(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 December 2001 (06.12.2001)

PCT

(10) International Publication Number
WO 01/92135 A1

(51) International Patent Classification[7]: B65D 85/48, 85/00, 85/02, A45C 13/10

(21) International Application Number: PCT/US01/15020

(22) International Filing Date: 9 May 2001 (09.05.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/202,585	9 May 2000 (09.05.2000)	US
60/217,656	10 July 2000 (10.07.2000)	US
09/851,499	8 May 2001 (08.05.2001)	US

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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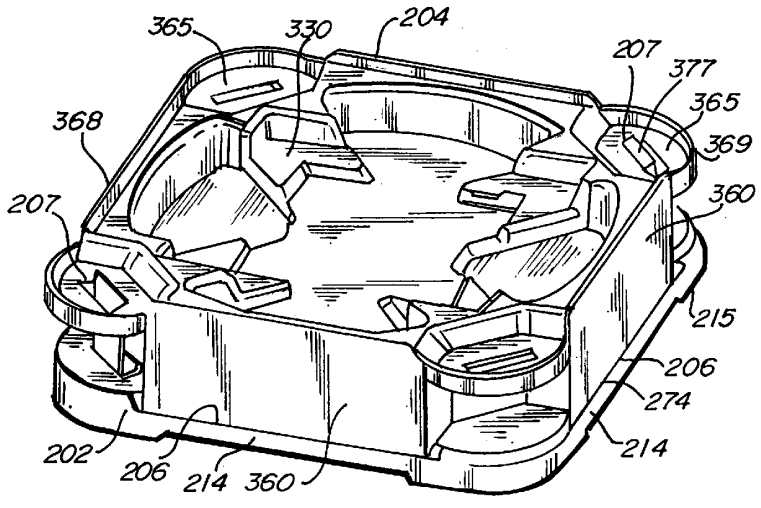
(54) Title: SHOCK RESISTANT VARIABLE LOAD TOLERANT WAFER SHIPPER



(57) Abstract: A wafer shipper (202, 204) for stacked wafers (510) provides significantly improved resistance to shock and impact as well as flexibility and tolerance in wafer capacities and guidance in optimal amount of packing material. These characteristics are provided by unique structural configurations that provide rigidity and desirable distribution of impact forces. The shipper (202, 204) has a base (202) and a top cover (204) both of which have a nominal wall that primarily forms all of the features of the respective components. The base (202) has four sides (214), four corners, and arcuate wall segments (208) defining a wafer stack pocket. The sides are formed of a downwardly extending nominal wall portion (216, 218, 200) and an upwardly extending lip (274). Both adjoin a nominal wall defining a planar surface (210) that extends around the base (202) and forms a seat for the top cover (204). A feature and advantage of particular embodiments of the invention is the unique form fit whereby impact forces that are received on the corners and/or sides of the top cover (204) are transferred to the base (202) through the top cover (204) to upright portions on the opposite side of the base (202) from where the impact occur.

WO 01/92135 A1

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SHOCK RESISTANT VARIABLE LOAD TOLERANT WAFER SHIPPER

This PCT Application claims priority to Provisional Application No. 60/202,585 filed May 9, 2000, to Provisional Application No. 60/217,656 filed July 10, 2000, and to Utility Application Serial No. _____, filed May 8, 2000, with the same title and same inventors. All three applications are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

This invention relates to carriers for semiconductor wafers and more particularly relates to shippers for same.

Integrated circuits are manufactured from semiconductor wafers that are conventionally round in shape and made of highly brittle silicon. Such wafers are subjected to a variety of processing steps in transforming the semiconductor wafer into integrated circuit components. The various processing steps must be performed under ultra-clean conditions to minimize the potential of contamination of the wafers as they are being processed. Each wafer may be subjected to dozens if not hundreds of steps in its processing cycle. The potential for contamination and destruction of a wafer or reduction in yield is ever present throughout the various processing and packaging steps. Particularly during the steps that take place at fabrication facilities, any minute particulates can destroy the integrated circuit on which it falls. Once the processing steps of the wafers are completed they are generally shipped while still in wafer form to a facility that will dice and encapsulate in integrated circuit packaging each individual circuit on the wafer.

The stringent particulate control that takes place during the processing steps is generally not necessary in shipping the completed wafers to the facility that dices and packages the individual circuits.

Traditionally, during the processing and storage and shipping of semiconductor wafers the wafers are supported and constrained at their edges to prevent any contact and possible damage and contamination to the faces of the wafers having the circuits thereon.

Even as semiconductor wafers are getting larger in scale, now up to 300 millimeters in diameter, the density of components is getting significantly greater. Moreover, disks are also are getting thinner providing much thinner completed integrated circuit packages. This has been driven, at least in part, by the cellular phone industry that has sought thinner cell phones.

Accompanying the trend towards larger, more dense and thinner wafers, the wafers are becoming more valuable, more brittle, more easily damaged during shipment. Although it is possible, desirable, and common to ship thicker wafers in enclosed containers that would support the wafers exclusively by their edges, using such devices to ship the thinner wafers has proven problematic due to breakage and damage of the wafers.

Thus for the thinner more fragile wafers, enclosures are utilized which have the wafers axially stacked on top of one another and separated by layers of paper-like flexible sheet material. Thus the support of each wafer is by adjacent wafers and the entire stack of wafers. Internal or external walls in the carrier will provide circumferential support to the stack. Foam material, such as urethane, is used to cushion the top, the bottom, and sometimes the circumferential surface of the stack..

A most important characteristic of such wafer shippers for stackable wafers is that the shippers provide protection from damage due to shock during the transportation. This shock may consist of direct impact with the shipper's top cover or base or consist of jarring of the entire shipper package. In either case it is important to provide protection from damage to the wafers packed therein.

Moreover, it is important that such wafer shippers provide latching means of high integrity that do not inadvertently open during shipment or handling, for example when a shipper is inadvertently dropped. These stacking wafer shippers may be both manually handled as well as robotically handled. Thus, means for opening and closing such containers must be both manually and robotically operable and for manual purposes should be intuitive as well as simple, and reliable and quick. Various means are known for latching such wafer shippers as illustrated in the prior art described below.

Such shippers are typically drop tested to determine the overall integrity of the shipper. Upon such dropping, unlatching, breakage of the shipper or damage to the wafers

constitutes a failure. The impact during dropping, including drop testing, creates shear, compressive and torsional forces on the shipper components. The shipper, including the latches must withstand combinations of these forces when loaded.

A prior art wafer carrier as illustrated in U.S. Patent No. 5,553,711 to Lin has a base, upright sidewalls defining a circular pocket, somewhat complicated wafer dividers and a cover that comes down and threadingly attaches to the base. The wafer dividers limit the wafer density and increase the cost of the packing material. It is not believed that this wafer shipper has good drop test characteristics. Moreover, the threaded top cover is difficult to open robotically and is time consuming and tedious to open and close manually.

FIG. 1 discloses a conventional wafer carrier in which the enclosure is defined by a cookie tin like plastic container having a bottom 40, a top lid 42 and utilizing a circular urethane foam bottom cushion 44, and sheet material 49 interspersed between wafer 50. It is not believed that this configuration has good drop test performance characteristics and has the same threaded top cover issues as the 5,553,711 shipper.

The wafer shippers that use the threaded engagements are awkward and subject to misalignment and improper attachment. These wafer shippers visually appear symmetrical in at least two planes and therefore there are typically four different options in assembling a top cover to a bottom cover. However, conventional prior art shippers generally require that the top cover be assembled in a specific orientation for proper latching.

Referring to FIGS. 2 and 3, another wafer shipper is disclosed for shipping the stacked wafers with dividers therebetween. This wafer shipper has a base 52 and a top cover 54. The base and top cover are injection molded and have circular shaped and axially extending structural members 56, 58 in the base component. Similarly, the top cover has axially extending circular structural members 59 and 60 and radially extending ribs 66, 69 that also project axially. It is understood that this configuration of wafer shipper provides better drop test performance characteristics than the previous shippers.

U.S. Patent No. 6,193,068 to Lewis, et al. discloses axially extending spring latches and utilizes a double wall to define the pocket for the stack of wafer carriers. Said double

wall thickness is defined by two spaced thin wall sections, which are not directly attached to one another, extending from the base. This configuration appears to allow the individual unsupported thin walls, supported only at the base, to take on and retain deformation. The concentric arrangement of the thin walls makes any such deformation visibility apparent. The double sidewall in this prior art embodiment may help to isolate direct impact on the top cover from direct communication from top cover structure to the wall defining the wafer pocket.

As illustrated in Prior Art FIG. 4, separation stress caused by overloading in the wafer shippers of the types such as illustrated in the 6,193,068 patent and FIG. 2 can result in carrier deformation such as illustrated by gap G in FIG. 11. Such loading of the wafer shipper can cause the deformation of the otherwise planar corners of the base to be stressed out of position causing wobbling when placed on a planar surface and potential error in seating when placed on a machine interface. Such deformation can be caused in part by an overloaded or even a fully loaded condition and also in part by the structural configuration of the wafer shipper. The top cover structure configured as concentric rings appear to provide minimal resistance to the twisting of the carrier as illustrated in FIG. 4

It would be desirable to provide sufficient structure in the top cover and base of such wafer shipper to prevent or better minimize such distortion and bowing. Moreover, it would be highly desirable to provide a wafer carrier that has indicating means therein to prevent such an overloaded condition. Moreover it would be desireable to provide features to minimize the effects of any such distortion that did occur.

Carriers will often need to have capabilities for carrying data regarding the wafers being stored in the carrier. Transponder tags and floppy discs are known for this function. The floppy disks have been secured on top cover by nubs extending therefrom defining a pocket that retains a floppy disk by an interference fit. In these carriers, the floppy is exposed and subject to being displaced from the carrier. Moreover, the floppy effectively increases the size of the carrier. It would be desireable to have a wafer carrier that more efficiently secures data carrying means.

Generally all embodiments of the wafer carriers herein will be injection molded of thermoplastic material such as polypropylene. Such material requires structure such as ribs and channels for rigidity.

In that these shippers do not have the severe particulate control issues that are necessary for carriers in the fab processing environment, it is not necessary to have hermetic sealing. In fact, such hermetic sealing is inimical to robotic handling and easy manual handling, specifically the opening and closing of the shippers. Still it is important to have the interface between the top cover and the base to provide as good of sealing characteristics as possible. Moreover, it is important to eliminate or reduce any bowing that occurs along one of the sidewalls intermediate the corners of the top cover or the base.

These types of containers may be utilized once and thrown away or may be recycled and utilized multiple times. Although the product shipped in such containers can be of immense value, it is still important to reduce the manufacturing cost of the shippers to as great as extent as possible, consistent with the other necessary characteristics.

