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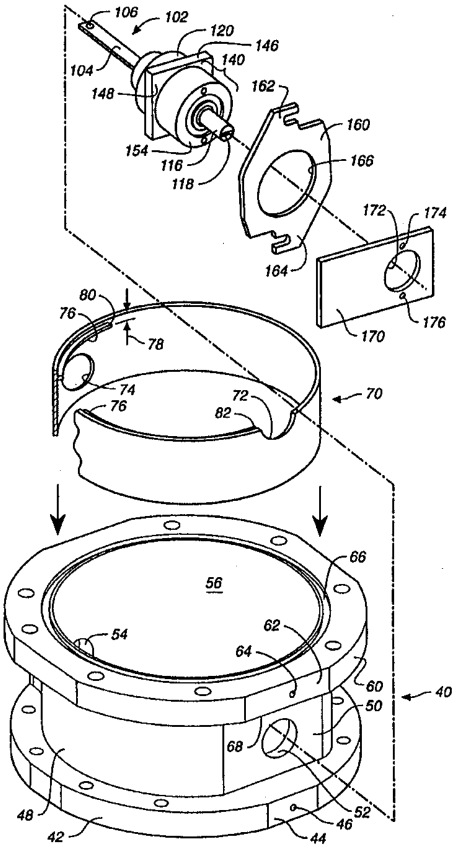
(57) Abstract

A lined butterfly valve for use in controlling the vacuum in a vacuum processing chamber includes one or more liners (70, 86) which can be easily changed out to control contamination particulate buildup in the processing chamber and closely adjacent vacuum system piping. A removable flapper disk (180) is attached to a stem portion (104) of a stem shaft which is supported by an easily removable valve stem bearing and seal cartridge assembly (100). The valve stem bearing and seal cartridge assembly (100) is keyed to and clamped to the outside of the valve body by an easily releasable clamping plate. A set of valve seating lips (76, 90) in the liner prevent excessive gaps between the flapper disk and the liner and also provide structural support to prevent the valve flapper from bending under severe pressure conditions. The connection between the valve flapper disk and the valve stem is accomplished by a captured screw assembly (210), which prevents the attachment screw between the flapper disk and the stem from being separated from the flapper disk during the disk's removal and re-installation. This arrangement reduces the mean time to recover from a cleaning cycle of the processing chamber.



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LINED BUTTERFLY THROTTLE VALVE

Field of the Invention

This invention relates to throttling valves used in low pressure (vacuum) systems used to achieve and maintain process conditions for processing semiconductor wafers.

Background of the Invention

In a substrate processing chamber 20 (Figure 1), the chamber is connected to a vacuum system including a butterfly throttling valve 22, having a bypass connection 24 connecting through a shutoff valve 32 to a roughing in vacuum system through piping 34. The roughing in vacuum system brings the process chamber pressure to about 100 millitorr. To achieve the vacuum needed for processing (approximately 1 - 200 millitorr) a turbo pump 30 is used. This turbo pump 30 is most effective at low pressures and may be damaged if exposed to gases at atmospheric pressure. So once a nominal low pressure (1 torr or less) has been achieved the roughing vacuum gate valve 32 is closed and the turbo pump gate valve 26 is opened to utilize the turbo pump 30. A coarse screen 28 protects the turbo pump 30 from being damaged by parts falling from the process chamber. The butterfly throttling valve 24 regulates the pressure in the processing chamber 20. The gases used in the process chamber for etching and other processes produce polymeric reaction products or other substances that deposit on film surfaces (e.g., PVD, CVD). These reaction products are drawn into the vacuum piping and rapidly coat the surfaces of the throttling valve with the polymeric reaction products tending to create particulate contamination which has been found to cause particulate contamination of the substrate in the process chamber.

The presence of heavy polymer deposits on the surfaces of the throttling valve requires that considerable time be spent to clean (and/or remove and replace) the throttling valve to maintain the particle performance of the process chamber. The throttling valve is an integral part of the process chamber vacuum system and is positioned close to, if not directly adjacent to the processing chamber. Cleaning the internal surfaces of the valve, whether done by removing the valve and cleaning it externally or cleaning it in situ as has been done in the past by scraping and rinsing the surfaces by hand while reaching down from above, through the process chamber or liner access opening in the process chamber, is a time consuming imprecise operation. Cleaning must be completed before the associated process chamber can be returned to operation.

