(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 197 214**
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **85304348.7**

(51) Int. Cl.⁴: **B 24 B 37/04**

(22) Date of filing: **18.06.85**

(30) Priority: **08.04.85 US 720644**

(43) Date of publication of application:
15.10.86 Bulletin 86/42

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

(71) Applicant: **Rodel, Inc.**
451 Bellevue Avenue Diamond State Industrial Park
Newark Delaware 19713(US)

(72) Inventor: **Budinger, William D.**
16 Southridge Road Kennett Square
Philadelphia PA 19348(US)

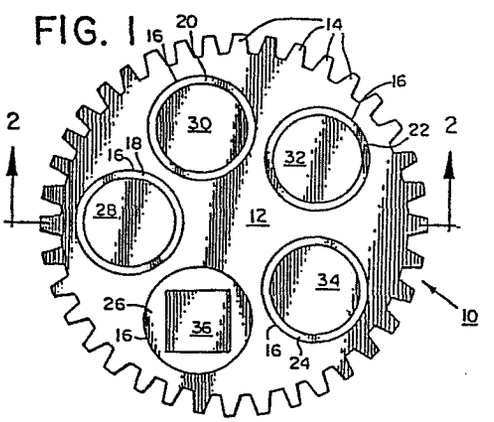
(72) Inventor: **Cabelli, Michael, D.**
1312 Oberlin Road
Wilmington, DE 19803(US)

(74) Representative: **Ackroyd, Robert et al,**
POLLAK MERCER & TENCH High Holborn House 52-54
High Holborn
London WC1V 6RY(GB)

(54) **Carrier assembly for two-sided polishing operation.**

(57) The present invention relates to a carrier assembly (10; 110) comprising a drive ring (12; 112; 212) made of a hard material in which at least one aperture (16; 116) is formed for retaining a preferably removeable workpiece holder (18, 20, 22, 24, 26; 118; 218) made of softer material than the material used to make the drive ring. The workpiece holder contains a cavity which holds and retains the workpiece (28, 30, 32, 34, 36; 128, 130; 228, 230). The softer material of the workpiece holder protects and cushions the workpiece while the drive ring made of hard material withstands the forces generated during polishing, lapping and grinding operations.

FIG. 1



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CARRIER ASSEMBLY FOR TWO-SIDED POLISHING OPERATION

Background of the Invention

Field of the Invention

This invention relates to a carrier assembly for holding workpieces for polishing, lapping or grinding operations and is particularly suited to two-sided operations. More specifically, the invention relates to a carrier assembly comprising a drive ring containing one or more workpiece holders in which the workpiece holders are of a softer material than the drive ring to diminish defect formation of the workpiece during the polishing, lapping or grinding operation.

The present invention is intended primarily for use in double-sided operations in which both sides of a substrate simultaneously are polished, lapped or ground to produce flat, uniform surfaces. Unless otherwise indicated, for the sake of convenience, the term "polish" will be used herein somewhat generically to refer to the different types of polishing, lapping or grinding treatments, since the present invention can be used with any or all of them.

Description of the Prior Art

Typical double-sided polishers use iron or steel plates and/or a variety of synthetic or natural polishing pads to effect the surface transformation of the workpiece to be polished. In a typical machine, carrier assemblies which hold workpieces are driven by a drive mechanism comprising a stationary outer circular member with teeth arranged on the inner periphery of the circle. Concentric to and centrally located within the stationary member is a rotating drive member with teeth on its outer periphery. Carrier assemblies having a toothed perimeter are mounted in meshing relationship between the stationary and rotating members. The carrier assemblies are circular disks which include apertures that retain the workpieces, such as semiconductor wafers and aluminum plates for example.

Typical materials of construction for durable, rigid carrier assemblies for two-sided polishing operations are steels and other metallic alloys, such as nickel alloys like INCONEL and MONEL, trademarked alloys of International Nickel Company, Inc. Their great strength and rigidity are important factors in the production of exterior teeth that are able to with-

stand the severe forces building up between the driving and driven teeth of the stationary and driving members and of the carrier assembly which build up during the polishing process. However, the same strength and durability which provide advantageous long life also create disadvantages which have yet to be overcome.