These wafer carriers rely heavily upon the separation of materials between wafers, which may be polyethylene sheet material with carbon providing a static dissipative characteristic, polyurethane foam, or other suitable flexible thin sheet material. Typically the packing material placed on the bottom and top of the stack will be the polyurethane foam that is compressible. The compressibility of the foam facilitates packing a variable number of wafers in a particular shipper which can leave some undesirable discretion to the packer as to how many wafers and/or how much padding material is appropriate for a particular shipper. As discussed above, inserting excessive or even a full load of wafers and foam padding can, in prior art wafer shippers, particularly those with latches on the diagonal corners, cause distortion and/or bowing of the top cover and/or base and create a gap that is visually undesirable, may provide a pathway to contamination of the contents, and may affect the integrity of the container during impact or shock, causing breakage or unlatching.

If the shipper is underpacked with foam or other packing material, breakage may occur at limits under normal impact limits. Known prior art wafer carriers have provided no ready assistance in identifying an appropriate range of foam and wafer stacked thickness

which is optimal for providing security to the wafers. Similarly the stacked wafer shippers with the latches on the diagonally opposite corners have provided no means to minimize the visibility of the gap at the sides of the shipper when the shipper is fully loaded or slightly overloaded. Moreover, these prior art shippers have inadequately provided structural means to the base and top cover to provide rigidity and minimize said bowing and gaps at the interface.

SUMMARY OF THE INVENTION

A wafer shipper for stacked wafers provides significantly improved resistance to shock and impact as well as flexibility and tolerance in wafer capacities and guidance in optimal amount of packing material. These characteristics are provided by unique structural configurations that provide rigidity and desirable distribution of impact forces. The shipper has a base and a top cover both of which have a nominal wall that primarily forms all of the features of the respective components. The base has four sides, four corners, and arcuate wall segments defining a wafer stack pocket. The sides are formed of a downwardly extending nominal wall portion and an upwardly extending lip. Both adjoin a nominal base wall which includes a planar bearing surface that extends around the base, outside the arcuate wall segments, and forms a seat for the top cover. The planar bearing surface adjoins the arcuate wall segments and also adjoins the upright stop portions which are part of four shoulders positioned at the corners of the base. Each of said shoulders extends to the side wall. Channels formed from the nominal base wall extend downwardly from the floor of the wafer stack pocket. The channels extend primarily radially or chordially.

The top cover has a continuous nominal side wall extending around the four sides. The lower periphery is a bearing surface for contacting a cooperating bearing surface on the base. The sides adjoin the top cover top wall which includes recessed nominal wall structure providing rigidity to the top cover, as well as the stack top engagement surfaces. Four ears extend outwardly at the corners and include oversided latch slots recessed structure and latch retention means. An upper lip at the top cover perimeter extends upwardly and is sized slightly less than the downwardly extending wall of the base so that several shippers may be stacked.

A feature and advantage of particular embodiments of the invention is the unique form fit whereby impact forces that are received on the corners and/or sides of the top cover are transferred to the base through the top cover to upright portions on the opposite side of the base from where the impact occurs. There is not the initial direct horizontal shock conduit from the corners or sides of the top cover to the adjacent portions on the base. This provides a significant improvement in the robustness of the container as well as significant improvement in the protection provided to the wafers, as well as much better resistance to unlatching upon such impact. Moreover, before the top cover wall at the corner of the impact engages and transfers the shock to the base at the corner of impact, the top cover must be slightly compressed. This compression will absorb the impact forces before they are transmitted to the base near the corner of impact.

A further feature and advantage of particular embodiments of the invention, an additional concentric set of arcuate wall segments of a lesser diameter are provided. These may cooperated with the first set of arcuate wall segments to provide a double wall for additional strength for resisting fracturing or damage to the wafers during occurrences such as dropping. Moreover, said second wall can be utilized to make a mold for molding a wafer carrier for a first size of wafers convertible into a mold for molding wafer carriers for a second sized of wafers, said second size smaller than the first. The convertible feature can be added by forming the appropriate concentric slots in the mold for the wafer carrier for the first size. Said appropriate concentric slots, are sized for the second size wafers. Suitably sized blanks may be inserted in said slots when the mold is to be used for the first size wafer carrier and the blanks may be removed when the mold is utilized for the second size. More broadly stated a mold for a wafer carrier can utilize separate inserts for converting from a first size pocket to a second size pocket.

A feature and advantage of the invention is that a single mold can be utilized for different carriers for carrying different size wafers. Moreover such a mold will provide a single footprint. Such a single footprint will facilitate automated handling with less changeover of equipment when wafer sizes are changed. Such a single footprint will allow stacking of carriers for different size wafers in a single stack. Moreover, shipping such single footprint carriers will be easier and less expensive in that packaging and cushioning material, which is often specifically sized for a particular carrier, is more universal.

A feature and advantage of particular embodiments of the invention is that it is easier to mold than other prior art wafer carriers that have structural rigidity members. Conventional ribs cause shrinking problems.

A further feature and advantage of particular embodiments of the invention is that the nominal wall rigidity members also are utilized to create a pocket for memory disks, either 3 ½ floppy disks or CD's. The pocket is recessed, protecting the data storage means as well as significantly contributing to the rigidity and resistance to twisting that is illustrated in FIG. 4.

A further feature and advantage of particular embodiments of the invention is that radially and chordially oriented channels and wall structure formed from the nominal wall in the provide significantly better resistance to twisting of the components and particularly the base.

A further feature and advantage of particular embodiments of the invention is that a labyrinth seal is provided along the sides of the assembled shipper at the interface between the top cover and the base. The labyrinth seal is formed from the upwardly extending peripheral lip on the base.

A feature and advantage of particular embodiments of the invention is that the latching arm extending from the base has a horizontal component to provide greater elongation capabilities of said arm. Such provides a latching force that remains consistent under a wider range of loads than conventional latching arms that extend directly and only vertically from the base. That is, the spring constant is effective over a greater distance that conventional latch arms.

A feature and advantage of particular embodiments of the invention is that the nominal wall is utilized for providing structural rigidity rather than ribs. The nominal wall is configured into straight channels rather than circular channels concentric with the wafer pocket that are known in the art. The straight channels are oriented radially or chordially on the base and top cover. Where there are multiple fastening locations connecting the base to

the top cover, for example four or more, that are circumferentially spaced around the wafer pocket, the concentric circular channels are appropriate. However, where there are two fastening locations positioned diagonally across from each other at the corners of the base and top cover, the structural rigidity and resistant to twisting of the base appear to be significantly improved when the radially and/or chordially extending channels are utilized.

A further feature and advantage of particular embodiments of the invention is that sidewall extending from the top cover has a single nominal wall with a shape, from the plan view, having four straight sidewalls and abbreviated corners that have inwardly extending channels. Such a configuration provides a significantly greater rigidity than conventional simple shapes, cylindrical or square, and utilizes substantially less material that double reinforced walls known in the art.

A further advantage and feature is that the wafer carriers as disclosed herein are stackable.

A further feature and advantage of particular embodiments of the invention is that same is easier to mold consistently and utilizes significantly less material than prior art stacked wafer shippers.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a prior art wafer carrier for carrying a stack of wafers.

FIG. 2 is a perspective view of a base of a prior art wafer carrier.

FIG. 3 is a perspective view of a top cover of a prior art wafer carrier

FIG. 4 is a perspective view of a prior art wafer carrier illustrating bowing stability issues.

FIG. 5 is a perspecive view of a wafer carrier in accordance with the invention herein.

FIG. 6 is a plan view of a base of a shipper with accordance with the invention herein.

FIG. 6a is a perspective view of a base and top cover according to the invention.

FIG. 6b is a perspective view of two carriers according to the invention stacked.

FIG. 6c is an exploded view of a carrier and wafers and packing material.

FIG. 7 is a bottom plan view of a base in accordance with the invention herein.

FIG. 8 a is a side elevational view of the base of FIG. 7.

FIG. 9 is a top plan view of a top cover in accordance with the invention herein.

FIG. 10 is a cross-sectional view taken at line CC of FIG. 9.

FIG. 11 is a perspective view of a corner of a base in accordance with the invention herein.

FIG. 12 is a bottom view of the top cover of FIG. 9.

FIG. 13 is a cross-sectional view of a wafer carrier illustrating the shock absorption characteristics.

FIG. 14 is plan view of a base illustrating the normal seating position of the top cover therewith.

FIG. 15 is an elevational view of a wafer shipper according to the invention herein illustrating the labyrinth seal and peripheral lip of the base.

FIG. 16 is a cross section view taken at line 16-16 of FIG. 14 illustrating the labyrinth seal and peripheral lip of the base.

FIG. 17 is a top view of the wafer carrier base illustrated in FIGS 18, 19, and 20.

FIG. 18 is a cross sectional view of the wafer carrier taken at line 18-18 of FIG. 17.

FIG. 19 is a sectional view of the wafer carrier taken along a line 19-19 of FIG. 17.

FIG. 20 is a bottom plan view of the base of FIG. 17.

FIG. 21 is a perspective view of a convertible mold with inserts for converting the mold between a mold for a carrier with a wafer pocket of a first size to a mold with a wafer pocket of a second size.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. 5, 6, 6a, 6b, 6c, 7, 8, 9, 10, 11 and 12, various perspective views of a wafer shipper comprised of two cooperating portions configured as a base 202 and a top cover 204. The top cover and base meet at an interface 206 and are secured by latch mechanisms 207.

Referring to FIGS. 6, 7, 8, and 11, the base has a plurality of arcuate lateral wafer support segments 208 which extend from a planar portion 210 of the base and define the wafer stack pocket 212. A floor 211 is positioned at the bottom of the pocket. The planar portion constitutes a seat and bearing surface for the top cover edge. A side wall 214 extends around the periphery 214 of the base. Nominal wall structures 216, 218, 200 in the pocket floor provide structural rigidity to the base by providing undulating attachment positions 221 between said floor and each wafer support sidewall segment. The radially extending structures formed from the nominal wall structure are comprised of a plurality of channels 222 which extend from the pocket floor downward.

Referring to FIGS. 5, 8, and 11, various perspective views of corners of the base portion are depicted. The planar surface 210, which constitutes a bearing surface for the top cover edge, extends around the lateral wafer support segments 208. Extending upwardly from the planar surface 210 is a protruding structure configured as a shoulder 250. The

shoulder includes an upright surface 254, which operates as an outer constraint to the top cover 204 primarily during impact or other stressing.

Extending from two of the four corners of the base are latching members 264. Latching members include a hook portion 266 with a cam surface 268 and an engagement surface 270. The cam surface deflects the latching member when the top cover is lowered into the latching position and snaps into place with the surface 270 engaged with top surface of the top cover. Significantly, the latching arm has a horizontal extending section 280 and a curved portion 282 extending into an upright portion 284. The horizontal portion reduces the spring constant of the latching member in the vertical direction by allowing up and down flex of said member. This compares to conventional wafer carriers with latches that do not include said horizontal member that have a spring constant in the vertical direction that equates to the spring constant of the material and any flex in the base where it is attached. This horizontal portion effectively extends the positions where the top cover may be fixed in position. Moreover, it softens the downward pull of the top cover toward the base, which allows greater shock absorption during impact, such as dropping of the shipper. Said shock absorption can prevent further damage to the wafers and prevent damage to the shipper that would otherwise occur.

