card to the reference member.

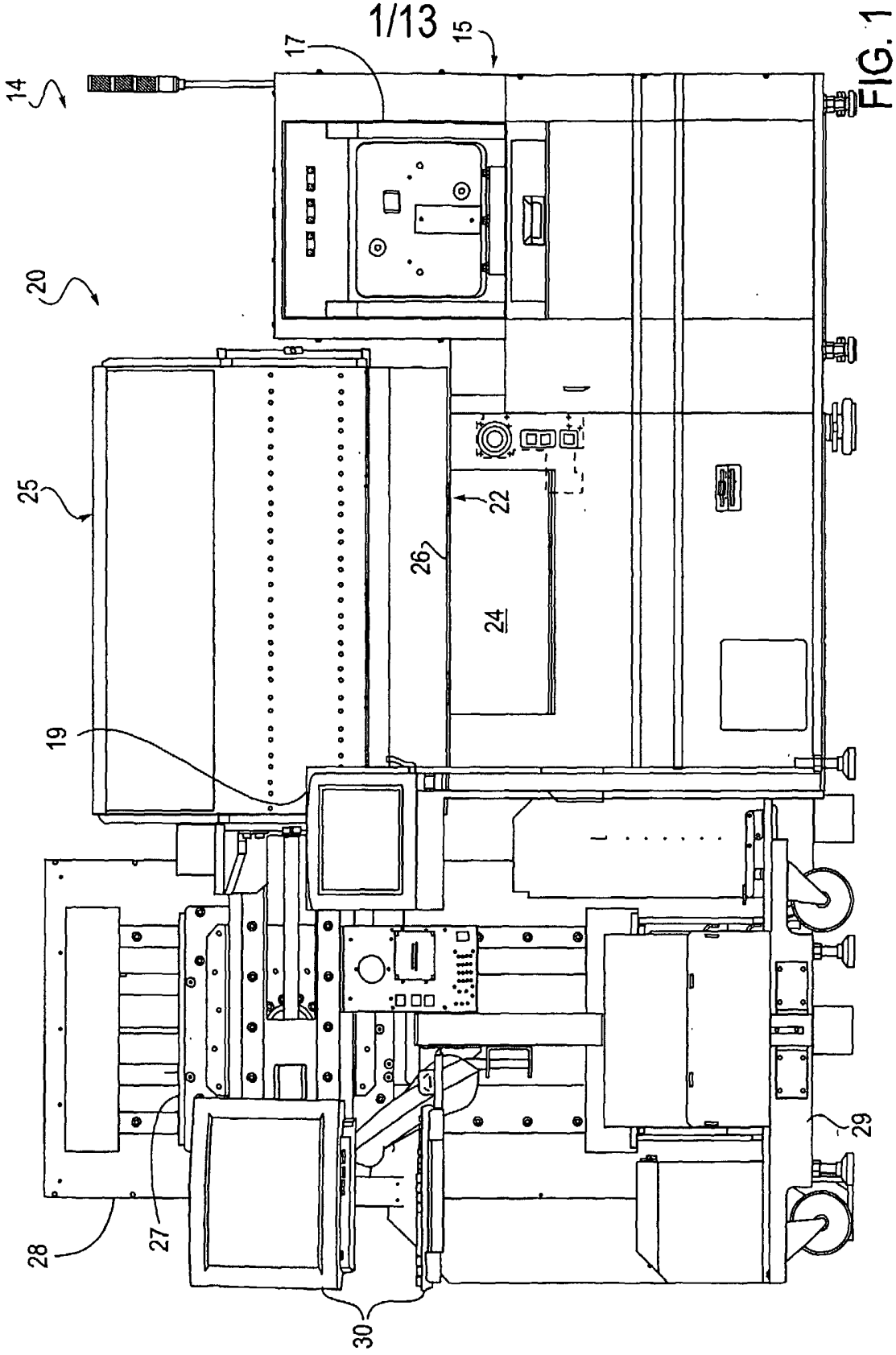
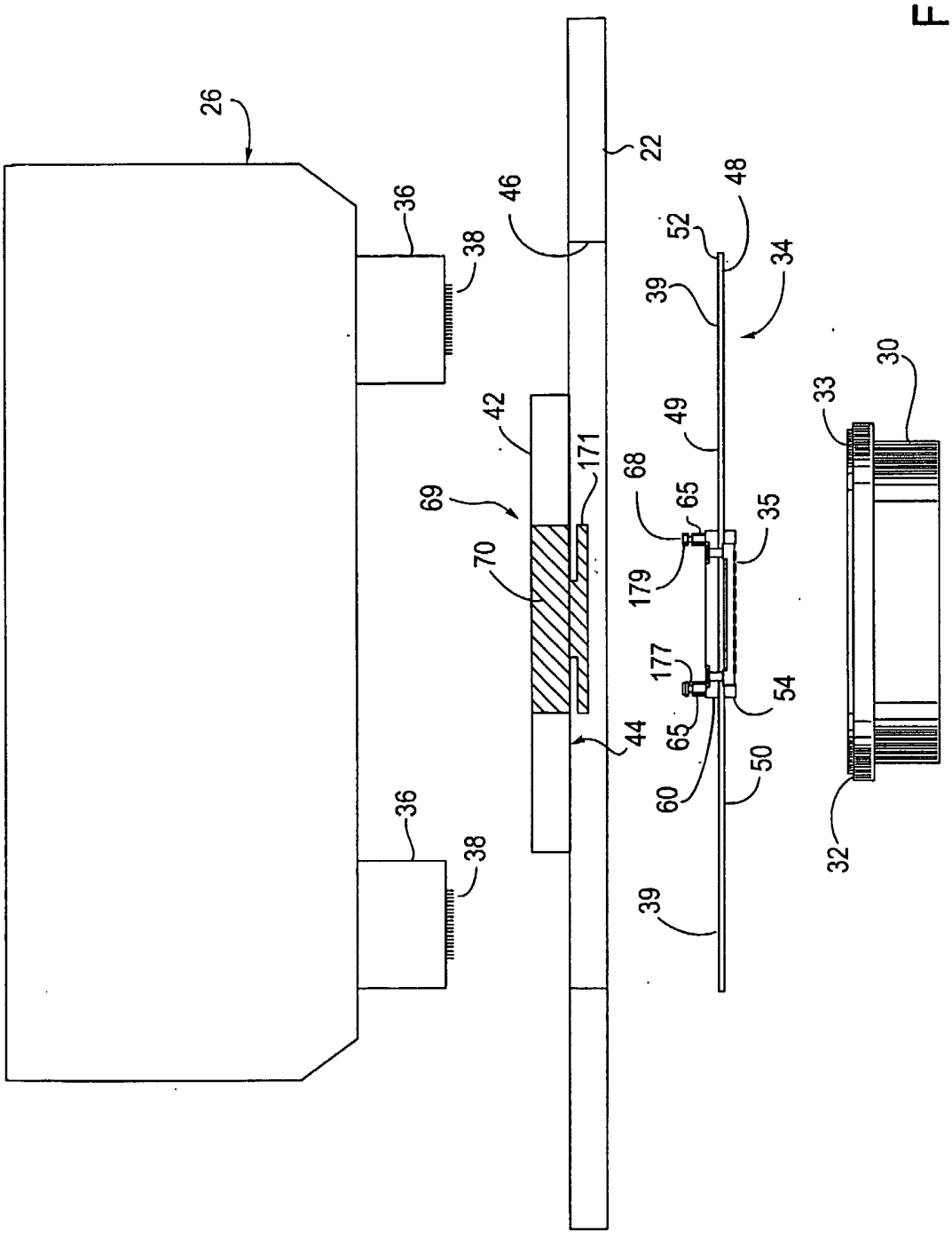