When polishing softer or friable materials, for example electronic substrates, such as silicon, GGG (gallium gadolinium garnet), GaAs, etc., the hard edge of the steel or other rigid metal forming the aperture in the carrier assembly, coupled with rapid carrier movement and/or the movement of the substrate within the aperture, may produce chipping and/or cracking of the substrate edge. The interaction may produce substrate deformations that are not visible to the unassisted eye, but which render the substrate partially or totally useless for further processing.

Attempts have been made to construct the carrier assembly entirely out of softer material, such as polyester, polyethylene, polycarbonate, nylon, polyvinylchloride, acrylate, polyurethane, epoxy, acetals (such as DELRIN, a trademark of E. I. du Pont de Nemours & Company), both unreinforced and reinforced

with various fibers. The use of the softer material helps prevent defects in the workpiece being polished, but results in excessive, premature wear of the carrier assembly teeth causing reduced lifetime and higher overall costs.

Incorporating the two types of materials, a relatively hard metal and a relatively soft material mentioned above, into a carrier by coating the harder core material with a softer surface material is an effective alternative for thicker carriers and correspondingly thicker substrates being polished. For thinner substrates, however, the core material must be made so thin that the resultant carrier becomes flimsy and substantially useless.

The present invention overcomes the problems associated with the prior art in that it allows the use of a hard, durable material for an outer drive ring and a softer material used as workpiece holders to hold and protect the workpieces to be polished.

Summary of the Invention

The present invention includes a carrier assembly for use in polishing, lapping or grinding operations comprising a drive ring adapted to be

mounted for rotation including drive connection means for drivingly connecting the drive ring to a driving source, the assembly characterized by the drive ring containing at least one aperture for retaining a workpiece holder, and a workpiece holder retained in the aperture, the workpiece holder being adapted to hold a workpiece in a cavity formed in the workpiece holder, the drive ring being made of a material relatively harder than a relatively softer material forming the workpiece holder, the relatively harder material being more capable of withstanding forces associated with the driving of the drive ring than the relatively softer material, the relatively softer material being more capable of protecting and cushioning against chipping and cracking any workpiece held within a workpiece holder formed thereof than the relatively hard material.

The present invention thus isolates and allows the effective and efficient operation of the two functions of the previously inefficient prior art unitary double-sided carrier: (1) transmission of motion to the workpiece being polished, and (2) protection of that workpiece while it is being polished.

A number of workpiece holders can be and preferably are used in one carrier assembly. The workpiece holders may include central cavities having different shapes to accommodate different shaped workpieces to be polished. The workpiece holders of the present invention preferably are removeable, replaceable and interchangeable within a carrier assembly.

Individual workpiece holders could be fabricated of the best materials, shape and size to correspond to the requirements of a particular workpiece. The invention allows the use of a single set of relatively expensive drive rings to be engaged with a number of less expensive workpiece holders adapted for different workpieces.

Brief Description of the Drawings

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

Figure 1 is a plan view of one embodiment of a carrier assembly according to the present invention.

Figure 2 is a vertical sectional view of the carrier assembly of Figure 1 taken along the line 2--2 in Figure 1 with polishing platens illustrated schematically in phantom.

Figure 3 is a plan view of a second embodiment of a carrier assembly according to the present invention.

Figure 4 is a vertical sectional view of the carrier assembly of Figure 3 taken along line 4--4 in Figure 3 with polishing platens illustrated schematically in phantom.

Figure 5 is a vertical sectional view of a third embodiment of a carrier assembly according to the present invention.

Detailed Description of the Preferred Embodiments

Referring to the drawings in detail, wherein like numerals indicate like elements, there is shown in Figure 1 a carrier assembly 10. Carrier assembly 10 comprises a drive ring 12 having teeth 14 on its outer periphery. Teeth 14 are illustrated as gear teeth and may be of any known tooth shape, for example involute. A pin tooth structure could also be used if desired.

Carrier assembly 10 of the present invention may be and preferably is used in double-sided polishing apparatus in place of currently available single-piece carrier assemblies.