Also depicted in FIGS. 5, 6, 8, and 11 is a lip 274 that extends upwardly from the planar surface 210. Said lip provides an additional impact surface for the top cover discussed in detail below.

Referring to FIGS. 5, 9, 10, and 12, various views of the second part or top cover are depicted. The significant features include a nominal wall 320 that comprises the vast majority of said top cover, including various stiffening structure 330. Referring to FIG. 21, the nominal wall is configured to provide a pocket 336 for a 3 ½ inch diskette and a larger pocket 338, sized for a CD case. The top cover has a periphery 350 that includes an upwardly extending lip 354 that follows the periphery. Said lip adds to the structural rigidity and provides a stacking means. Four planar sidewalls 360 extend downwardly from the upper lip 350 and along with inset corner portions 365, define a wafer enclosure. The wafer enclosure perimeter 368 is generally square in shape with the corners 369 inset with an expanded channel shape, as indicated by the numeral 372. At each corner 369 is a flange portion 374

with apertures 376 to receive the head 377 of the latch member. The aperture is defined in part by cam surface 380 to engage the inclined surface at the top of the latch member. The flanges have a planar portion 390 and a lip portion 392, which in combination provide significant rigidity to the corner portions. The significant downwardly extending structure 395 from the top cover in conjunction with the sidewalls 360 provide a top cover that is highly rigid, even when formed with such soft plastics as polypropylene.

Referring to FIG. 13, one aspect of the cooperation of the top cover with the base is illustrated. The base 502 is engaged with the top cover 504 and contains a stack 510 of wafers. The stack of wafers is cushioned at its bottom by polyurethane foam cushion 514, and at its top by a circular-shaped polyurethane cushion 516. Intermediate the wafers are sheets of separating material 530. When, due to a drop or similar occurrence, a shock is exerted on the top cover, such as indicated by the arrow F, the force of such shock is transmitted through the top cover 540 and sidewalls 542 and is ultimately transferred to the base 502 by the engagement of the sidewall 542 with the shoulder 546 of the base. The engagement point is indicated by the region designated 550. This is located on the opposite side of the wafer shipper from the point of force. This dispersion of the force through the top portion and sidewalls effectively transfers the impact force around the stack of wafers, thereby protecting said wafers. Note that there is illustrated the engagement at region 550 there remains a gap at region 552. The planar surface and gap between the shoulders and lateral sidewall segments are appropriately configured to provide this force transfer effect. With sufficient force the gap at region 552 will close.

Referring to FIG. 6 and 13, the normal position of the top cover on the planar surface is indicated by the dashed lines labeled with the numeral 600. The effect is accomplished in part by having the gap indicated by G2 between the lateral wall segment and the top cover sidewall be greater than the gap G3 between the wall of the top cover and the engagement surface of the shoulder 250. Where the impact force is of sufficient magnitude, the top cover sidewall will engage the shoulder opposite the point of impact first, and then the top cover sidewall adjacent the region of impact will subsequently engage the base of the lateral wafer support sidewall segment or other structure extending upwardly from the planar surface as may be suitable. This occurs only after compression of the top cover, primarily at the sidewalls as illustrated by the arrows Cf. The compression absorbs the impact forces

minimizing the force transmission at region 552 and the proximate arcuate wall 553. Thus, it is noted that the planar surface 210 effectively operates as a bearing surface for the edge surface of the top cover downwardly extending wall. Also, due to the fact that under all but extraordinary conditions, the top cover will not contact the lateral wafer support segments 208. Additional strengthening ribs 710 as shown in FIG. 11 may be added in the region indicated by the arrow 720. FIG. 6 additional support ribs may be added without the potential for contact with the top cover sidewall, due to the jog in the sidewall at this location.

Referring to FIGS. 8 and 11, a portion of the lateral wafer support wall has structure 740 which is configured to provide visual indicators to provide a range of appropriate or optimal load height, including cushions. This reference has two horizontal surfaces labeled 742 and 746, which define a range 748 wherein the wafers and cushions may suitably extend.

The embodiments herein provide a container for stacked wafers wherein the base and top cover provides a secure latching mechanism, provides a wider range of the numbers of wafers that can optimally be carried and quantity of spaces and cushioning material that resists impacts and effectively isolates the wafers from such impacts, that is highly suitable to robotic operation, that provides effective sealing of the wafers, that resists bowing and base instability, and that receives memory disks in part of the top cover reinforcing region. Referring to FIG. 14 a plan view of the engagement of the bearing surfaces of the top cover and the base at an unstressed state are illustrated with the gaps exaggerated. With F acting on the corner of the top cover (not shown) the transfer of the force to the base will be at the base opposite the corner receiving the force, and will be principally at the shoulder 602. Note that at the sides of the base a lip 605 may extend upwardly to provide a supplemental or alternative engagement member for receiving forces on the opposite side of the shipper.

Referring to FIGS. 15 and 16, a further feature of the invention is illustrated. Although the structural configuration disclosed above will reduce or minimize distortion of the top cover 804 and base 802 compare to prior art FIG. 11) to the extent that some twisting of the top cover occurs which causes disengagement of the top cover lower edge 810 with the seat 812, the peripheral lip 813 keeps the uplifted edge below the top of said lip 813 thus maintaining a labyrinth path 815 into the wafer pocket and eliminating visual exposure of the gap G4.

Referring to FIGS. 17, 17a, 18, 19 and 20, an alternative embodiment of the wafer carrier is illustrated. The wafer carrier has a first plurality of arcuate lateral wafer support segments 908 that extend from the base 902 and define a first wafer stack pocket 912. The first wafer stack pocket 912 is substantially symmetrical about a central axis 914. A diameter of the first wafer stack pocket 912 is preferably about 8 inches.

The wafer carrier also includes a second plurality of arcuate lateral wafer support segments 918 that extend from the base 902 and define a second wafer stack pocket 922. The second wafer stack pocket 922 is substantially symmetrical about the central axis 914. A diameter of the second wafer stack pocket 922 is preferably about 6 inches. Providing the second wafer stack pocket 922 within the first wafer stack pocket 912 further enhances the ability of the wafer carrier of the present invention to protect wafers placed in the wafer carrier from damage caused by external forces placed on the wafer carrier.

Each of the arcuate lateral wafer support segments 918 are preferably aligned with one of the arcuate lateral wafer support segments 908. The arcuate lateral wafer support segments 918 are located between the arcuate lateral wafer support segments 908 and the central axis 914.

A side wall 914 extends around the periphery 914 of the base 902. Nominal wall structures 916 in the pocket floor 911 provide structural rigidity to the base 902 by providing undulating attachment positions between the floor 911 and each wafer support segment 908.

The base 902 has a bearing surface 910 and a shoulder 950 that extends upwardly from the bearing surface 910. The shoulder 950 has an upright surface 954 that operates as an outer constraint to the top cover 904 during impact or when other similar stresses are exerted upon the wafer carrier.

The base 902 has a latching members 964 extending from at least two corners thereof. Each latching member 964 has a hook portion 966 with a cam surface 968 and an engagement surface 970. The latching members extend into the apertures formed into a least two corners

of the top cover. The apertures 976 are placed on the top cover 904 in locations that correspond with the location of the latching members 964 on the base 902.

A further aspect of the invention is the mold for manufacturing the wafer carriers of two different pocket sizes. A further aspect is the methodology of molding carriers with a pocket for a first size of wafers and converting to carriers with a pocket for a second size of wafers Referring to FIG. 44 a mold 988 is shown with a lower portion 990 and an upper portion that cooperate to form a mold cavity. Such a mold is shown for molding the base portion is has a mold cavity 991 including a first set of slots 991 or recesses which are for forming the outer arcuate lateral wafer support segments and a second set of slots 992 or recesses which are for forming the inner or second set of arcuate wafer support segments. Plugs or blanks 993 sized to fill or cover the second set of arcuate wafer support segment slots are utilized for converting from, for example, an 8 inch carrier to a 6 inch carrier. The methodology of accomplishing comprises insertion of the blanks into the slots and performing the molding operation.

WHAT IS CLAIMED IS:

1. A wafer carrier for carrying a plurality of stacked wafers, the carrier comprising:

a cover comprising a generally horizontal top portion having four corners and four sidewall portions extending downwardly from the horizontal portion, each of the four sidewall portions having a downwardly facing bearing surface, an inward facing surface and a outward facing surface, the four sidewall portions defining a wafer receiving region therein, and

a base comprising a generally horizontal bottom portion having a perimeter, a pocket for receiving a stack of wafers, wafer support portions, upwardly extending shoulder portions and an upwardly facing bearing surface for operably receiving the downwardly facing bearing surface of the cover, wherein

the upwardly extending shoulder portions are configured such that a force having a horizontal component acting on the top cover causes an engagement of the outwardly facing surface of the cover with the upwardly extending shoulder portions of the base before engagement of the inward facing surface of the cover with the wafer support portions of the

base.

2. The wafer carrier of claim 1, wherein the four side wall portions are contiguous.

3. The wafer carrier of claim 2, wherein the four side wall portions are joined by corner portions that jog inwardly.

4. The wafer carrier of claim 1, wherein the wafer support portions of the base are arcuate and define a circular pocket for containing a stack of wafers.

5. The wafer carrier of claim 1, wherein the wafer support portions are arcuate and define a first circular pocket having a first diameter and a second circular support pocket having a second diameter, wherein the second diameter is greater than the first diameter.

6. The wafer carrier of claim 1, wherein the wafer support portions include a stacking level indicator.

7. The wafer carrier of claim 6, wherein the stacking level indicator is a notch in the wafer support portions.

8. The wafer carrier of claim 1, wherein the base further includes a plurality of latching members and the cover further includes a plurality of apertures configures to receive the latching members therethrough.

9. The wafer carrier of claim 8, wherein the latching members have a horizontal portion extending horizontally inward, a vertical portion extending upwardly and an engagement portion, wherein the engagement portion is configured to engage the apertures of the cover thereby releasably securing the base to the cover.

10. The wafer carrier of claim 9, wherein the latching member adjoins the base along the horizontal portion.

11. The wafer carrier of claim 1, wherein the base further includes a lip extending

upwardly along the perimeter.

12. The wafer carrier of claim 11, wherein the lips extends upwardly to a height sufficient to conceal a gap formed between the downwardly facing bearing surface of the cover and the upwardly facing bearing surface of the base, the lip forming a labyrinth seal with the downwardly facing bearing surface and the upwardly facing bearing surface.

13. The wafer carrier of claim 1, wherein at least one of said cover and base further includes a plurality of nominal wall channels formed therein for rigidity, the wall channels linear and directed in at least one of a radially or chordially direction.