An alternate cleaning methodology has been to remove adjacent piping to better access the valve for cleaning or replacement with a clean valve. This later procedure requires that the piping be disturbed if not disassembled to permit the throttling valve to be removed. Such a removal and reassembly process increases the possibility of damaging the piping or the valve or their seals, and each removal, cleaning and reassembly cycle increases the possibility that vacuum leakage will occur.

The deleterious effect of particulate contamination of the processing chamber and substrate (wafer) being processed is unacceptable in relation to evolving process requirements. Both in situ cleaning and the repeated breach of the vacuum system to remove, clean and reinstall the throttling valve is a very burdensome and time consuming procedure which reduces the process chamber throughput (utilization) as well as creates a repeated risk of equipment damage during the disassembly, cleaning, and reassembly of the process piping.

Summary of the Invention

This invention provides a throttling butterfly valve body which allows quick removal of all internal valve surfaces, without disrupting the process piping and with a simple swap out of substantially all valve components exposed to the process fluid. The arrangement reduces the mean time to recover the operation of a chamber due to cleaning. Among the components that can be removed and replaced, or removed and cleaned are a valve body liner, a valve throttling disk, and a valve stem cartridge assembly. As in the prior art, a butterfly valve body is permanently mounted between the process chamber and the vacuum system(s). The internal surfaces of the valve body are lined with liners and other pieces which can easily be removed and replaced without disturbing the valve body in the vacuum piping system.

The liners are easily removable from the valve body through openings in the process chamber and through the piping leading to the process chamber once the flapper disk and valve stem cartridge (assembly) keyed into the liners are removed. The liners are held in place by gravity and interference with a valve stem inserted through a stem receiving opening in the side of the valve body.

The throttling butterfly valve includes a valve body having a removable liner, wherein the valve body and liner include a stem receiving opening. A stem cartridge assembly is removably fixed to the stem receiving opening of the valve body and rotatably supports and seals a valve stem shaft as the shaft passes through the stem receiving opening of the valve body and extends inwards from a portion of the liner to support a throttling barrier which is removably fixed to a stem portion of the valve stem shaft. The liner lines a substantial portion of the inner surfaces of the valve body which would otherwise be exposed to the fluid flowing through the valve. The liner is removable by removing the stem cartridge assembly and moving the liner in a direction parallel to a flow path of fluid through the valve body and through the adjacent piping. The removable liner can be configured in two or more parts, for example when the clearances for removal do not allow for movement of a full vertical dimension of a single liner in the adjacent piping. A portion of the liner or parts of the two or more parts of the liner form a hollow cylinder. Flapper seating lips extend from a portion of the liner or a portion of a part of the liner. A stem portion of the stem shaft extends only approximately half way (partially) across a flow path of the valve body. A portion of one of the valve seating lip in the liner prevents a portion of the throttling barrier extending beyond the stem portion from deflecting beyond the position of the lip. The throttling barrier is a flapper disk which includes a self retaining flapper attachment screw. Only one retaining screw is used to fix the flapper disk to the stem portion of the valve stem shaft. The stem cartridge assembly includes a static seal which seals against a sidewall stem receiving (opening) flat of the body when the stem cartridge assembly is fixed to the stem receiving opening. A flat on a side of the cartridge assembly coincides with a surface of the outside of the valve body when the stem cartridge assembly is fixed to the stem receiving opening to prevent relative rotation between the cartridge assembly and the valve body. A cartridge assembly retaining shoulder is configured to mate with a cartridge retaining plate to clamp the stem cartridge assembly to the valve body. A drive mechanism for the valve may be mounted to the cartridge assembly.

The invention also includes a method of reducing the contamination in a vacuum piping system of a substrate processing chamber, comprising the steps of providing a lined butterfly throttle valve in the vacuum piping system, and replacing the liner in said valve, by removing a flapper disk, removing a valve stem bearing cartridge and seal unit, removing the contaminated lining of the valve, installing a clean lining in the valve, installing a clean valve stem bearing cartridge and seal, installing a clean flapper disk.