One or alternately a plurality of apertures 16, each adapted to retain a workpiece holder, are formed in drive ring 12. Preferably, and as set forth below with respect to Figure 3, only one aperture is formed in drive ring. It is preferred that apertures 16 be milled or otherwise machined in drive ring 12, rather than pressure stamped. Milling or machining provides an aperture edge profile which is straight and true, resulting in a longer workpiece holder life.

The spacing and placement of workpiece holder apertures 16 are discretionary, so long as there is a sufficient distance between the apertures and the perimeter of the drive ring and sufficient spacing between each of the adjacent apertures so as not to unduly weaken the drive ring or cause interference among the various polishing processes occuring in alignment with each of the apertures. It is presently preferred to space the apertures equidistant from each other as indicated in a circular orientation surrounding the

center of the drive ring. Preferably, workpiece holder apertures 16 are arranged in a circular pattern in which the perimeter of the circle passes through the center of each aperture whereby twice the distance from the center of the drive ring 12 to the center of any aperture 16 defines a dimension which may be called the workpiece holder circle diameter.

Workpiece holders 18, 20, 22, 24 and 26 are inserted within and retained by apertures 16. The workpiece holders may be retained in apertures 16 fairly loosely, such that they and the workpiece held within each workpiece holder generally will be supported by the lower polishing pad or platen, schematically represented at 30 in Figure 2. Hydraulic forces and other forces associated with the polishing processes may cause the workpiece and workpiece holder to be located somewhat above the lower pad or platen in some circumstances.

It is preferred that the workpiece holders used in connection with any particular drive ring have a uniform outer diameter so that they may be removed and interchangeably replaced with other workpiece holders. The workpiece holders have a cavity formed

therein in which workpieces or substrates 28, 30, 32, 34 and 36 are inserted.

The workpieces or substrates can be either unitary substrates where both major surfaces are polished, or two substrates placed back to back within the cavity of the workpiece holder, with or without a polymeric film or fibrous paper separator. In this latter instance, only one major face of each substrate would be polished efficiently using a double-sided polishing machine.

The workpiece holder cavities may be of the same shape and dimension as each other, as illustrated by workpiece holders 18, 20, 22, and 24, or may have a different shape and dimensions, as illustrated by workpiece holder 26. Thus, the substrates 28, 30, 32 and 34 are all circular in horizontal cross-section, while workpiece 36 is square in horizontal cross-section. The shapes shown in Figure 1 are for purposes of illustration only, since the cavity of any workpiece holder can be custom designed to correspond with the shape of the workpiece. Moreover, despite the different shape of workpiece 36 and the corresponding different shape of the cavity in workpiece holder 26, workpiece holder

26 could be interchanged with any of the other workpiece holders illustrated in Figure 1.

The workpiece holders in Figure 1 are illustrated as having a circular perimeter to correspond with the general shape of many substrates which are polished, however, other shapes for apertures 16, workpiece holders 18, 20, 22, 24 and 26 and workpieces 28, 30, 32, 34 and 36 may be used and the shapes need not be identical or similar in any given drive ring.

As illustrated in Figure 2, drive ring 12 generally is the thinnest of the elements associated with the carrier assembly. The workpiece holders, such as workpiece holder 18 of Figure 2, generally are thicker than drive ring 12 to protect the workpiece, illustrated as workpiece 28 in Figure 2. Generally, the workpieces, such as workpiece 28, are thicker than all of the other elements of the carrier assembly so that they can be polished by the lower and upper polishing pads or platens schematically represented in phantom and identified by numerals 38 and 40, respectively.

Figure 3 illustrates another embodiment of a carrier assembly 110 according to the present inven-

tion. Carrier assembly 110 comprises drive ring 112 having teeth 114 around its perimeter. A single central aperture 116 is formed in drive ring 112. Workpiece holder 118 is inserted into and retained within aperture 116.

In many instances, it is desired to prevent the rotation of a workpiece holder in the drive ring. One means for preventing such rotation would be to have noncircular apertures and corresponding workpiece holders with noncircular outer peripheries. Another way of preventing rotation is illustrated in Figure 3 by providing aperture 116 with a plurality of protrusions 117 which mate with a plurality of notches 119 formed in workpiece 118. It should be apparent that the protrusions and notches could be formed in the opposite members.