14. The wafer carrier of claim 1, wherein the cover further includes a pocket portion in the horizontal top portion configured to receive a data storage media.

15. The wafer carrier of claim 14, wherein the data storage media is a 3.5 inch diskette.

16. The wafer carrier of claim 14, wherein the data storage media is a compact disk in a jewel case.

17. The wafer carrier of claim 1, wherein at least one of the cover and base further includes a nominal wall forming straight channels to provide resistance to twisting.

18. A wafer shipper for carrying a plurality of stacked wafers, the carrier comprising:

a cover comprising a generally horizontal top portion having four corners and four sidewall portions extending downwardly from the horizontal portion, the sidewall portions defining a wafer storage region therein, and

a base comprising a generally horizontal bottom portion having a pocket for receiving a stack of wafers, wafer support portions and upwardly extending shoulder, wherein

at least one of the wafer support portions include a stacking level indicator.

19. The Wafer shipper of claim 18, wherein the stacking level indicator is a notch in the wafer support portions.

20. The wafer carrier of claim 18, wherein the cover further includes a pocket portion in the horizontal top portion configured to receive a data storage media.

21. A wafer shipper for carrying a plurality of stacked wafers, the carrier comprising:

a cover comprising a generally horizontal top portion having four corners and four sidewall portions extending downwardly from the horizontal portion, the sidewall portions defining a wafer storage region therein, and

a base comprising a generally horizontal bottom portion having a pocket for receiving a stack of wafers, wafer support portions and upwardly extending shoulder, wherein

at least one of the base and cover includes a plurality of nominal wall channels formed therein for rigidity, the wall channels being linear and directed one of radially, chordially or both.

22. The wafer carrier of claim 21, wherein the cover further includes a pocket portion in the horizontal top portion configured to receive a data storage media.

23. A method for carrying a plurality of stacked wafers in a wafer container, the method comprising:

providing a storage base, the storage base comprising a generally horizontal bottom portion having a perimeter, a pocket for receiving a stack of wafers, wafer support portions, upwardly extending shoulder portions and an upwardly facing bearing surface

providing a cover, the cover comprising a generally horizontal top portion having four corners and four sidewall portions extending downwardly from the horizontal portion, each of the four sidewall portions having a downwardly facing bearing surface for cooperating with the upwardly extending bearing surface, an inward facing surface and a outward facing surface, the four sidewall portions defining a wafer receiving region therein, wherein the upwardly extending shoulder portions are configured such that a force having a horizontal component acting on the cover causes an engagement of the outwardly facing surface of the cover with the upwardly extending shoulder portions of the storage base before engagement of the inward facing surface of the cover with the wafer support portions of the storage base.

placing a first wafer stack cushion in the pocket of the storage base,

placing a stack of wafers in the first wafer stack cushion, the stack of wafers comprised of a plurality of individual wafers stacked on top of one another with a wafer cushion interposed between the individual wafers,

placing a second wafer stack cushion on top of the stack of wafers, and

placing the cover on the storage base.

24. The method of claim 23, further comprising the step of releasably latching the cover to the storage base.

25. The method of claim 23, wherein the base further includes a plurality of latching members and the cover further includes a plurality of apertures configures to receive the latching members.

26. The method of claim 25, wherein the latching members have a horizontal portion extending horizontally inward, a vertical portion extending upwardly, and an engagement portion, wherein the engagement portion is configures to engage the apertures of the cover thereby releasably securing the storage base to the cover.

27. The wafer carrier of claim 26, wherein the latching member adjoins the base along the horizontal portion.

28. The wafer carrier of claim 23, wherein the storage base further includes a lip extending upwardly along the perimeter.

29. The wafer carrier of claim 28, wherein the lips extends upwardly to a height sufficient to conceal a gap between the downwardly facing bearing surface of the cover and upwardly facing bearing surface of the storage base, thereby forming a labyrinth seal.

30. The wafer carrier of claim 23, wherein at least one of said cover and base further includes a plurality of nominal wall channels formed therein for rigidity, the wall channels linear and directed in at least one of a radially or chordially direction.

31. The wafer carrier of claim 23, wherein the cover further includes a pocket portion in the horizontal top portion configured to receive a data storage media.

32. The wafer carrier of claim 31, wherein the data storage media is a 3.5 inch diskette.

33. The wafer carrier of claim 31, wherein the data storage media is a compact disk in a jewel case.

34. The wafer carrier of claim 23, wherein at least one of the cover and storage base includes a nominal wall forming straight channels to provide resistance to twisting.

35. The method of claim 23, further including the step of checking the height of the first wafer stack cushion, wafer stack, and second wafer stack cushion against a stacking level indicator.

36. The method of claim 36, wherein the stacking level indicator is a notch in the wafer support portions.

37. A mold system for a wafer carrier, the mold having recesses for forming a first set of walls defining a wafer pocket of a first size for the wafer carrier and further has generally concentric recesses for forming a second set of walls for defining a wafer pocket of a second size, the mold system further having inserts for insertion into at least one of said sets of recesses for converting the mold.

38. A method of forming a wafer carriers having a first pocket size and for forming a wafer carrier having a second pocket size, the method comprising:

providing a mold portion having a mold cavity with two sets of recesses, each set for forming a plurality of wall segments for defining a different size wafer pocket, and

inserting blanks into at least one set of recesses, and

injecting molten plastic into the mold cavity.

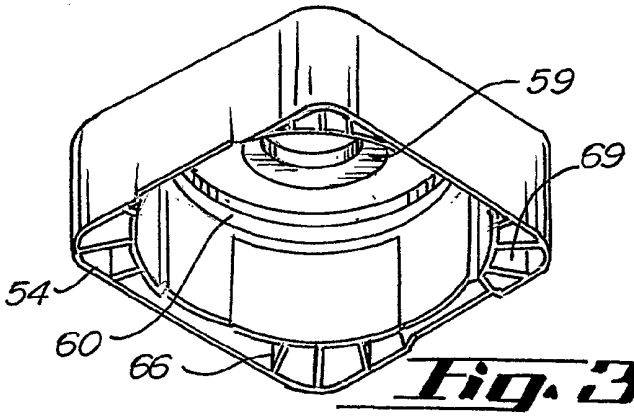


Fig. 3.
PRIOR ART

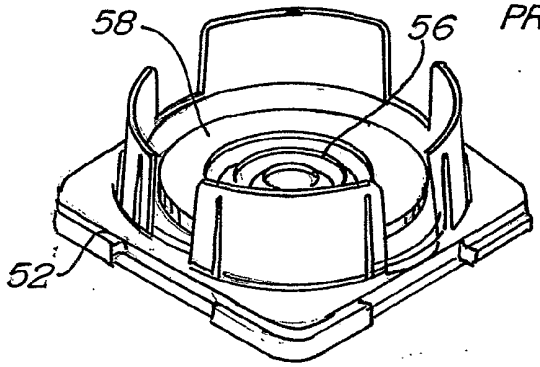


Fig. 2.
PRIOR ART

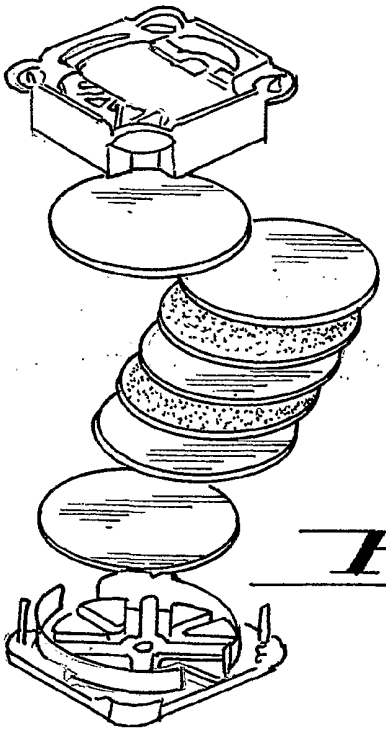


Fig. 6c.