FIG. 1

FIG. 2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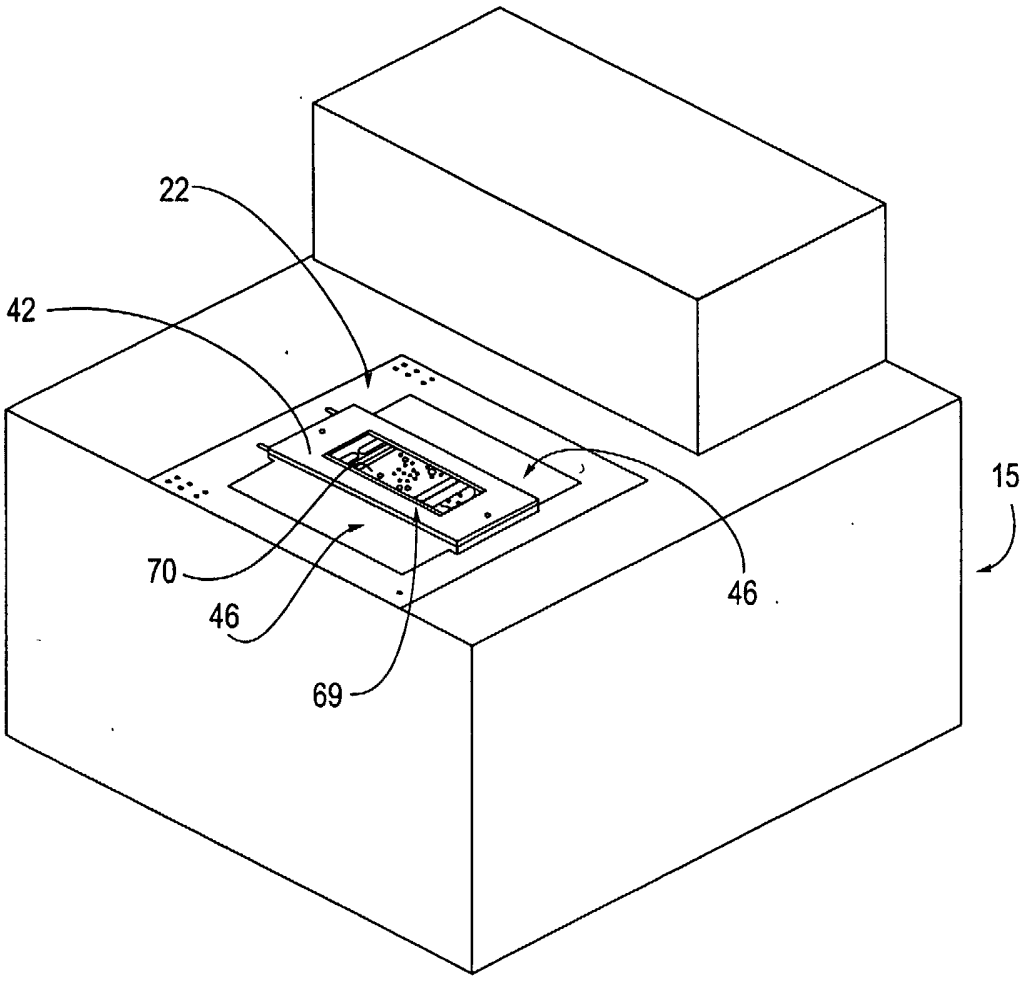