Two cavities are formed within workpiece holder 118. Two cavities are shown in Figure 3 only for purposes of illustration, with the understanding that different sizes or shapes of cavities could be formed in workpiece holder 118. Workpiece 128 is retained by one cavity and workpiece 130 is retained by the other cavity.

Figure 4 is a vertical sectional view of the carrier assembly illustrated in Figure 3 taken along line 4--4 of Figure 3. The Figure should be self-explanatory in view of the description of Figures 2 and 3 and illustrates the relative thicknesses of the various elements in relation to lower and upper polishing pads or platens schematically represented in phantom and identified by numerals 132 and 134, respectively.

Figure 5 is a vertical sectional view of another embodiment of the present invention in which the various elements have different relative thicknesses than the previously described embodiments, but which in plan view is identical to Figure 3, for purposes of illustration. In this embodiment, workpiece holder 218 is thinner than drive ring 212 and workpieces 228 and 230. The carrier assembly of Figure 5 may be particularly well suited for use in a polishing operation, as distinct from a lapping or grinding operation. In polishing, the polishing pads, not illustrated, may be subject to the formation of a glazed coating or layer of spent slurry, removed fines and other dross. By making the workpiece holder thinner than the drive ring and the workpiece, the edges of

aperture 216 may act to scrape or dress the pads to help remove the excess glazed coating or layer.

While the type of material used to make the drive ring on the one hand and the workpiece holders on the other hand are not crucial in an absolute sense, they must have the following important characteristics in accordance with the present invention.

Drive ring 12, 112 should be made of a hard, durable material, usually metal, such as steel, stainless steel, and any number of various metal alloys, such as INCONEL AND MONEL, for example. The material should be strong and hard enough to be capable of withstanding forces associated with the driving of the drive ring generated during polishing operations and, in any event, more capable of withstanding such forces than the relatively softer material forming the workpiece holders. The drive ring is made of a material relatively harder than the material used to make the workpiece holders. Typically, the drive ring may be made of a metal, such as steel, having a Brinnell hardness of at least 75. The drive ring should not wear prematurely or become brittle during the polishing operation.

The workpiece holder should be made of a material relatively softer than the material forming the drive ring. The material forming the workpiece holder should also be softer than the substrate being polished so as not to chip, crack, scratch or otherwise damage the substrate. The presently preferred materials used to make the workpiece holder are synthetic polymeric resins. Resins which could be used, for example, but without limitation, include polyurethane, polyester, polyethylene, polycarbonate, polyvinylchloride, nylon, epoxy, phenolic, melamine, acrylate and acetal (such as du Pont's DELRIN) polymers. Depending on the substrate to be polished, the preferred polymers may be reinforced, if desired, with various fibers, including for example fiberglass and carbon fibers.

The material used to form the workpiece may be sufficiently soft and elastomeric to absorb shocks transmitted by the edge of the substrate toward the aperture by the polishing process. The material may be sufficiently soft whereby it can be cut to the appropriate shape and size in the field with rudimentary tools, such as a razor knife. This does not mean that

the workpiece holder must be elastomeric, although that may be preferred with some substrates in some polishing operations. The workpiece holder may be fairly rigid to support the workpieces firmly, again depending on all of the circumstances associated with any given polishing operation.

The selection of the appropriate material used to form the drive ring and the workpiece holder will depend upon several factors, including the type of substrate being polished, the substrate thickness, the size and horizontal and cross-sectional shape of the substrate, the type of machine in which the carrier assembly is to be mounted, the type of polishing medium being used, the temperature generated during polishing, and others known to those of ordinary skill in the art.

The carrier assembly of the present invention provides a user with a great deal of flexibility. The drive ring is hard and durable and can withstand the forces built up during a polishing, lapping or grinding operation. The workpiece holders in any given carrier assembly preferably are removeable, replaceable and interchangeable. This allows for the maximum degree of use with a minimum amount of inventory and allows for

on-site fabrication of appropriate workpiece holders to hold the particular substrates being polished.

The present invention will now be described further by reference to the following prospective, specific, non-limiting examples.