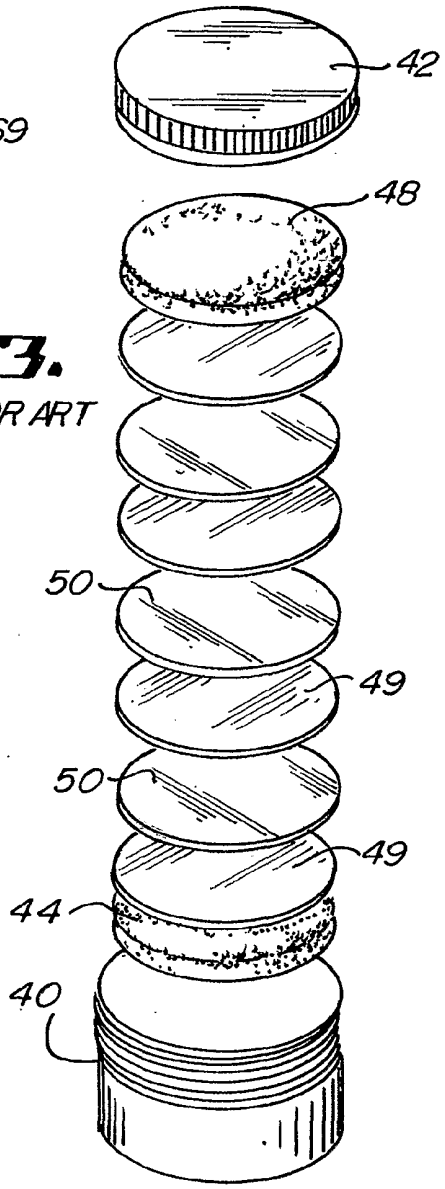


Fig. 1.
PRIOR ART

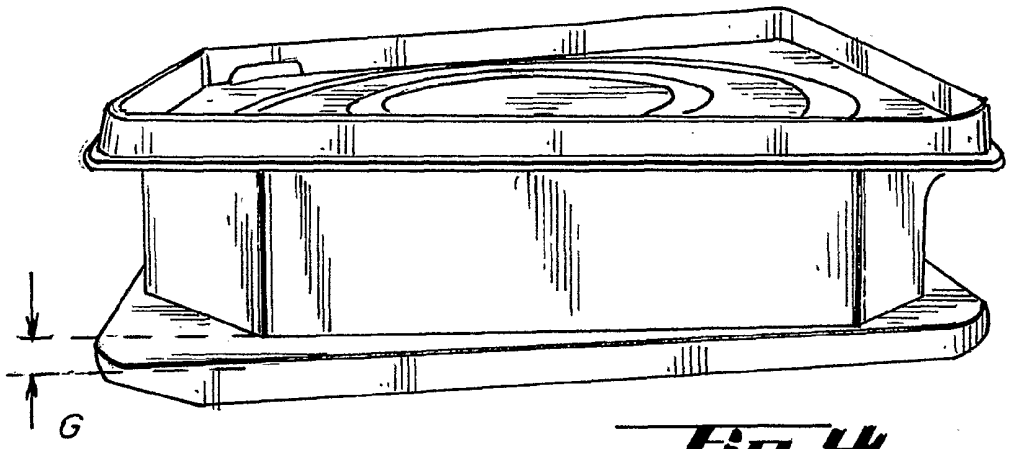


Fig. 4.
PRIOR ART

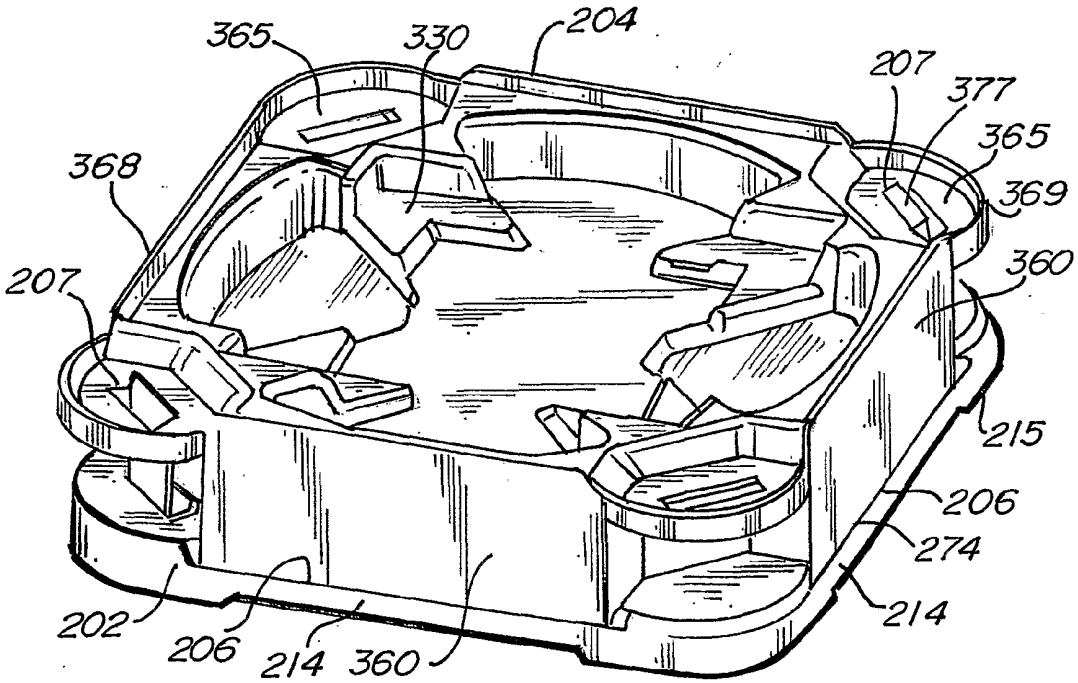


Fig 5.

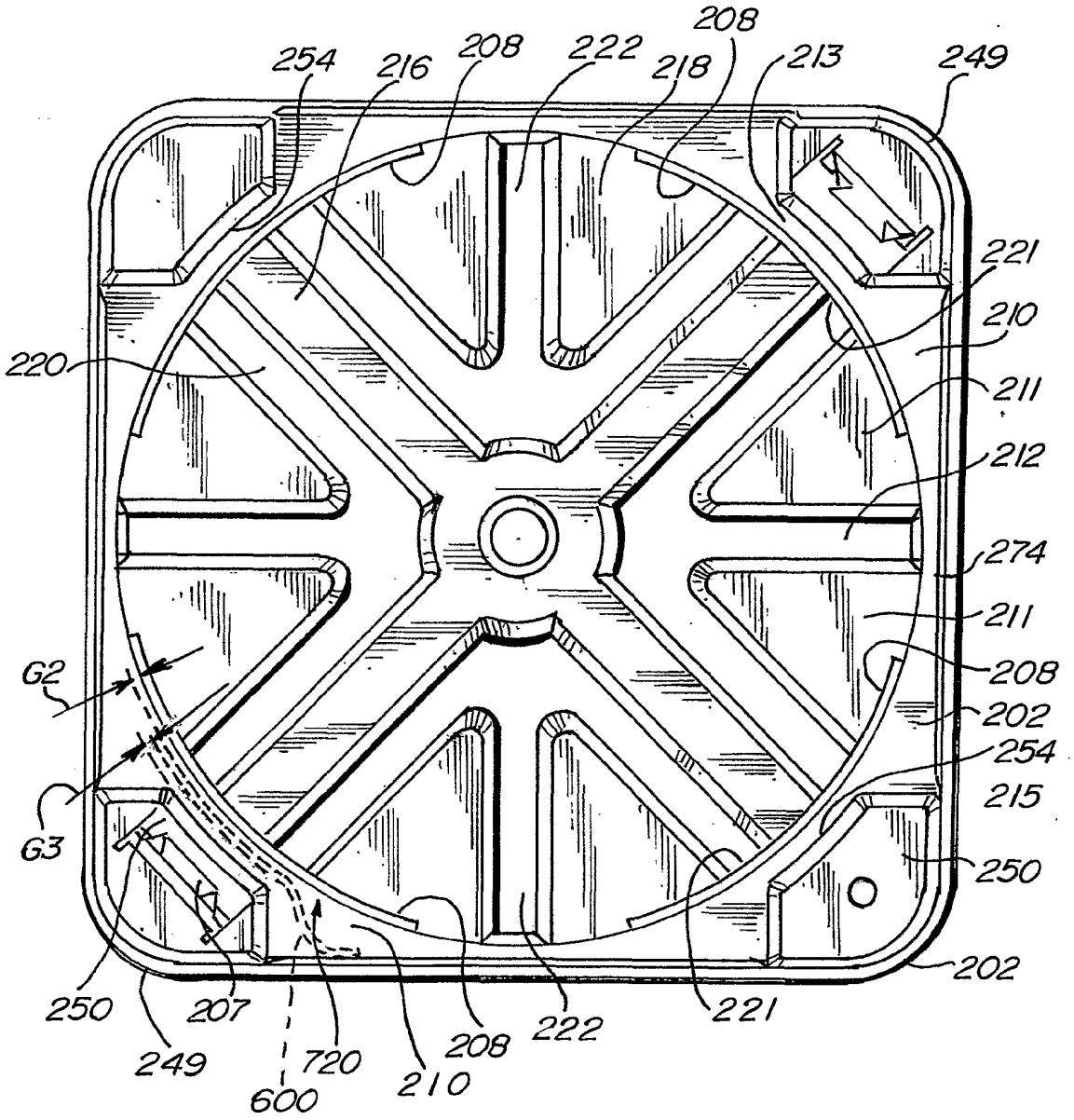

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Fig. 6.

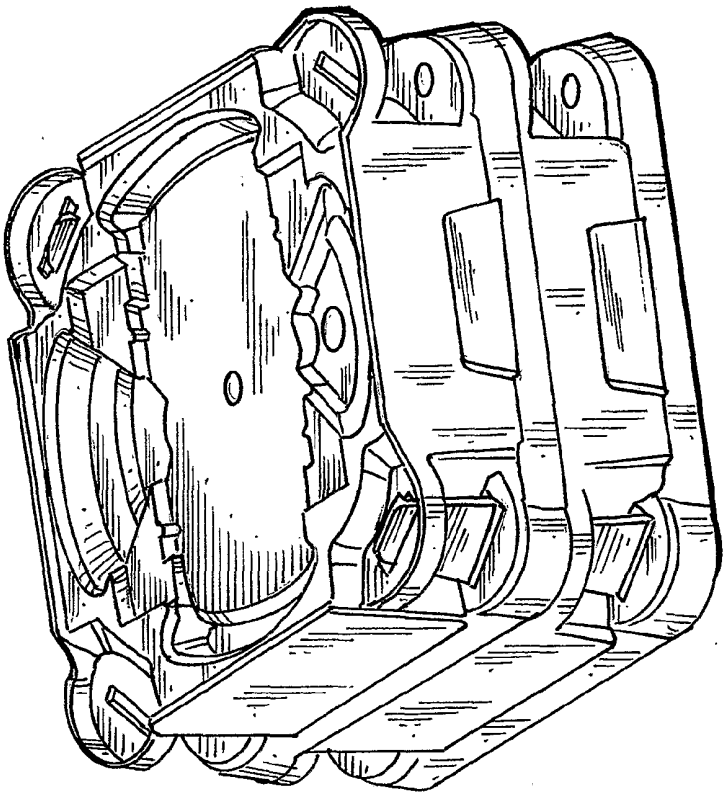

Fig. 6b.

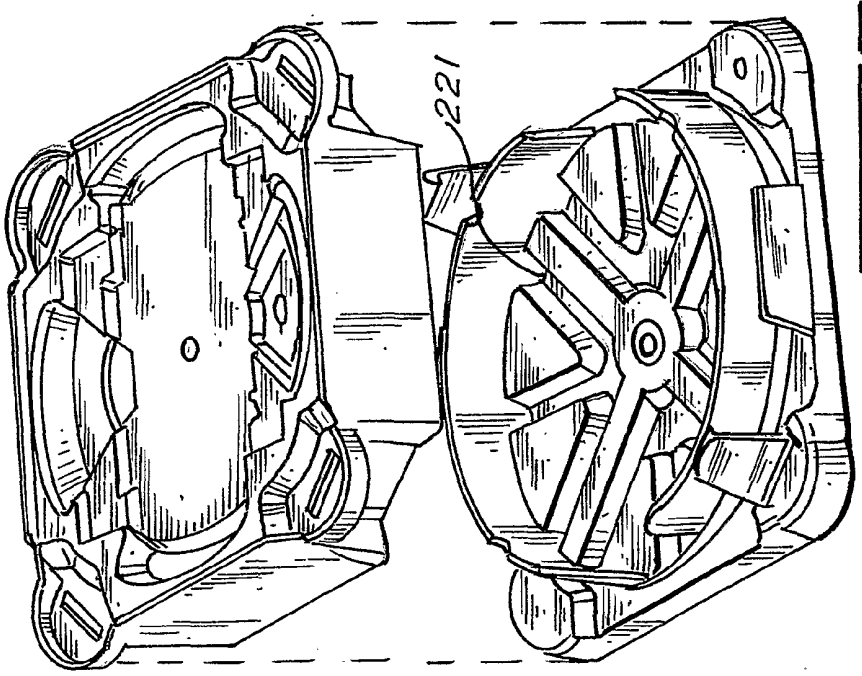

Fig. 6a.