FIG. 3

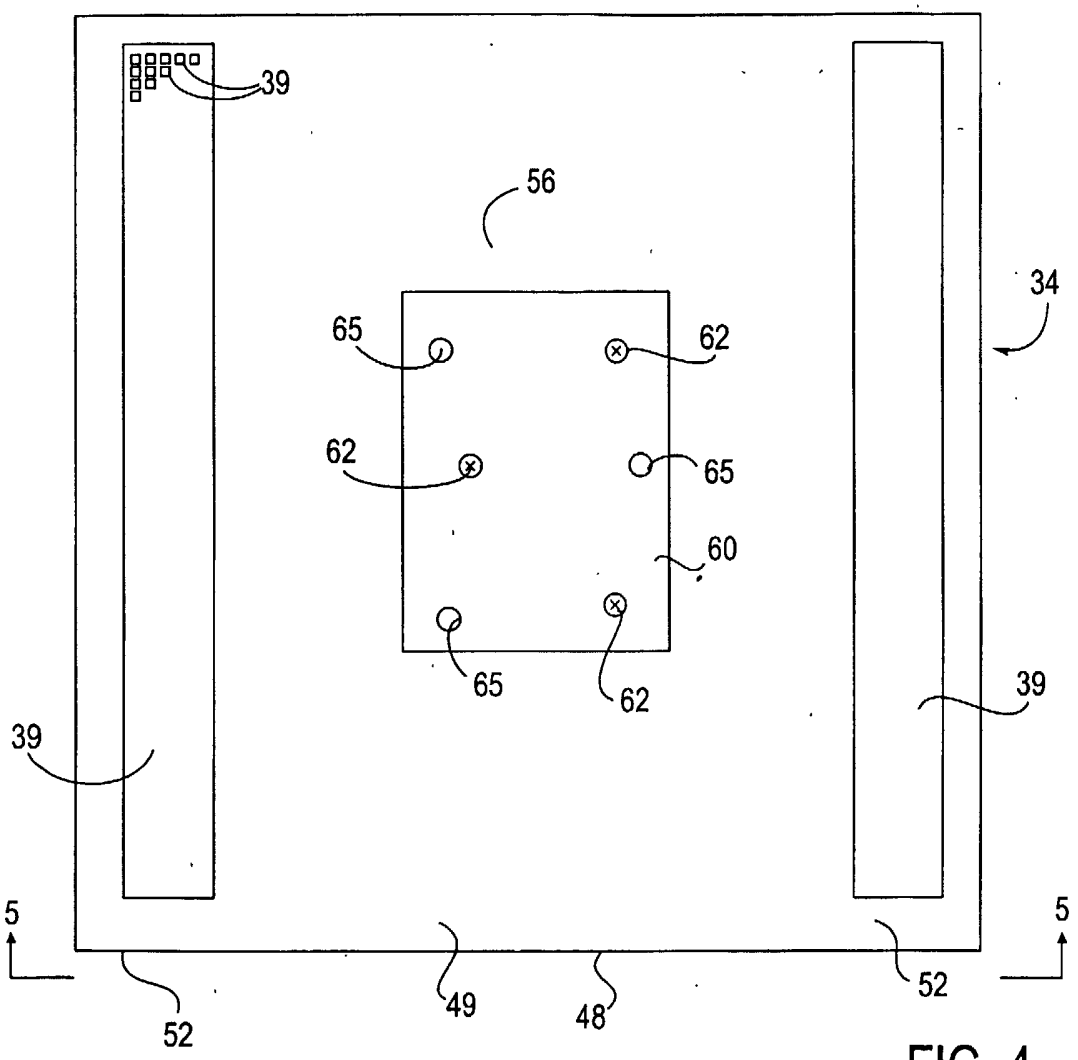
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FIG. 4

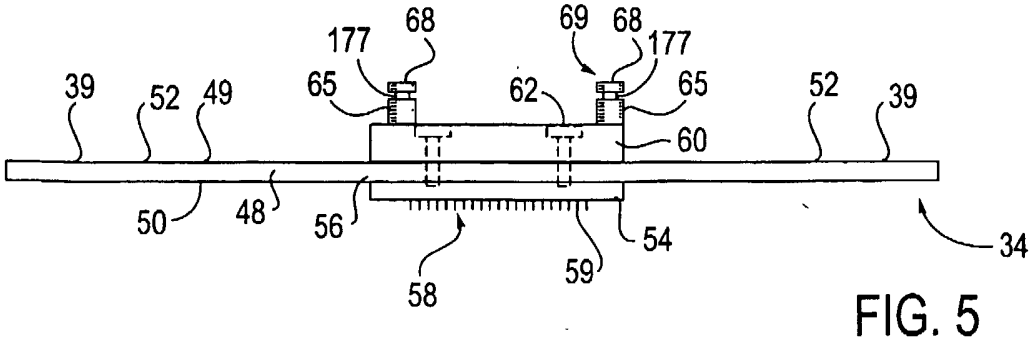
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FIG. 5