Example 1

This example describes a carrier assembly to retain five 5.08 cm (2 inch) round semiconductor substrates during fine polishing. Each substrate is individually retained by its own workpiece holder nested in separate apertures within the drive ring. The diameter of the carrier assembly (including the teeth) is 22.38 cm (8.81 inches). The apertures are formed to have a workpiece holder circle diameter of 17.68 cm (6.96 inches). The diameter of the apertures is 6.439 cm (2.535 inches) and the outer diameter of the workpiece holders is 6.414 cm (2.525 inches). The cavity has a diameter of 5.144 +/- 0.013 cm (2.025 +/- 0.005 inches). The distance between the outer perimeter and the cavity of each workpiece holder is about 0.64 cm (0.25 inch). The general arrangement is illustrated in Figure 1, although workpiece holder 26 would have a circular cavity, rather than a square cavity. The

workpiece holders and cavity formed therein are formed in a milling operation so that the sides are straight and true. However, the cavities of the workpiece holders may be milled individually to accommodate an infinite variety of possible substrate diameters.

The drive ring is prepared from 28 gauge (0.038 cm (0.015 inch) maximum thickness) type 304 stainless steel. The drive teeth are designed to interface with a pin drive double-sided polishing machine. The drive ring has 43 teeth with a pitch diameter of 21.8 cm (8.6 inches).

The workpiece holders are prepared from a 0.038 cm (0.015 inch) thick sheet of fiberglass reinforced epoxy resin commercially available from several sources having a G-10 grade.

Example 2

This example illustrates the use of a workpiece holder which can accommodate a polygon or irregularly shaped workpiece. Such may be the case with GaAs semiconductor substrates which will fit within a 5.08 cm (2 inch) cavity formed in a workpiece holder.

A drive ring is formed of the material and has the dimensions set forth in Example 1. The work-

piece holders may be composed of cast, high density polyurethane resin which may be cut by firm pressure with a razor knife. The irregularly shaped substrate is placed on top of the workpiece holder in which no cavity previously has been milled or otherwise formed. The shape of the substrate is traced and the workpiece holder is cut with the razor knife. The traced and cut area is removed from the workpiece holder to form the workpiece holder cavity which matches perfectly with the substrate to be polished. This matching operation can occur either at the site where the workpiece holders are manufactured or at the site of the actual polishing.

Example 3

This example describes a carrier assembly for use in lapping semiconductor substrates. The carrier assembly diameter is 31.45 cm (12.38 inches). The drive ring has 60 standard, involute teeth with a pitch diameter of 30.48 cm (12.00 inches). The diametral pitch is 5. The drive ring is made of 25 gauge cold rolled steel sheet with a maximum thickness of 0.0531 cm (0.0209 inches).

A single aperture is formed in the drive ring to retain a single workpiece holder of the type generally illustrated in Figure 3. Interlocking notches and protrusions as illustrated in Figure 3 prevent rotation of the workpiece holder with respect to the drive ring. In this way, rotary motion is prevented which might otherwise eject the workpiece or the workpiece holder or defeat the transmission of the drive ring rotation to the workpiece holder. The workpiece holder is made of grade G-10 fiberglass reinforced epoxy composite laminate with a thickness of 0.053 cm (0.021 inches).

The drive ring aperture diameter (not including the protrusions) is 26.759 cm (10.535 inches). The workpiece holder outer diameter is 26.734 cm (10.525 inches). Unlike the holder illustrated in Figure 3, six 7.62 cm (3 inch) round substrates are retained and lapped within the workpiece holder cavities. The workpiece holder cavity has a diameter of about 7.684 +/- 0.013 cm (3.025 +/- 0.005 inches). The center of the six cavities are spaced along a workpiece holder circle having a diameter of 17.40 cm (6.85 inches). With this spacing, the workpiece holder cavi-

ties are spaced from each other (about 1.02 cm; 0.4 inch) and from the outer perimeter of the workpiece holder (about 0.826 cm; 0.325 inch) by a sufficient distance so that there is adequate material to hold, support and retain the workpieces and to allow for lapping of each workpiece.