This new configuration and method provides a very fast and easy way to gain access to the polymer coated pieces in the throttling valve for removal, cleaning and/or replacement without fear of dropping small items (e.g., screws) which are unscrewed and could be lost inside the bowels of the vacuum piping system and find their way to a vacuum and cause damage.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic view showing the location of a butterfly throttle valve in a vacuum piping system from a processing chamber;

Figures 2A and 2B are collectively an exploded perspective view of a butterfly throttle valve configuration according to the invention;

Figure 3 is a perspective view of a butterfly throttle valve according to the invention assembled from the parts as shown in Figs. 2A and 2B with the valve flapper disk about to be inserted;

Figure 4 is a top view of a butterfly throttle valve according to the invention;

Figure 5 is a cross-sectional view of the butterfly throttle valve of Fig. 4 taken at 5-5; and

Figure 6 is a partial cross-sectional view of a central portion of the butterfly valve body of Fig. 4 taken at 6-6.

DETAILED DESCRIPTION

Figures 2A and 2B show an exploded perspective view of a valve body 40 having a lower flange 42, an upper flange 60 and a body sidewall 48 that extends between the two flanges. The lower flange 42, as can be seen in Figure 2B and as further discussed below, includes a lower flange stem retaining flat 44 which has a lower flange flat bolt hole 46. The upper flange 60, similarly includes an upper flange stem retaining flat 62 having an upper flange flat bolt hole 64. As can be seen for the upper flange 60, an upper flange O-ring piping seal groove 66 provides sealing for the valve body against adjacent piping. A similar groove is present on the bottom of the bottom flange 42, as can be seen in Figure 5. The size of the valve body in this instance is either 8.5 inches or 10 inches, sized according to the needs of the system and adjacent piping. The sidewall 48 includes a vacuum bypass opening 54, which is connected to the roughing vacuum system, and a valve stem receiving opening 52 which extends through a stem receiving flat 50 on the outside of the sidewall which is parallel to the upper and lower flange flats, 62, 44. The upper and lower flange flat bolt (screw-receiving) holes 64, 46 are located in alignment with the stem-receiving opening 52 to uniformly retain a stem cartridge assembly 100 to be received therein.

A lower liner 70 (approximately 0.125" thick) is configured to slide within the inner surface 56 of the valve housing 40. The lower liner 70 is a hollow cylindrical sleeve having a diameter which provides a sliding fit within the valve body, and is retained in position by gravity supported on the gate valve flange (for example as configured in Figure 1) located below it (not shown). The gate valve fluid flow opening (flange) is smaller and as a result prevents the lower liner 70 from sliding down. A half circle shaped opening 72 which corresponds to the valve stem opening 52 in the valve housing, provides a reference key for locating the lower liner 70 rotationally. A liner bypass opening 74 is matched with the body bypass opening 54 in the valve body 40. A valve disk seating lip 76 (approximately 0.1" thick and extending

0.17" from the inside of the liner) is located offset a distance 78 (approximately 0.050") from the top edge of the lower liner 70 around approximately half the circle of the inside of the liner. This lip reduces the amount of blowby in the valve and permits tolerances between a flapper disk 180 and the liner to be larger without unreasonably increasing the leakage rate at small valve angle (openings) due to the larger tolerances and coarse alignment between adjacent components. The distal 80 and proximal 82 ends of the seating lip 76 are configured to allow the valve flapper disk 180 to turn freely without interference. The proximal end could extend further, but it does not extend beyond the edge of the half circle opening 72 in the liner. A clear view of the lip configurations ends can be observed in the top view of Figure 4.

The upper liner 86, is generally configured to be the same as the lower liner 70, discussed above, except that it is turned over, is not as tall, and does not include the vacuum bypass opening 74. For the upper liner, a half circle shaped opening 88 which corresponds to the valve stem opening 52 in the valve housing, also provides a reference key for locating the upper liner 86 rotationally. In this instance the half circle shaped opening 88 is facing down. A valve disk seating lip 90 is located offset a distance 92 from the bottom edge of the upper liner 86 around approximately half the circle of the inside of the liner. The distal 94 and proximal 96 ends of the lip are configured as discussed for the lower liner 70, above.