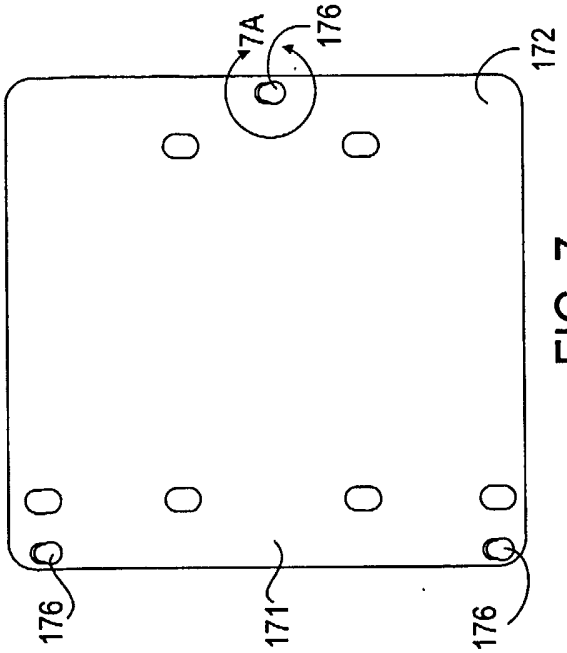

FIG. 7

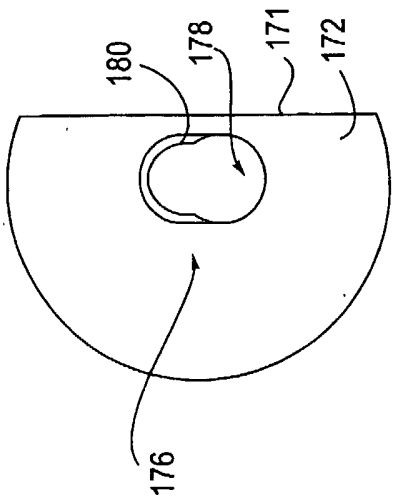

FIG. 7A

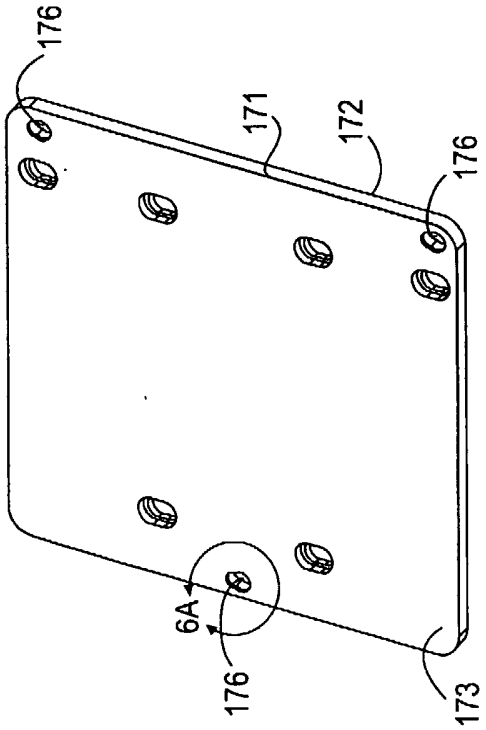

FIG. 6

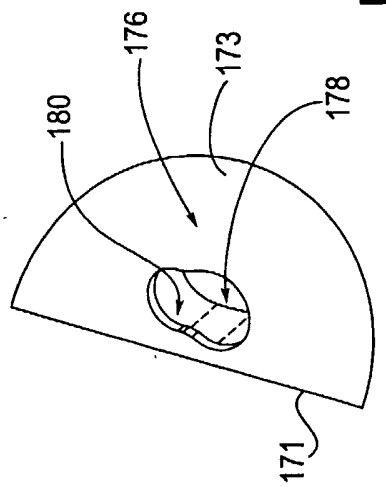

FIG. 6A

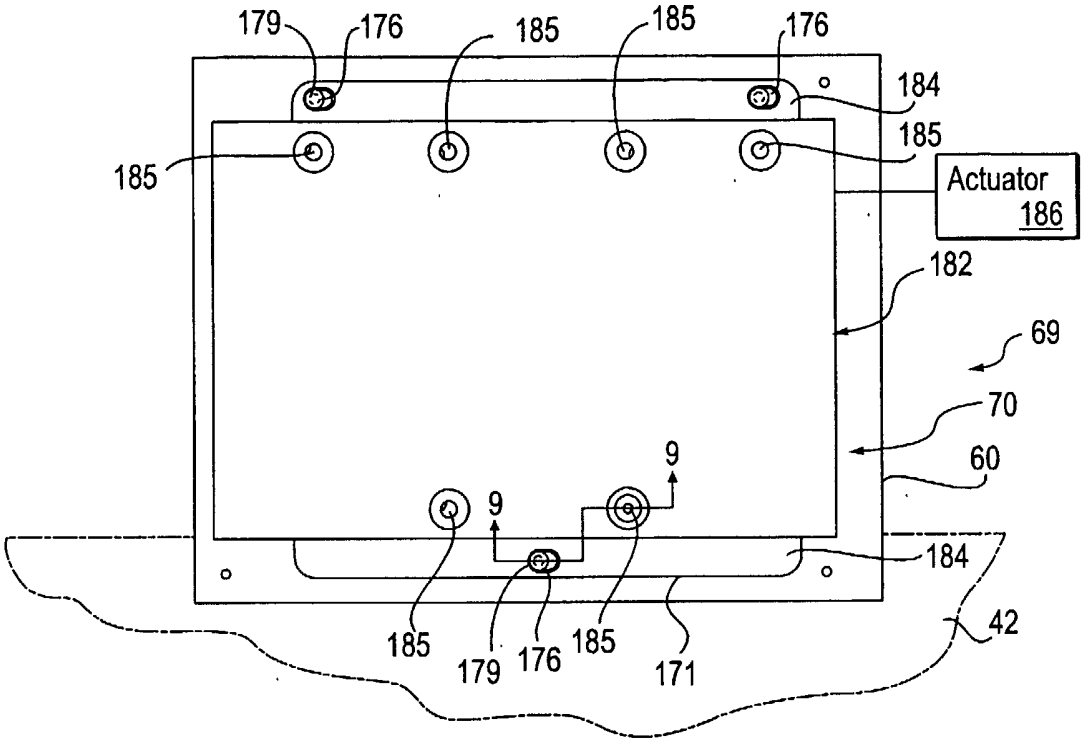
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FIG. 8

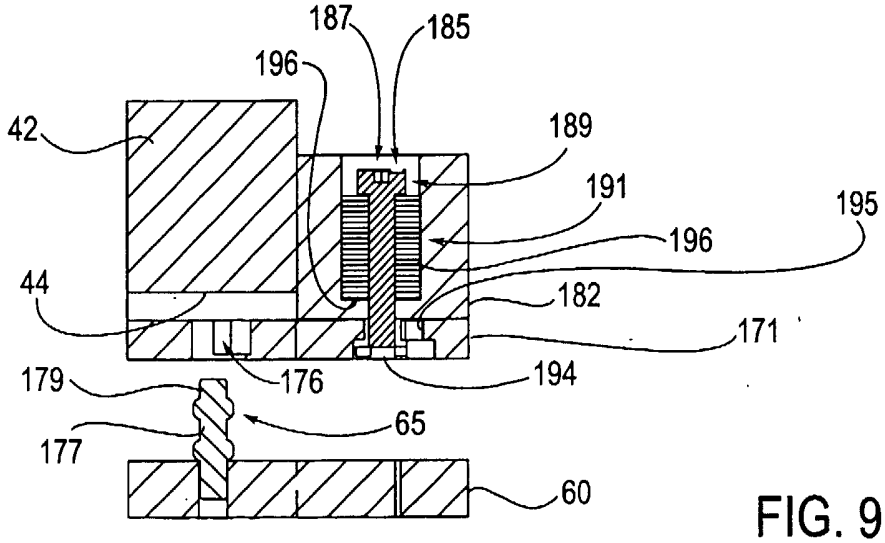
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FIG. 9

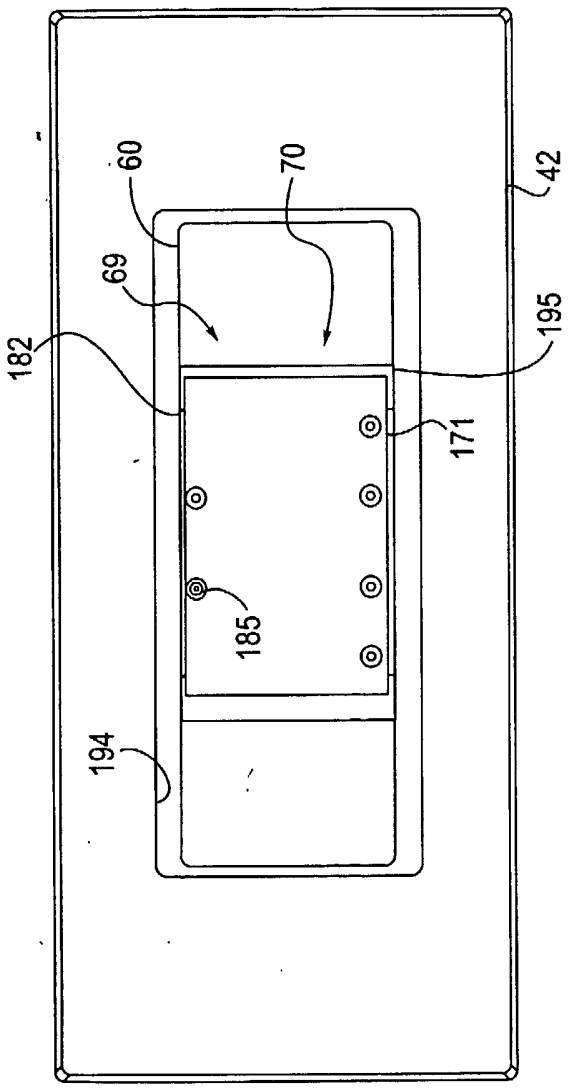
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FIG. 10