This example illustrates the effectiveness of using a single workpiece holder which greatly simplifies wafer loading. This is particularly important for an operation such as lapping in which, typically, less care is taken, since the substrate is not as highly processed and, hence, is less valuable. Currently, steel carriers are used almost exclusively with lapping processes. The use of a softer workpiece holder greatly diminishes the formation of defective semiconductor substrates.

Example 4

This example illustrates that a carrier assembly carrying a single workpiece holder also may be applied to a polishing operation.

A type 304 stainless steel 26 gauge drive ring with a maximum thickness of 0.0452 cm (0.0178 inch) is formed to have a carrier assembly diameter of

31.29 cm (12.32 inches). The drive ring includes 61 involute teeth with a diametral pitch of 5. A workpiece holder aperture similar to that illustrated in Figure 3 is formed in the drive ring to have a diameter of 27.521 cm (10.835 inches). A grade G-10 fiberglass epoxy composite laminate workpiece holder having a thickness of 0.46 cm (0.18 inch) and a diameter of 27.496 cm (10.825 inches) is retained within the aperture.

Two cavities, each with a diameter of 12.637 cm (4.975 inches), are milled in the workpiece holder with the centers spaced 13.34 cm (5.25 inches) apart. The minimum distance between the workpiece holders is 0.699 cm (0.275 inch).

The workpiece holder will help to maintain the in-plane shape of the stainless steel drive ring during polishing. Moreover, where the drive ring is toroidal and because it is strong yet reasonably flexible, if through inattentive handling or mounting, the drive ring may become distorted and may no longer lay flat on the lower polishing pad, the drive ring may be straightened to correct any out-of-plane distortion.

CLAIMS

1. A carrier assembly (10; 110) for use in polishing, lapping or grinding operations comprising a drive ring (12; 112; 212) adapted to be mounted for rotation including drive connection means (14; 114; 214) for drivingly connecting the drive ring to a driving source, the assembly characterized by the drive ring containing at least one aperture (16; 116) for retaining a workpiece holder, and a workpiece holder (18, 20, 22, 24, 26; 118; 218) retained in the aperture, the workpiece holder being adapted to hold a workpiece (28, 30, 32, 34, 36; 128, 130; 228, 230) in a cavity formed in the workpiece holder, the drive ring being made of a material relatively harder than a relatively softer material forming the workpiece holder, the relatively harder material being more capable of withstanding forces associated with the driving of the drive ring than the relatively softer material, the relatively softer material being more capable of protecting and cushioning against chipping and cracking any workpiece held within a workpiece holder formed thereof than the relatively hard material.

2. A carrier assembly according to claim 1, characterized by the workpiece holder (18, 20, 22, 24, 26; 118, 218) being removably retained in the aperture (16; 116).

3. A carrier assembly according to claim 2, characterized by the drive ring (12; 112; 212) containing a plurality of apertures (16; 116), each aperture retaining a workpiece holder (18, 20, 22, 24, 26; 118; 218).

4. A carrier assembly according to claim 2, characterized by a first workpiece holder (18) having a peripheral shape corresponding to the shape of the aperture (16) and a cavity shaped to correspond to the shape of a first workpiece (28), the first workpiece holder (18) being replaceable by a second workpiece holder (26) having a peripheral shape corresponding to the shape of the aperture (16) and a cavity shape different than the cavity shape of the first workpiece holder (18) to correspond to the shape of a second workpiece (36).

5. A carrier assembly according to claim 4, characterized by the drive ring (12; 112; 212) being

made of metal and the workpiece holder (18, 20, 22, 24, 26; 118, 218) being made of synthetic polymeric resin.

6. A carrier assembly according to claim 5, characterized by the drive ring (12; 112; 212) being made of a metal selected from the group consisting of steel, stainless steel and nickel alloys, and the workpiece holder (18, 20, 22, 24, 26; 118; 218) being made of a synthetic polymeric resin selected from the group consisting of polyurethane, polyester, polyethylene, polycarbonate, polyvinlychloride, acetal, nylon, epoxy, phenolic, melamine and acrylate polymers.