An alternate configuration of the sealing lips is to adjust the vertical dimension of the liners to offset their mating edge, either slightly up or slightly down, so that the lip on one piece is at its edge, forming an inward facing flange, while the lip on other liner is offset from the edge twice its previous distance. In this way the manufacturing complication of placing a lip inwards from the edge of a hollow cylinder only needs to be done on one liner.

The surface finish of the liners is made rough, a sandblast type finish, to improve the adhesion between the deposited material and the liner to avoid the migration of particles back into the processing chamber, where such particles might cause defects on the substrates being processed. The surfaces of the flapper disk 180 may be bead blasted.

A valve stem shaft 102 is supported by a valve stem bearing and seal cartridge assembly 100. The cartridge assembly 100 whose cross section is shown in Fig. 5 supports the stem shaft 102 by two bearings 150, 152 in a spaced relationship. The shaft 102 includes a stem portion 104 having a disk screw retaining hole 106, a seal portion 108, an inner bearing portion 110, a bearing shoulder 112, an outer bearing portion 114, and an end stub 116. The stub end 116 includes an indicator slot 118 whose orientation matches the orientation of the valve flapper disk (vane) 180 when it is clamped to the stem shaft 102, so that the position of the flapper disk can be directly observed by viewing the outside of the valve.

The inner portion of the cartridge assembly 100 includes a seal housing 120 which at its inner end has a lip surrounding the seal portion 108 of the shaft 102, and retains a vacuum O-ring 122 separated by a cylindrical spacer 124 from a vacuum grease O-ring 126 which in turn is separated by a washer type spacer 128 from the inner bearing 150. The spacers 124, 128 prevent the O-rings 122, 126 from becoming misaligned. The outwardly facing side of the flange of seal housing 120 contacts the outer bearing race of the inner bearing 150. The inside of the flange of the seal housing 120 includes a static O-ring seal groove 130 which when it contains an O-ring (not shown) seals against the sidewall stem receiving flat 50 on the outside of the valve body 40 when clamped tightly and/or subject to vacuum. A bearing housing 140 encloses the bearings 150, 152 and is clamped to the seal housing 120 by bolts extending through the holes in a bearing retaining plate 154, through the holes 142, 144 in the bearing housing 140, and tightened into the threaded holes 132, 134 in the seal housing 120.

The outside surface of the cartridge assembly 100 as shown in Figure 2B includes the seal housing 120 which mates with a flanged end of the bearing housing 140. The top surface of the flange forms a flat (surface) 146, which fits against a bottom surface 68 of the top flange 60 of the valve body 40, directly aligned with the stem receiving hole 52. Thus, for the seal portion 120 of the cartridge assembly to move into engagement with the seal receiving opening 52 in the valve body 40, the flat 146, must be aligned with the underside (bottom) surface 68 (Fig. 2B) of the upper flange 60. This arrangement also prevents relative rotation between the stem cartridge assembly 100 and the valve body 40 during subsequent operation.

The cartridge assembly 100 is pressed towards the valve body 40 by engagement of a hole 166 in the cartridge retaining plate 160 with a cartridge retaining shoulder 148 on the outside of the bearing housing 140 (Fig. 2B). The upper and lower plate ears 162, 164, engage bolts (not shown) in the upper and lower flange flat bolt holes 64, 46 for quick and easy removal and replacement.

A drive mounting plate 170 having bolt holes 174, 176 for mounting to the cartridge assembly 100 and can be connected to a drive mechanism (motor, crank, etc. - not shown) through access hole 172.

Now completing the discussion of Figures 2A and 2B the valve flapper disk 180, includes a screw retaining member 190 and a captured flapper attachment screw 210 to connect the circular flapper 180 to the threaded hole 106 in the stem portion 104 of the stem shaft 102.