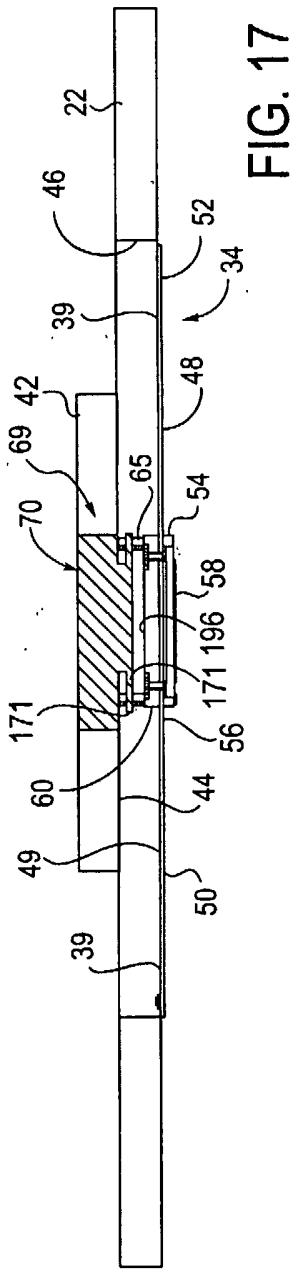
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FIG. 17

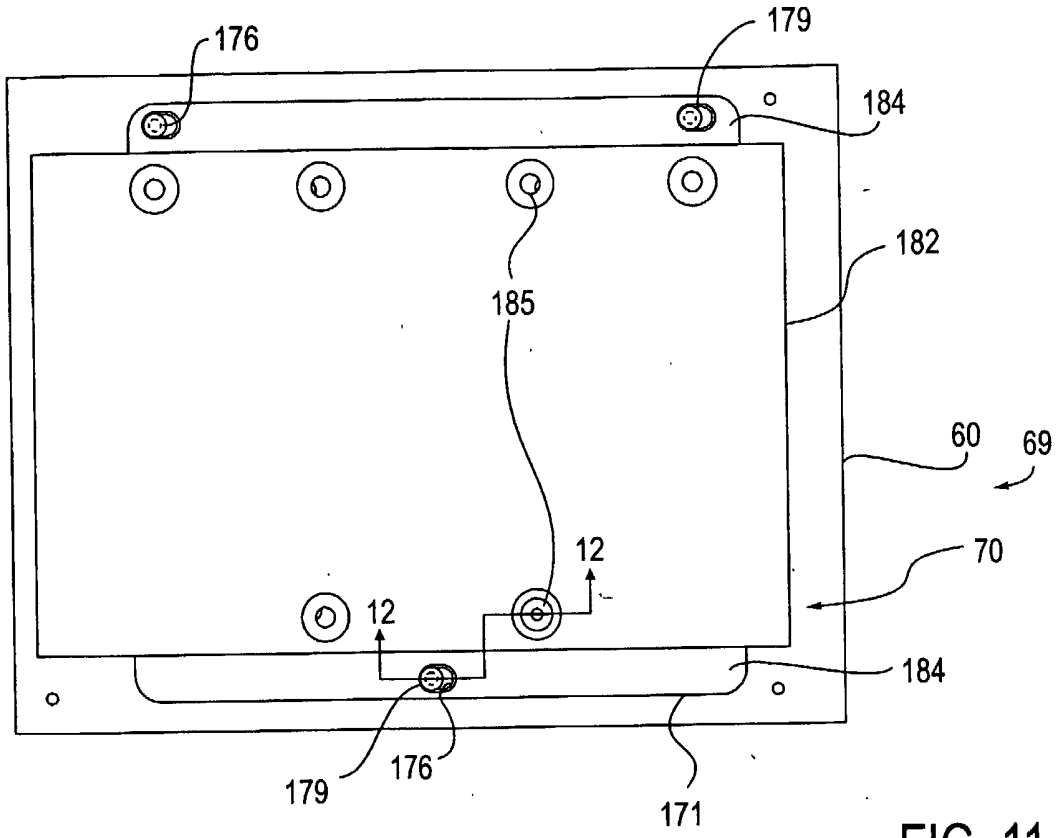
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FIG. 11

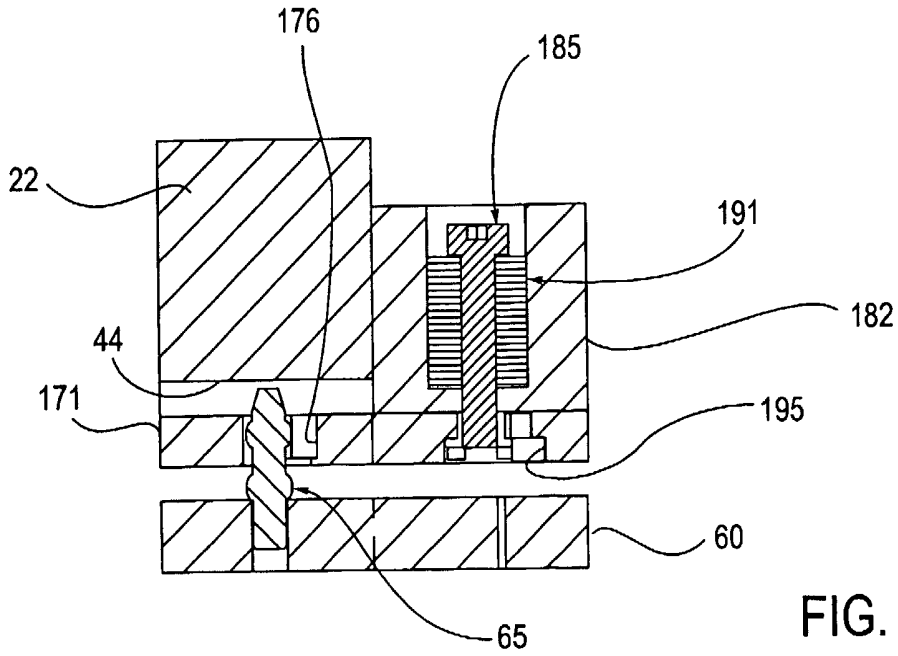
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FIG. 12