7. A carrier assembly according to claim 6, characterized by the synthetic polymeric resin being fiber reinforced.

8. A carrier assembly according to claim 1, characterized by the drive ring (12; 112; 212) being made of metal and the workpiece holder (18, 20, 22, 24, 26; 118; 218) being made of synthetic polymeric resin.

9. A carrier assembly according to claim 8, characterized by the drive ring (12; 112; 212) being made of a metal selected from the group consisting of steel, stainless steel and nickel alloys, and the workpiece holder (18, 20, 22, 24, 26; 118; 218) being made

of a synthetic polymeric resin selected from the group consisting of polyurethane, polyester, polyethylene, polycarbonate, polyvinlychloride, acetal, nylon, epoxy, phenolic, melamine and acrylate polymers.

10. A carrier assembly according to claim 9, characterized by the synthetic polymeric resin is fiber reinforced.

11. A carrier assembly according to claim 1 characterized by the aperture (116, 117) and the outer periphery of the workpiece holder (118, 119) having complementary shapes to prevent rotation of the workpiece holder in the aperture.

12. A carrier assembly according to claim 11, characterized by the drive ring (12; 112; 212) being made of metal and the workpiece holder (18, 20, 22, 24, 26; 118; 218) being made of synthetic polymeric resin.

13. A carrier assembly according to claim 12, characterized by the drive ring (12; 112; 212) being made of a metal selected from the group consisting of steel, stainless steel and nickel alloys, and the workpiece holder (18, 20, 22, 24, 26; 118; 218) being made of a synthetic polymeric resin selected from

the group consisting of polyurethane, polyester, polyethylene, polycarbonate, polyvinlychloride, acetal, nylon, epoxy, phenolic, melamine and acrylate polymers.

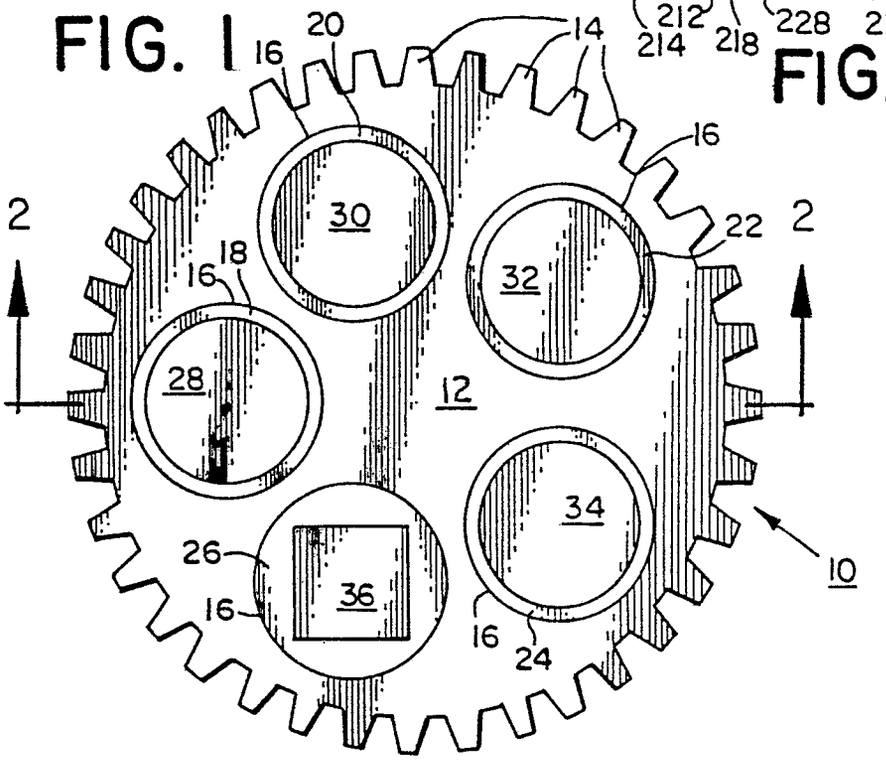
14. A carrier assembly according to claim 13, characterized by the synthetic polymeric resin being fiber reinforced.

15. A carrier assembly according to claim 1, wherein the drive connecting means (14; 114; 214) comprises drive teeth (14; 114; 214) formed along the outer periphery of the drive ring (12; 112; 212).