Figure 3 shows the earlier discussed parts in Figures 2A and 2B assembled. The lower liner 70 is contained within the inside wall 56 of the valve body 40. When mounted in a vertical position, as shown here, the lower liner 70 now rests on the piping structure below it, for example, the upper flange of a gate valve 26 as pictured in Figure 1. The lower liner 70 is initially free to move vertically except for the effects of gravity and once in position its movement is restricted by being keyed to the valve stem cartridge assembly 100. The upper liner 86 rests on the upper surface of the lower liner 70 and is supported by it and is aligned to the valve stem bearing and seal cartridge assembly 100 whose body cannot be seen in Figure 3. The valve stem bearing and seal cartridge assembly 100 is clamped into position engaged with the stem receiving opening 52 and against the side wall stem receiving flat 50. The cartridge retaining clamp 160 holds and clamps the cartridge assembly 100 in place. In Figure 3, only the distal end of the stem portion 104 of the cartridge assembly and the end stub 116 of the cartridge assembly 100 can be seen. The flapper 180 is being brought into position by tilting it so that it passes between the lower liner distal lip end 80 and the upper liner distal lip end 94. During assembly the flapper disk 180 can be handled from one side by holding the screw retaining member 190. The valve operator mounting support plate 170 is clamped to the outside of the cartridge assembly 100 and is available to support the powered valve operators (not shown) for automatic control of the valve motion. The offset between the valve seating lip 76 of the lower liner 70 and the valve seating lip 90 of the upper liner 86 is approximately equal to the thickness of the valve flapper approximately 0.1 inches thick when the valve flapper is in a completely horizontal orientation (closed position).

Figure 4 shows a top view of the valve according to the invention. It clearly shows the orientation of the liners and their valve seating lips 76, 90 in relation to the stem portion 104 of the cartridge assembly 100. The lower liner distal lip end 80 is separated from the upper liner distal lip end 94 by a distance sufficient to allow rotational motion of the flapper disk 180 as it rotates with the stem portion 104 and makes a slight arc as a result of its slight offset. The position of the lower liner proximal lip end 82 and upper liner proximal lip end 96 function similar to the distal lip ends, but the closest approach distance between the two is limited by the diameter of the openings in the liners which allow passage of the cartridge assembly 100. The spatial relationship of the cartridge containing plate and valve operator mounting support plate 170 with respect to the cartridge assembly 100 and its end stub 116 is pictured. A standard type clamping collet can be used to assure motion of a round end stub 116 or a flat or through hole may be provided on the stub end according to the needs of the driving mechanism (not shown).

Figure 5 shows a cross section of the valve of Figure 4 taken at 5-5, and has been discussed extensively above with respect to the cartridge as shown in Figure 2B. That discussion will not be repeated here. Figure 5 - unlike Figure 4 - shows the flapper disk 180 in its operating position fixed to the stem portion 104 of the stem shaft 102 by a flapper attachment screw 210 through a disk screw retaining hole 106. Note that the flapper disk 180 extends from the end of the seal portion 108 of the stem shaft 102 all the way to the proximal end of the inside of the valve where the upper liner distal lip end 94 of the valve seating lip 90 is spaced from the lower liner distal lip end 80 of the valve seating lip 76. Note that the cross-sectional cut 5-5 is offset at the proximal end of the liner to show both the upper and lower and distal lip ends 94, 80.

Under normal operating circumstances a differential pressure across the flapper disk 180 is very small, in a range of 1 torr, or less. With such differential pressures, the strength of the structure as described here is sufficient to provide throttling and withstand the small forces associated with such small pressures even over the large area of the valve which may be 8-1/2 or 10 inches in inside diameter. However, in instances when a sudden pressure surge might be experienced as a result of transients during operation or conditions approaching a catastrophic failure, such as when the process chamber is vented to atmosphere suddenly, pressures on the flapper disk 180 when the disk is an a closed or substantially closed position, may cause it to deflect (bend). Under such conditions the stem portion 104 of the stem shaft 102 must support the total force of the differential pressure. The differential pressure around a longitudinal axis of the stem 102 is balanced such that bending of the disk will be approximately balanced on both sides of the flapper disk 180. However, bending of the flapper disk 180 may occur as the outer portion of the flapper disk 180 is not supported by the stem portion 104 which extends only half-way across the valve opening approximately to its center. However when there is a large differential pressure (for example downwards), the bending of the portion of the flapper disk 180 opposite from the stem portion 104 will be limited by its contact with the lower distal lip end 80 and the lower valve seating lip 76. In most instances differential pressures are so small that there will be little or no deflection and no contact between the outer portion of the flapper disk 180 and the lower liner distal lip end 80.