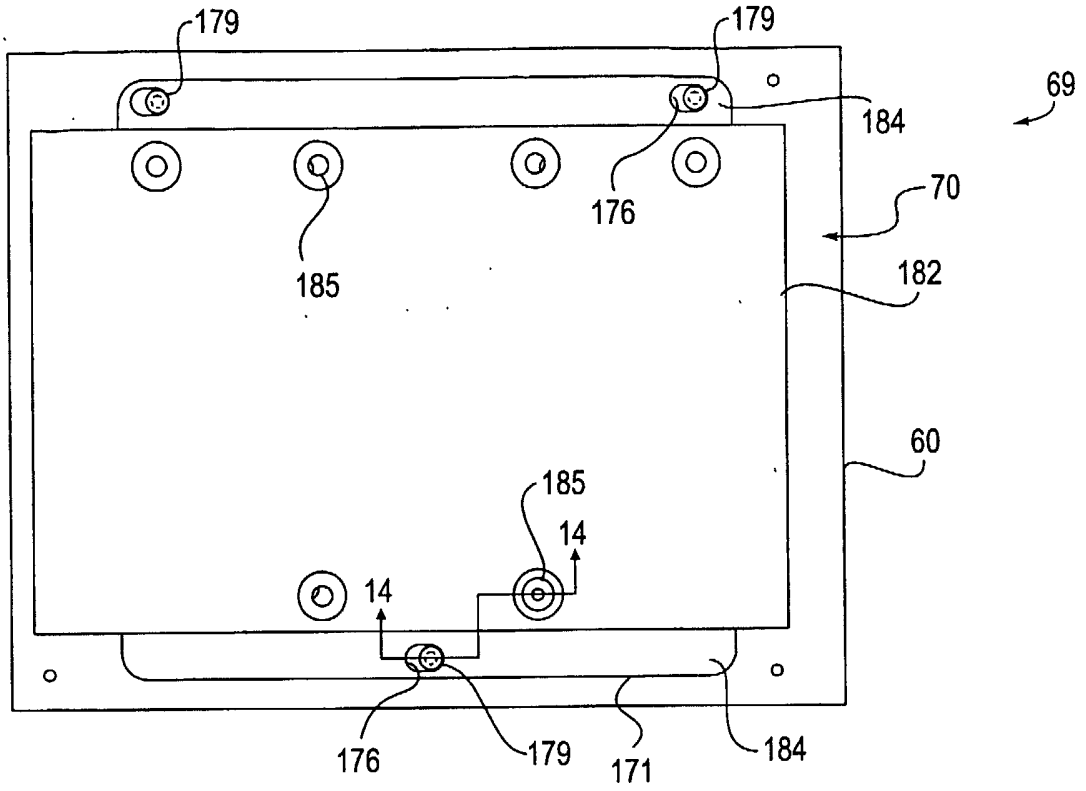
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FIG. 13

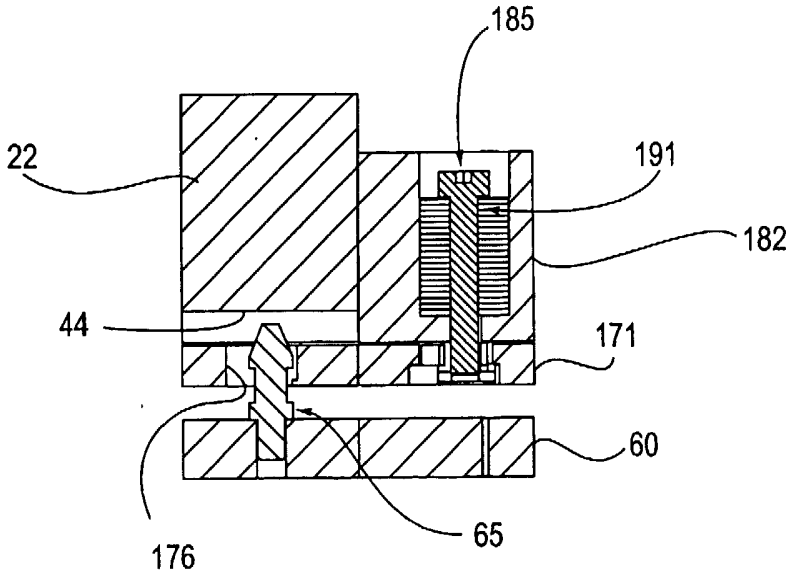
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FIG. 14

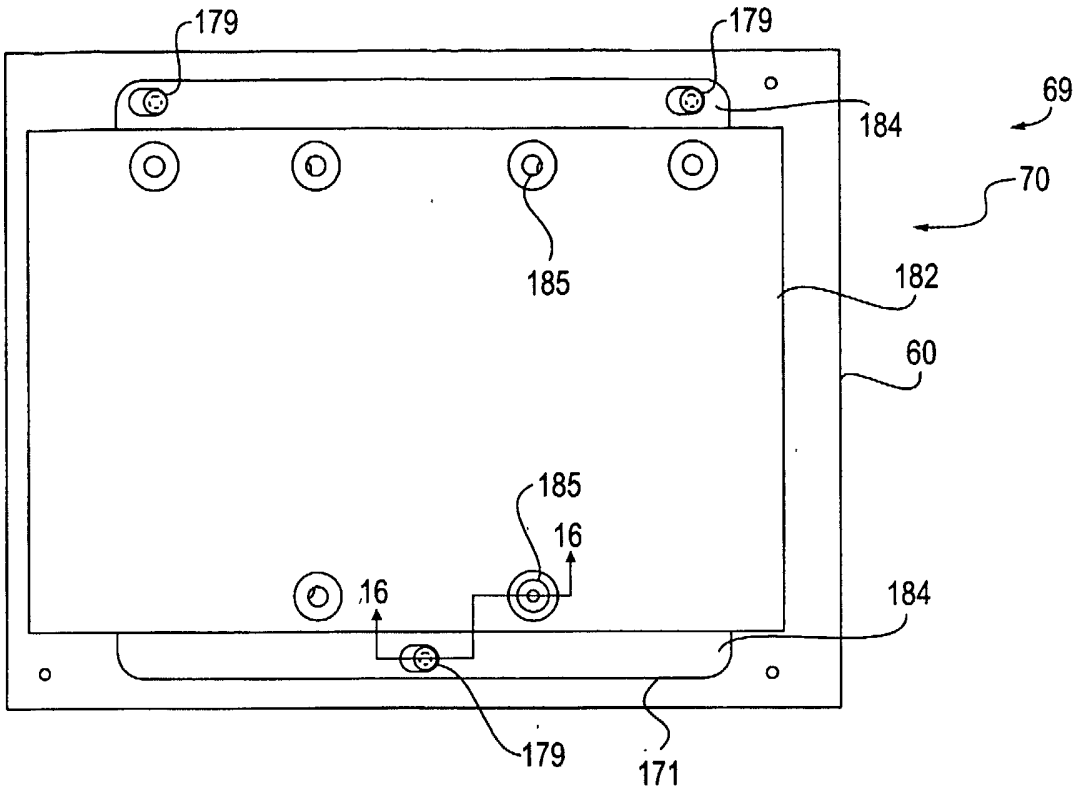
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FIG. 15