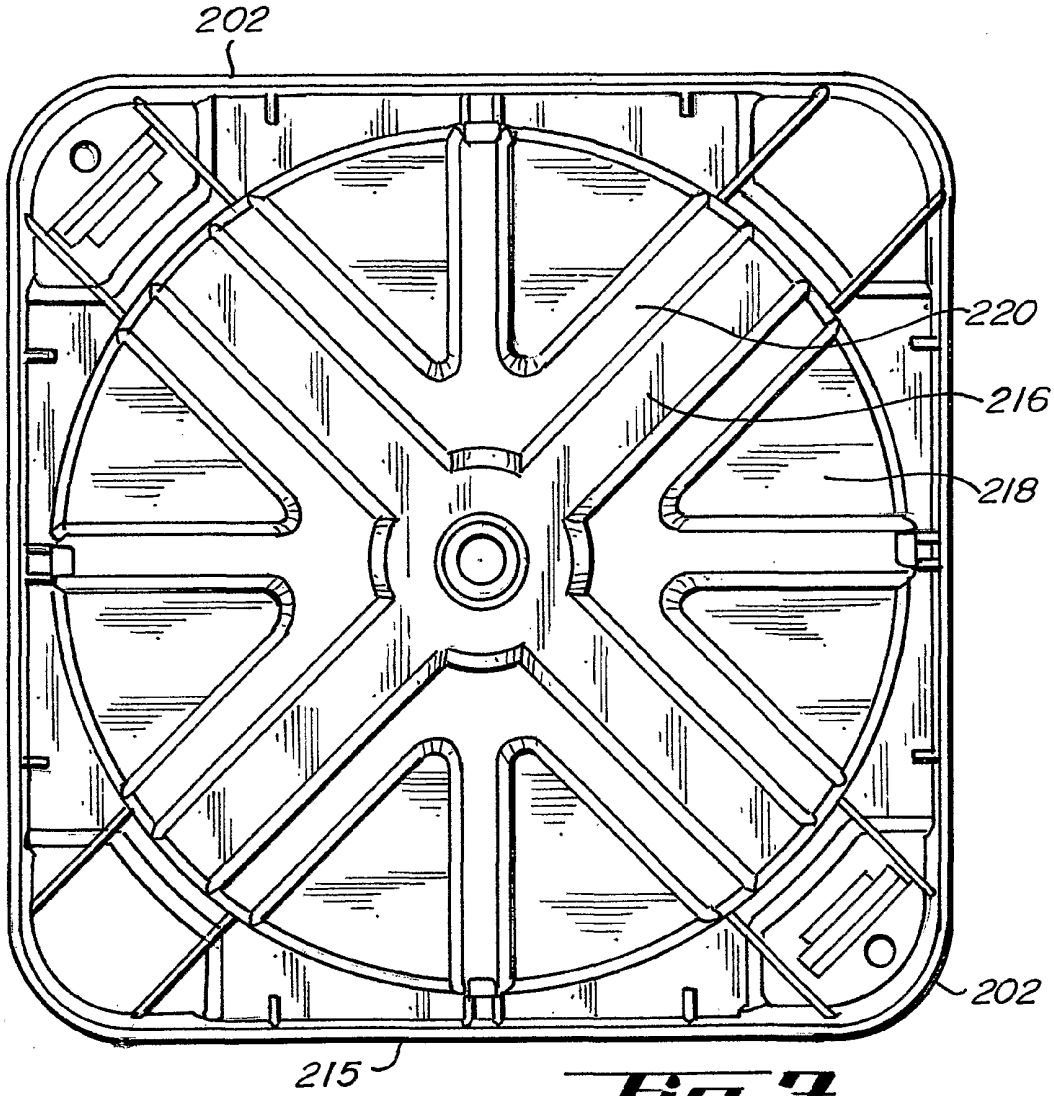
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Fig. 7.

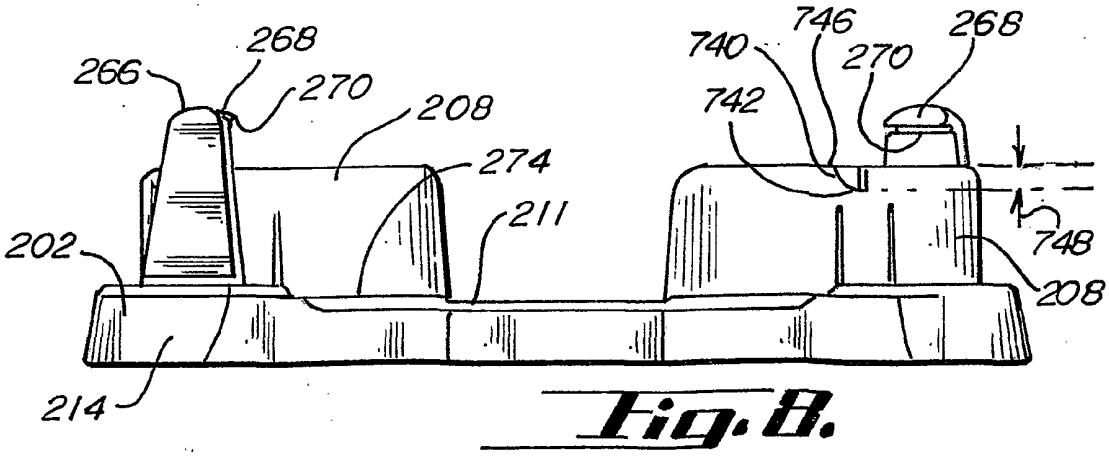
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Fig. 8.

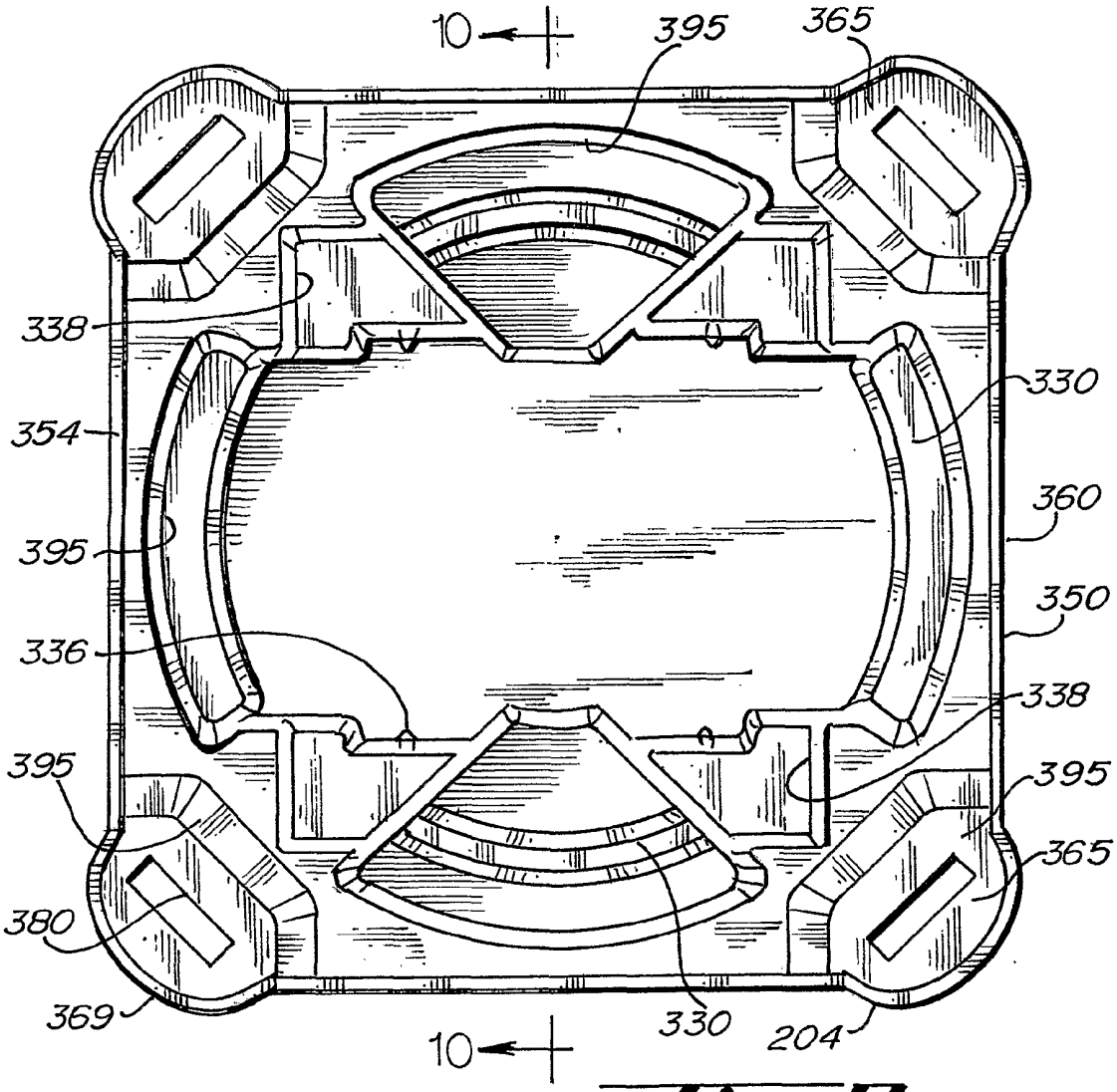
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Fig. 9.

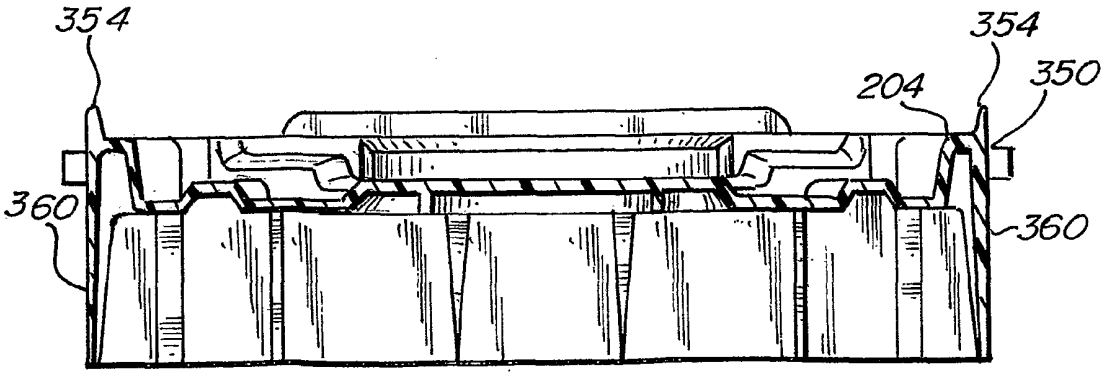
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Fig. 10.