Figure 6 is a close-up cross sectional view of Section 6-6 of Figure 4 with the flapper disk 180 shown in position. To prevent the dropping of small screws into the bowels of the vacuum system it is necessary that such screws be eliminated or captured in some way that they cannot be dropped. One such a system is shown in Figure 6. The flapper disk 180 includes a center hole 182 which receives through a press fit or other similarly permanent connection a lower portion 192 of the screw retaining member 190. The upper portion 194 of the screw retaining member 190 is thereby fixed to the flapper disk 180 and flapper disk 180 can be supported by holding the screw retaining member without having to touch or otherwise access the edge of the flapper disk 180. The screw retaining member 190 includes a central hole 196 having a counterbore 202, a threaded narrow portion 198 and a wide sleeve portion 200. The flapper attachment screw consists of a screw head 216 (for example, an Allen head) and a smooth narrow midsection (shaft) 214 connected to a threaded section 212 at its bottom. The threaded section 212 of the flapper attachment screw 210 is inserted into the counterbore 202 and threaded through the threaded narrow portion 198 of the screw retaining member 190. Once the threaded section 212 is completely through the threaded narrow portion 198, the flapper attachment screw 210 is free to slide up and down through the threaded narrow portion 198 but it is captured by the screw head 216 at one end and the interference of the threaded section 212 at the other end. Unless there is a simultaneous pulling and turning motion, the flapper attachment screw 210 cannot be removed from the screw retaining member 190. In a normal situation, the flapper attachment screw 210 is threaded into the disk screw retaining hole 106 in the stem portion 104 of the stem shaft 102, and the screw head 216 tightly clamps the screw retaining member 190 and the flapper disk 180 to the top flat portion of the stem portion 104. When it is desired to release the flapper disk 180 to allow removal of the cartridge assembly 100, the screw head 216 is turned until the threaded section 212 is completely removed from the disk screw retaining hole 106. Further counter clockwise turning (assuming a right-handed thread) will have no effect except to spin the flapper attachment screw 210 and the flapper attachment screw 210 will be retained by the screw retaining member 190. Lifting the flapper attachment screw 210 will cause the threaded section 212 of the screw to interfere with the threaded narrow portion 198 of the screw retaining member 190 and the screw retaining member and the attached flapper disk 180 can be raised and lifted or manipulated away.

Assembly and use of the throttling butterfly valve assembly as configured together with a substrate processing chamber, for example as shown in Figure 1, involves the permanent positioning of the valve body 40 in the piping system. In such a configuration. the size of the piping bore of the piping elements below the valve body are smaller than the bore of the valve body 40, such that when the lower liner 70 is moved into the piping system from the process chamber or other access openings, the lower liner 70 slips through the valve body 40 and is supported on the flange of the piping element below (e.g., a gate valve). The lower liner 70 is oriented so that its half circle stem opening 72 is aligned with the stem receiving opening 52 of the valve body 40. The upper liner 86 can then be inserted and slipped into the valve body 40, the bottom edge of the upper liner 86 being supported on the top edge of the lower liner 70. The half circle stem opening 88 of the upper liner 86, must oriented to match the stem receiving opening 52 of the valve body 40. The stem cartridge assembly 100, can then be oriented with its upper flat 146 facing the bottom surface 68 of the upper flange 60 of the valve body 40 and the seal housing end of the cartridge assembly 100 is inserted into the stem receiving opening 52. The insertion stops when the sealing face of the seal housing containing the O-ring groove 130 (Figure 5) comes into contact with the sidewall stem receiving flat 50 of the valve body 40. To clamp and hold the cartridge stem assembly 100 in place the opening (hole) 166 of the cartridge retaining plate 160 is slipped over the end of the cartridge assembly and the surface of the plate 160 presses on the shoulder 148 of the cartridge assembly as the plate 160 is slightly rotated so that the bolt receiving slots in the upper and lower ears 162 and 164 of the plate 160 engage bolts (not shown) which extend from the upper and lower flange bolt holes 64, 46. The valve operator (not shown) mounted to the valve operator mounting can remain fixed to the cartridge during clamping and unclamping of the cartridge retaining plate 160, this is one assembly operation that is eliminated when a flexible connector the valve operator mounted to the support plate 170 is used. The cartridge retaining plate can rotate out of the way of the bolts holding it so that the bolts only have to be loosened and not completely removed. An additional time savings.