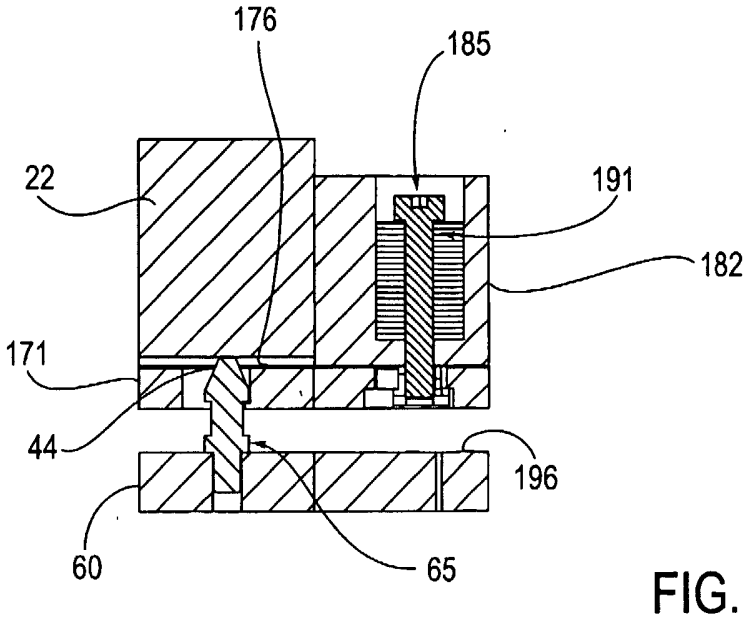
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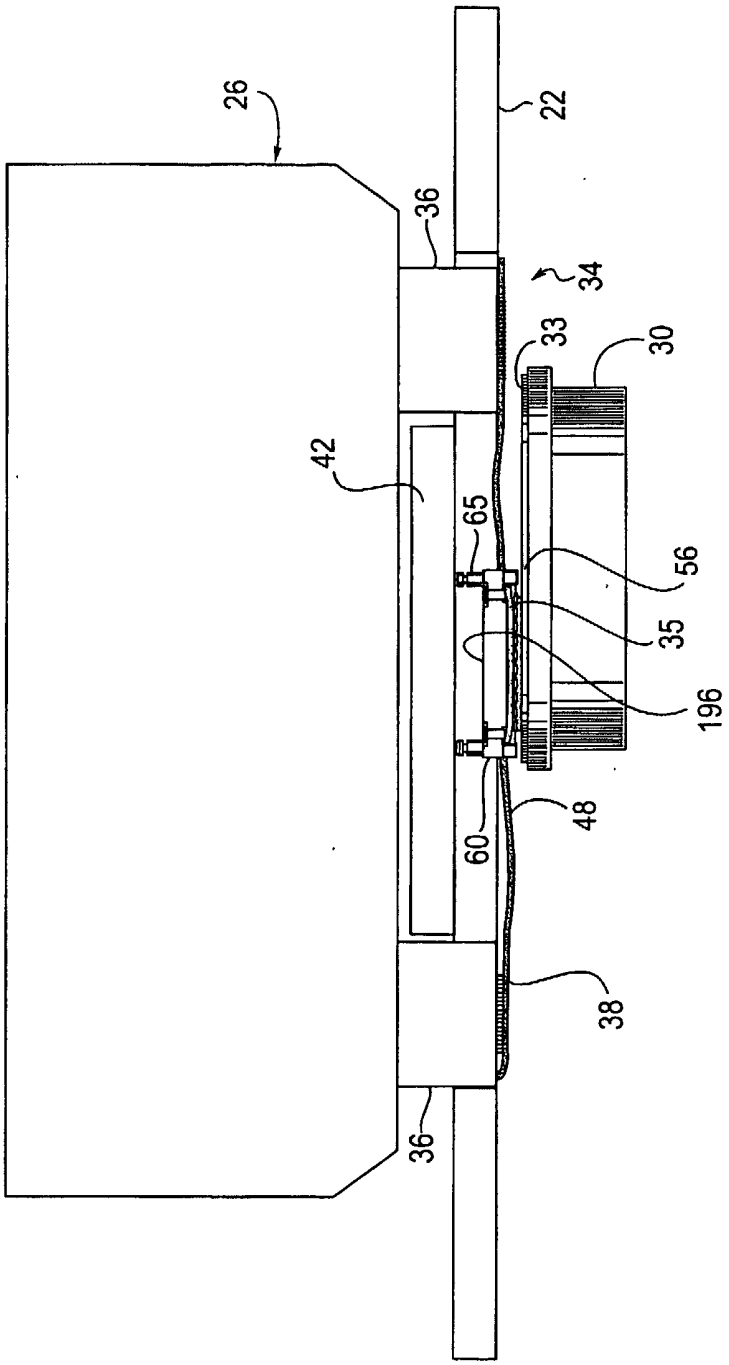
FIG. 16