16. A carrier assembly according to claim 1 wherein the workpiece holder (18, 20, 22, 24, 26; 118) is thinner than the workpiece (28, 30, 32, 34, 36; 128, 130) and thicker than the drive ring (12; 112).

17. A carrier assembly according to claim 1 wherein the workpiece holder (218) is thinner than both the workpiece (228, 230) and the drive ring (212).

FIG. 1



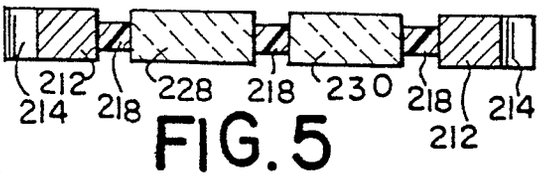


FIG. 5

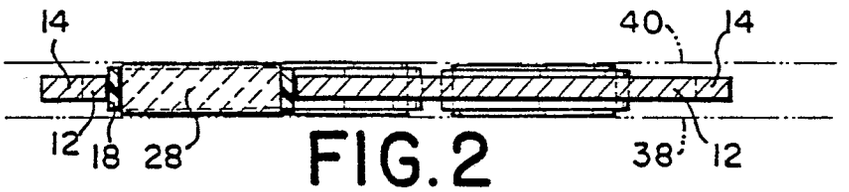
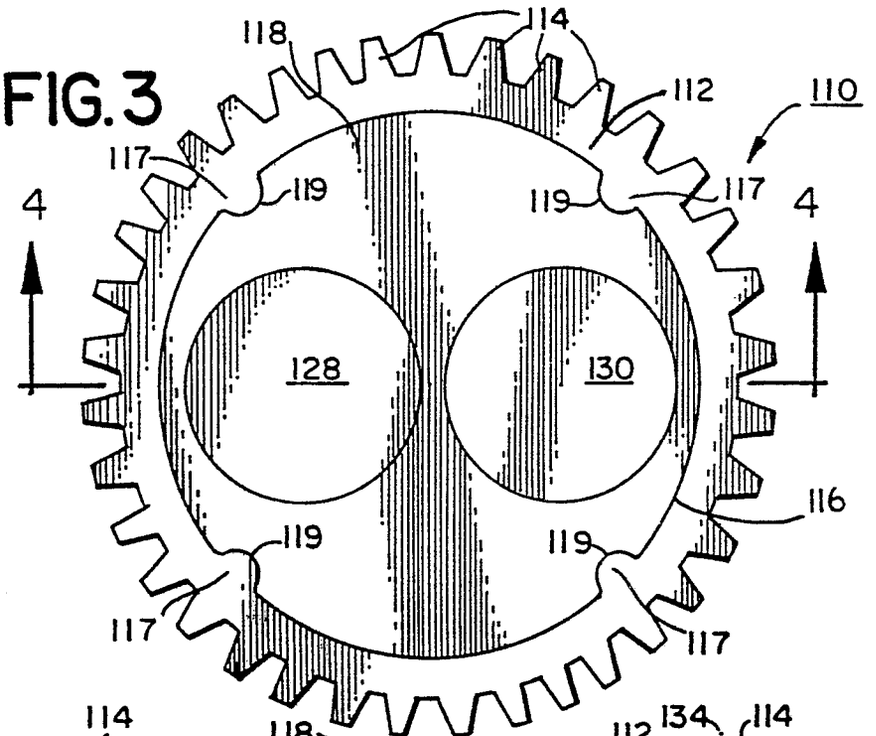


FIG. 2

FIG. 3



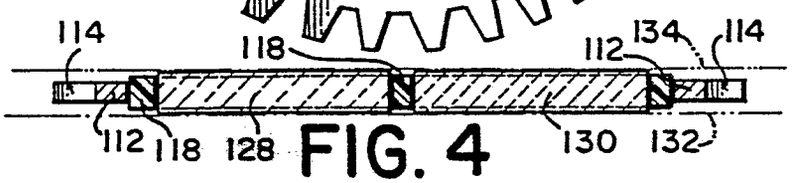


FIG. 4