Once the cartridge assembly 100 is in position the flapper disk 180 is manipulated into position between the ends 80, 82, 94, 96 of the seating lips (see Fig. 4) and the flapper attachment screw 210 is engaged with the disk screw retaining hole 106 to clamp the flapper disk 180 firmly to the stem portion 104 of the cartridge assembly 100.

The order of installation requires that the lower liner 70 be installed first, but the choice of whether the cartridge assembly 100 or the upper liner 86 is installed next, affects only the installation orientation of the flapper disk 180. When the upper liner 86 is not in place the flapper 180 can be moved into place in a horizontal orientation, as it does not need to avoid the valve seating lip 90 of the upper liner 86.

The liner while shown in two pieces, is constructed in that way, to provide clearance to pass through a particular piping arrangement. If the piping arrangement allowed passage of a full height liner there is no reason such a configuration could not be used. In such an arrangement the portion of the seal housing extending into the chamber would act as key for liner orientation and retention purposes. Further, while the lower liner described above is supported by resting on the piping member below, the fixing of the lower liner to the valve body or the other liner half can be accomplished in a variety of structures known to persons skilled in the art, e.g., clamping rings, flush through bolts, and snap rings. None are as efficient as a simple slip fit, described above.

Removal of the liners requires loosening and removal of the flapper attachment screw 210, lifting of the flapper disk 180, untightenting of the bolts clamping the cartridge assembly 100, sliding out of the cartridge assembly 100, sliding out of the upper liner 86, and sliding out of the lower liner 70. Each of these parts can be replaced by new clean parts immediately, or a cleaning of the portions of the pieces coated from the process can take place and once cleaning is complete the parts can be easily reinstalled.

The advantages of this arrangement are the easy removal and reinstallation of substantially all surfaces directly exposed to deposition from the process, without having to disturb the throttling valve body in the piping and/or the main vacuum system connection to the processing chamber. If the stem cartridge assembly is to be immediately re-used only a small exposed portion of it need be cleaned and the cleaning can be done outside the chamber. In the configuration shown except for the opening to the vacuum bypass 54, all exposed internal surfaces of the valve are covered and the throttling function is not affected. Further the assembly is such that parts are keyed to one another in a way that installation of the assembly is prevented unless the parts are correctly oriented. In this arrangement, because both bearing supporting the stem shaft are together in the cartridge assembly 100, there is no fixture needed in the wall of the flow path on the opposite side of the valve from the stem receiving opening. This thereby eliminates one potential source of maintenance which may require alignment and coordination of the two ends of the stem shaft. Further, the bearings supporting the stem shaft 102 are isolated from the process and can be replaced as a package unit which can be dissembled in a work shop distant from the process chamber and vacuum system. Each of these features provide a rapid exchange of parts which reduces the down time and improves serviceability and utilization of process machinery so that delays due to servicing and cleaning these parts are greatly reduced compared to the manual cleaning operations, and whole valve changeouts done in the past.

A method of reducing contamination is a vacuum piping system of a substrate processing chamber is also understood, the steps of which are discussed in the summary of the invention above.

All parts except the stem, bearings, and O-rings are made of aluminum which is acceptable in the chemical environment present during semiconductor wafer processing. The stem shaft 102 is a stainless steel, while the O-rings are Viton.

While the invention is described with regard to specific embodiments, those skilled in the art will recognize that changes can be made in form and detail without departing from the spirit and scope of the invention. The examples described herein are merely representative of the invention and should not be considered to limit the scope of the invention to the structure or method herein described.