FIG. 18



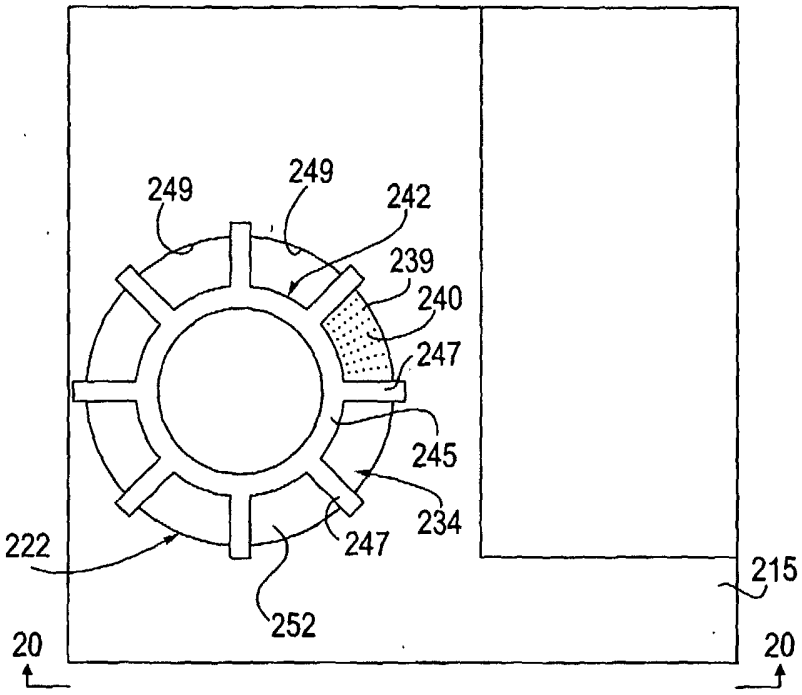

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FIG. 19

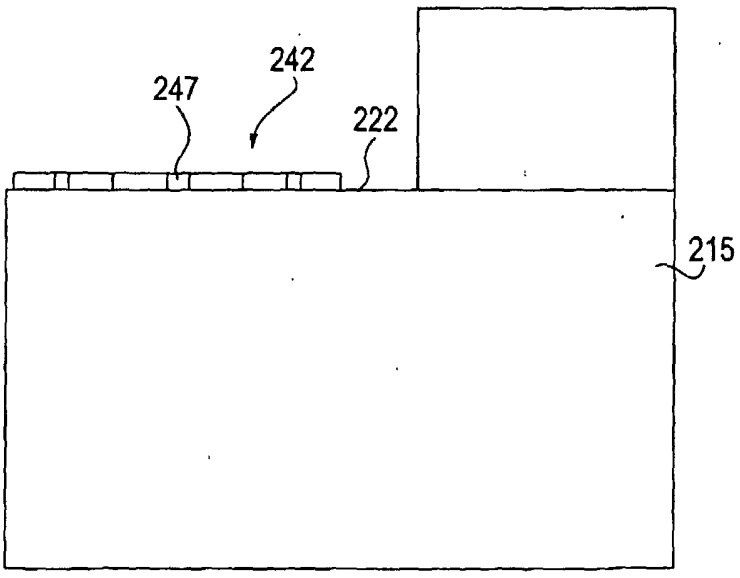
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FIG. 20

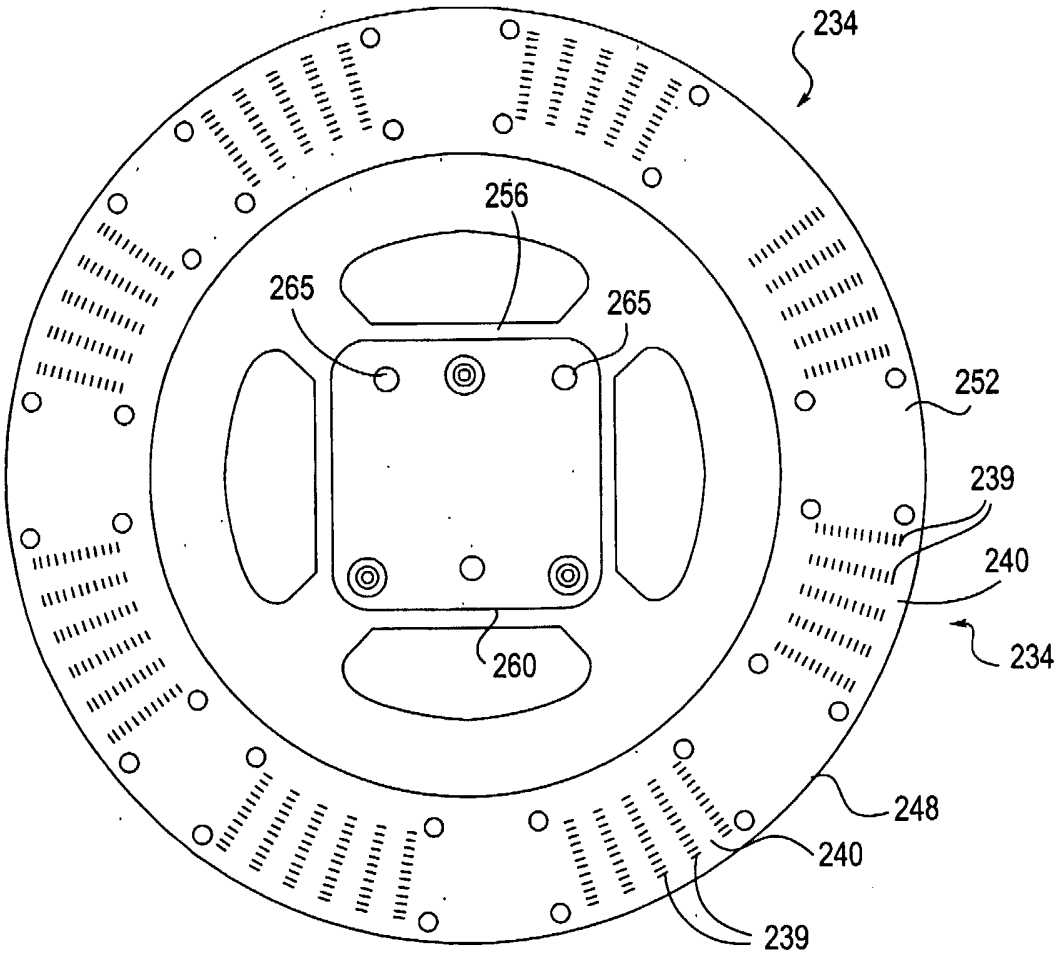

FIG. 21