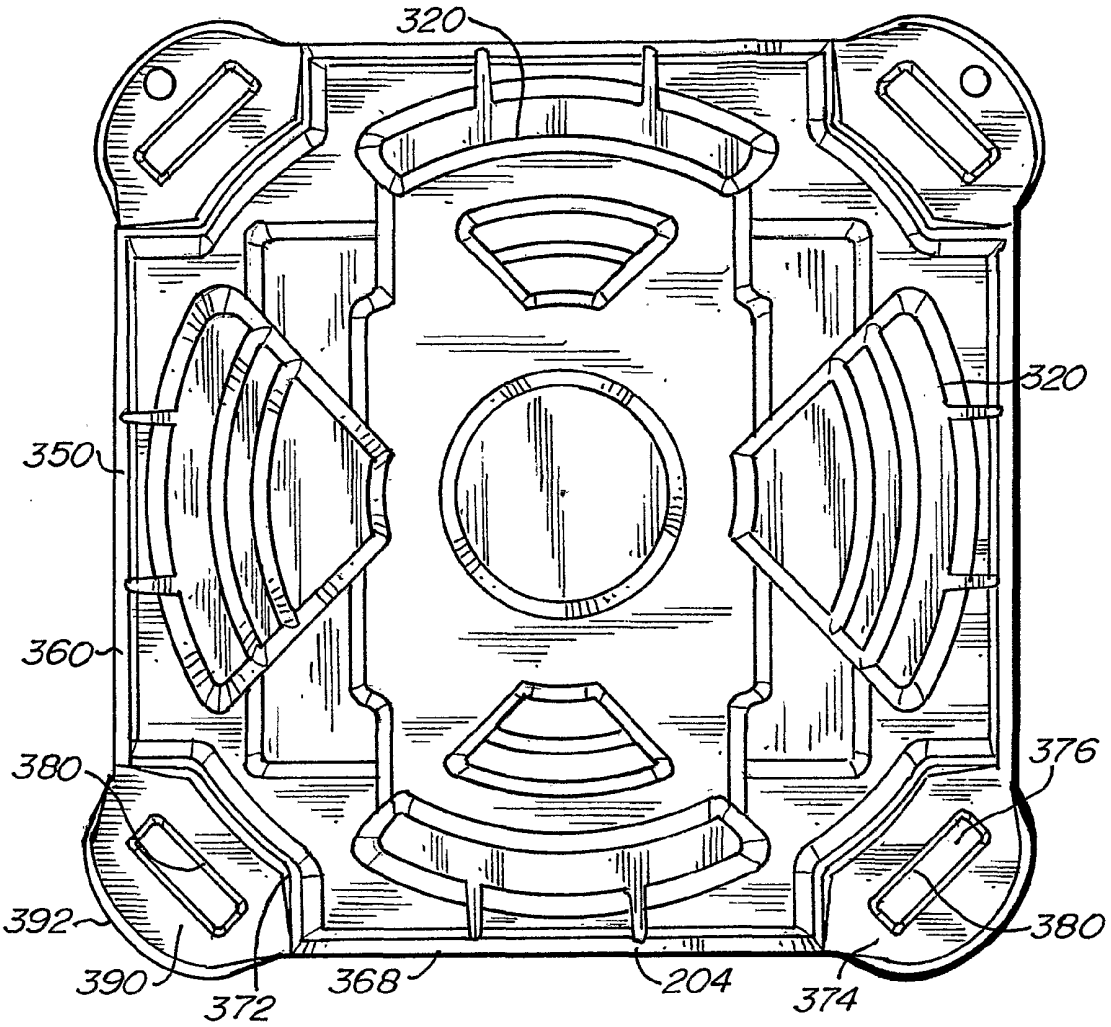
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Fig. 12.

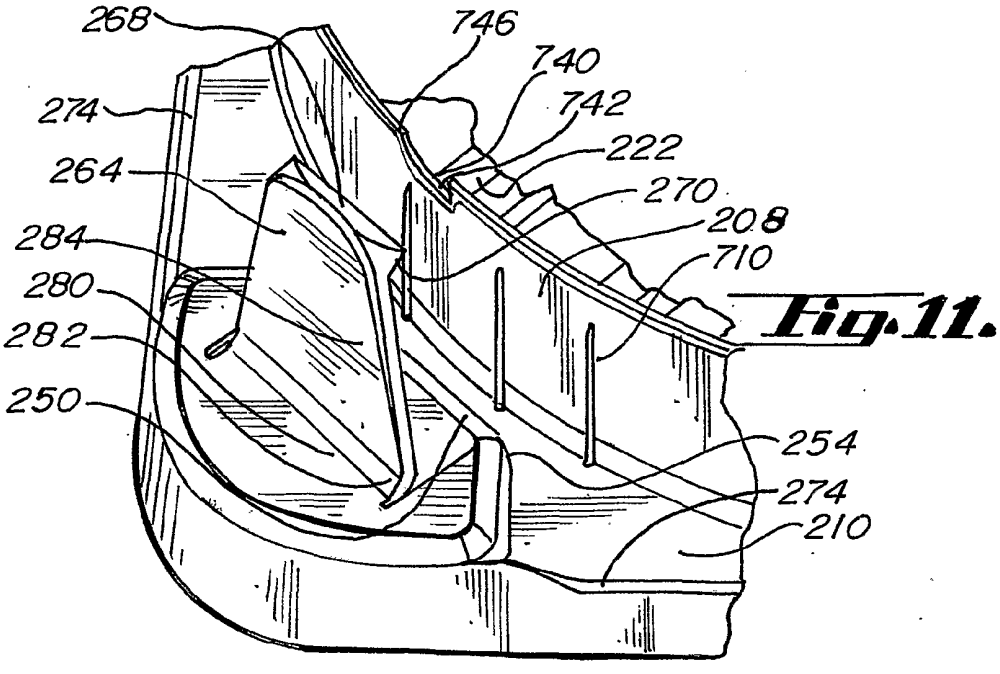
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Fig. 11.

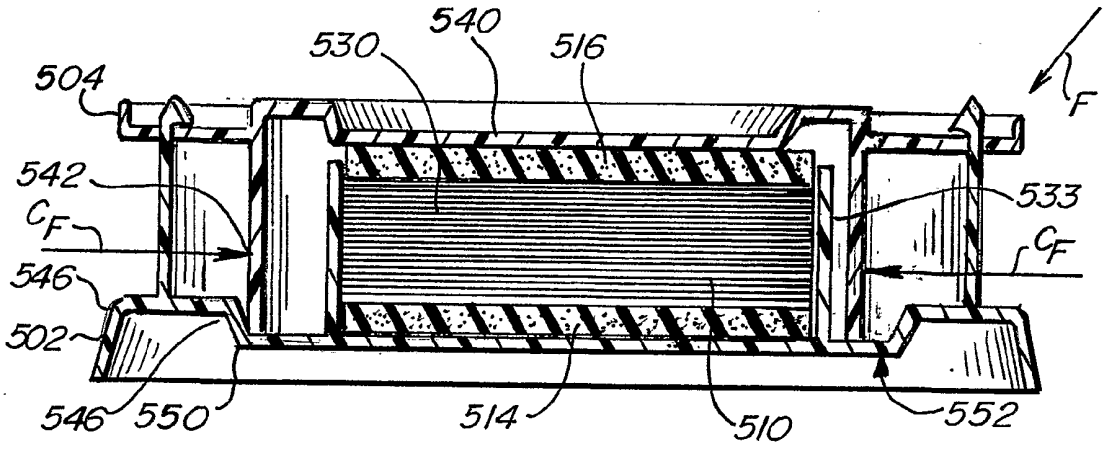

Fig. 13.

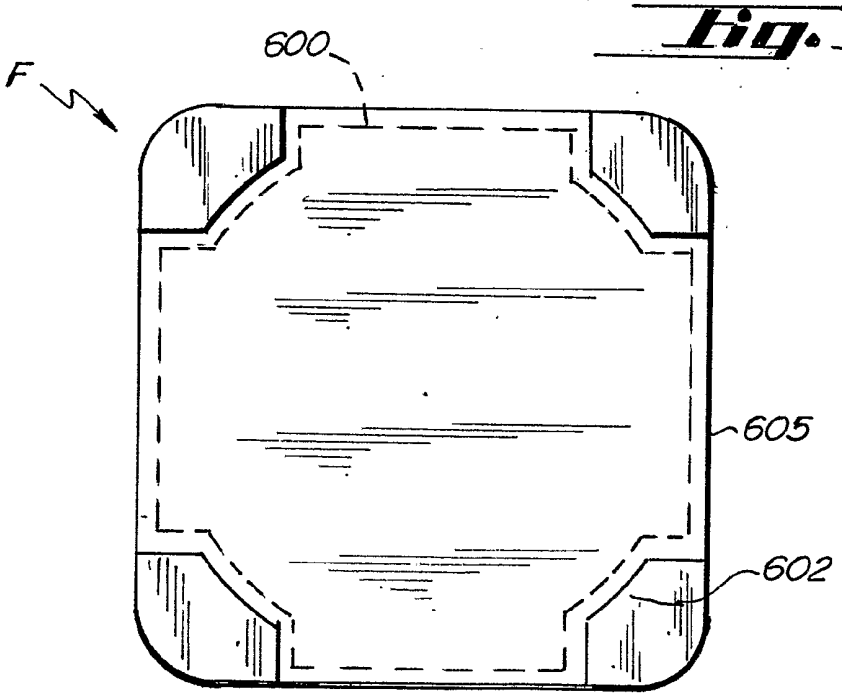

Fig. 14.

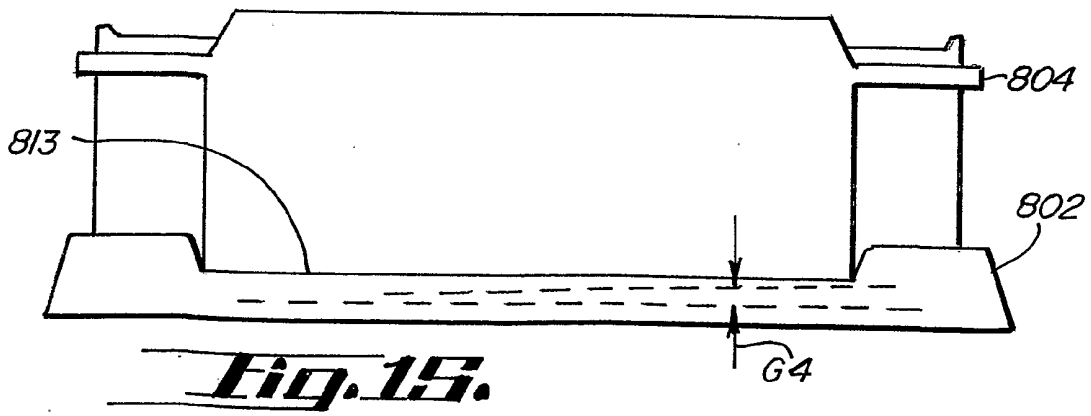

Fig. 15.

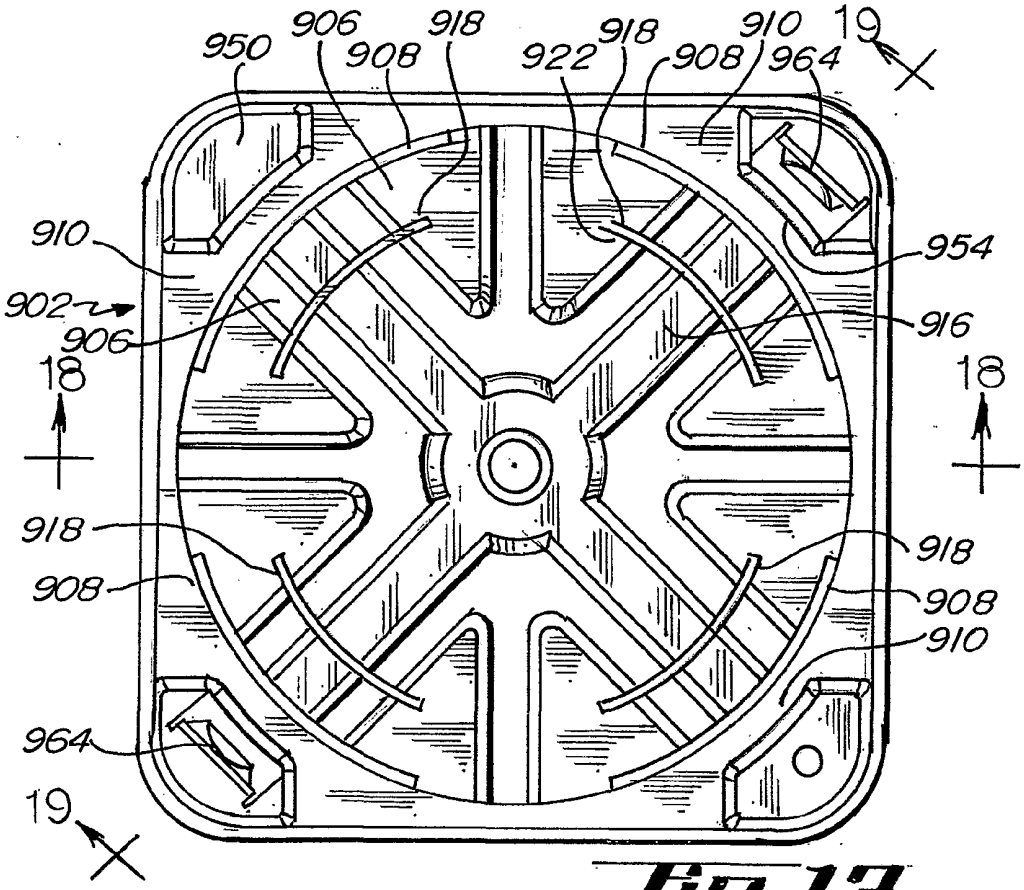

Fig. 17.

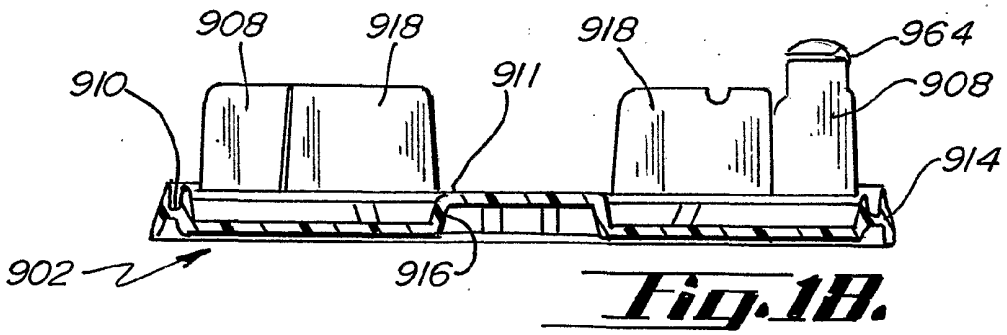

Fig. 18.

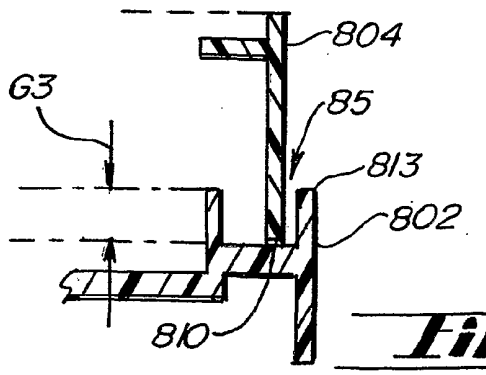

Fig. 16.

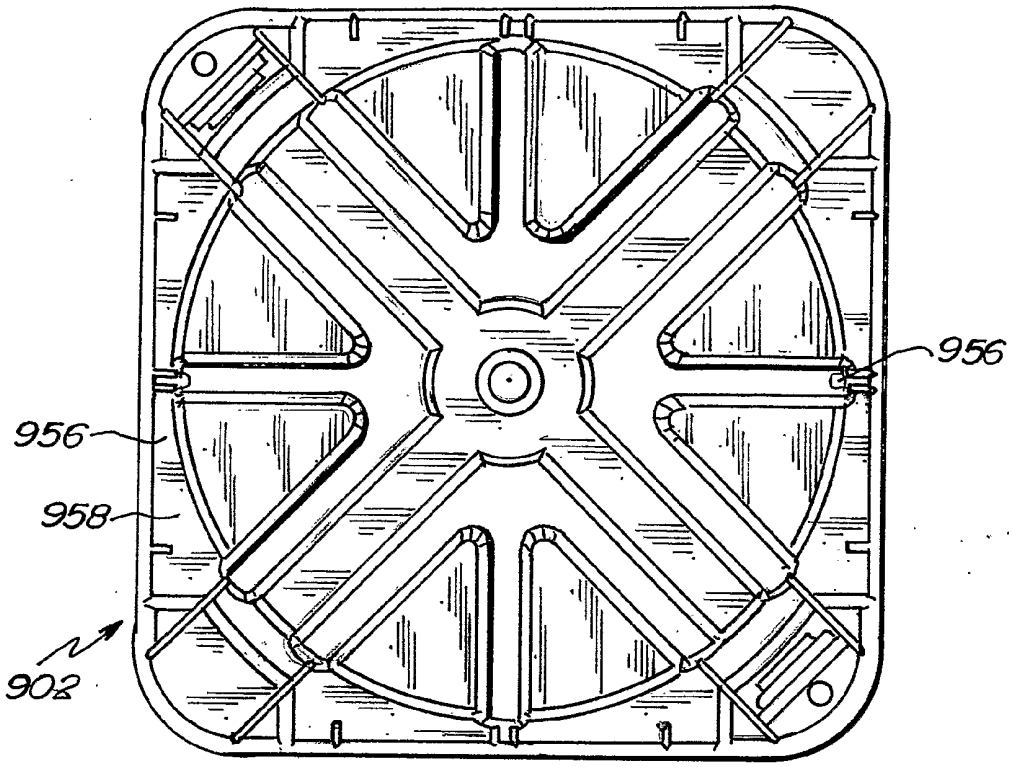

Fig. 20.

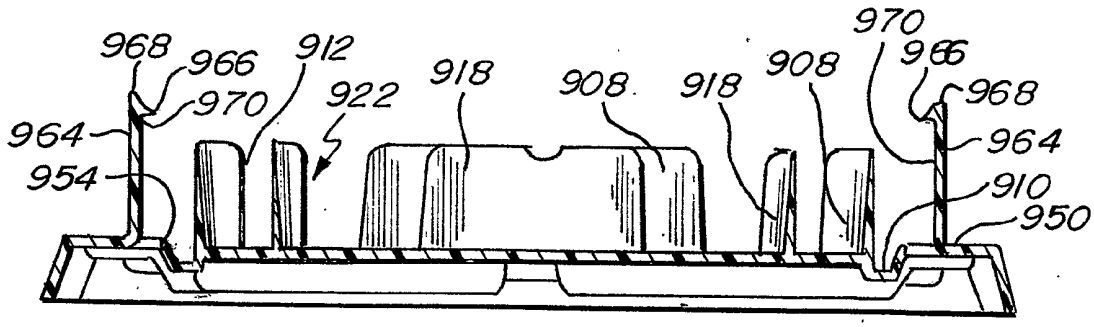

Fig. 19.

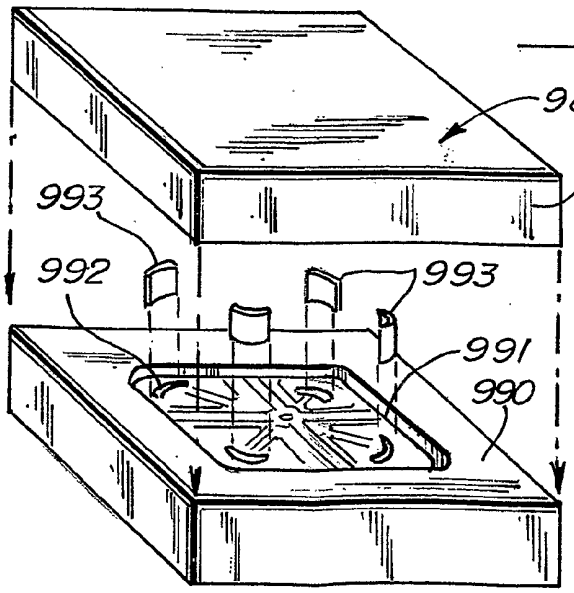

Fig. 21.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/15020

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B65D 85/48,85/00,85/02; A45C 13/10
US CL :206/454, 449, 710, 303, 1.5; 211/41.18; 118/500
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 206/454, 449, 710, 303, 1.5; 211/41.18; 118/500

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 4,817,799 A (GREGERSON et al) 04 April 1989, see cols 2 and 3.	1,2,4,11,12,17,21 ---------- 6,7,13,14, 15,16, 18,19, 22
Y	US 5,402,890 A (YAJIMA et al) 04 April 1995, see col. 4, lines 63-68 and col.5, lines 1-5.	14, 15,16, 20, 22
Y	US 5,366,079 A (LIN et al) 22 November 1994, see abstract.	6,7, 14, 15, 16,18, 19, 22
Y	US 5,553,711 A (LIN et al) 10 September 1996, See col.2, lines 26-40.	6,7,14,15, 16,18,19, 22

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 29 AUGUST 2001	Date of mailing of the international search report 19 SEP 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer SHIAN LUONG Telephone No. (703) 308-1148 Sheila Veney Paralegal Specialist Technology Center 3700

Form PCT/ISA/210 (second sheet) (July 1998)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/15020

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,135,625 A (MERRILL) 23 January 1979, see cols 4-5.	37-38
A	US 3,850,296 A (HIRATA et al) 26 November 1974, see abstract.	37-38

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/15020

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/15020

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claims 1-22, drawn to a wafer shipper.
Group II, claims 23-36 and 38, drawn to a method of forming a wafer carrier.
Group III, claim 37, drawn to a mold system.

The inventions listed as Groups I, II and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of Group I is a wafer container with the upwardly extending shoulder portion and stacking level indicator while the special technical feature of Group II is a mold and the steps of inserting the blanks into the mold and the special technical feature of Group III is a mold system for a wafer carrier. Since the special technical features of Groups I, II and III do not concur, they lack unity of invention.