CLAIMS

1. A throttling butterfly valve having a moveable throttling barrier comprising:

a hollow valve body having fluid inlet and outlet openings, said body having a removable liner, wherein the valve body and liner include a stem receiving opening;

a stem cartridge which is removably fixed to the stem receiving opening of the valve body, said cartridge including a rotatable valve stem shaft extending into said valve body and away from the liner, said stem shaft supporting and being removably fixed to the throttling barrier so that the rotation of the barrier partially or completely blocks a fluid flow path between the inlet and outlet openings.

2. The throttling butterfly valve as in Claim 1,

wherein the liner lines a substantial portion of the inner surfaces of the valve body which would otherwise be exposed to the fluid flowing through the valve.

3. The throttling butterfly valve as in Claim 2,

wherein the liner is removable by removing the stem cartridge and moving the liner in a direction parallel to a flow path of fluid through the valve body.

4. The throttling butterfly valve as in Claim 3,

wherein the stem cartridge is removable from the outside of the valve body

5. The throttling butterfly valve as in Claim 1,

wherein only a stem portion of said stem cartridge extends beyond an inner surface of said liner.

6. The throttling butterfly valve as in Claim 1,

wherein the removable liner is in at least two parts.

7. The throttling butterfly valve as in Claim 6,

wherein a portion of each of said two parts of said liner forms a hollow cylinder.

8. The throttling butterfly valve as in Claim 1,

wherein said liner is a portion of a hollow cylinder.

9. The throttling butterfly valve as in Claim 8,

wherein a flapper seating lip extends from a portion of said liner.

10. The throttling butterfly valve as in Claim 7, wherein a flapper seating lip extends from a portion of each part of said liner.

11. The throttling butterfly valve as in Claim 1, wherein a stem portion of said stem shaft extends only partially across a flow path of said valve body.

12. The throttling butterfly valve as in Claim 11, wherein a lip in the liner prevents a portion of the throttling barrier extending beyond the stem portion from deflecting beyond the position of the lip.

13. The throttling butterfly valve as in Claim 1, wherein the throttling barrier is a flapper disk which includes a self retaining flapper attachment screw.

14. The throttling butterfly valve as in Claim 13, wherein only one retaining screw is used to fix the flapper disk to the stem portion of said valve stem shaft.

15. The throttling butterfly valve as in Claim 1, wherein the stem cartridge includes a static seal which seals against a sidewall stem receiving flat of the body when the cartridge is fixed to the stem receiving opening.

16. The throttling butterfly valve as in Claim 15, wherein a flat on a side of the cartridge coincides with a surface of the outside of the valve body when said cartridge is fixed to the stem receiving opening to prevent relative rotation between the cartridge and the valve body.

17. The throttling butterfly valve as in Claim 1, wherein a cartridge retaining shoulder is configured to mate with a cartridge retaining plate to clamp said cartridge to said valve body.

18. The throttling butterfly valve as in Claim 1, where a drive mechanism for the valve is mounted to the cartridge.

19. The valve as in Claim 1,

wherein the stem cartridge is mounted to an external surface of the valve body with said valve stem shaft extending through the stem receiving opening and into the interior of the valve body.

20. The valve as in Claim 1,
wherein substantially only the valve stem shaft extends into the valve body.

21. The valve as in Claim 1,
wherein the liner shields substantially all of the stem cartridge except for the stem shaft portion within the interior of the valve body.

22. A liner for use in a throttling butterfly valve having a hollow body, a movable throttling barrier, and a removable valve stem support, comprising:
a hollow tube configured to be positioned within and closely adjacent to internal surfaces of said hollow body and having a stem receiving opening, through which said removable valve stem support extends when the valve is assembled.

23. The liner as in Claim 22,
wherein said liner is configured to line substantially all internal surfaces of the hollow body.

24. The liner as in Claim 22,
wherein in an assembled configuration of the valve, a portion of the valve stem support extends into the stem receiving opening and interferes with movement of the liner relative to the hollow body.

25. The liner as in Claim 22,
wherein the hollow tube is configured in at least two pieces.

26. The liner as in Claim 25,
wherein a first of said at least two pieces is a hollow tube and a second of two pieces is a hollow tube.

27. A method of reducing the contamination in a vacuum piping system of a substrate processing chamber, comprising the steps of:
providing a lined butterfly throttle valve in the vacuum piping system; and
replacing the liner in said valve, by
removing a flapper disk,

removing a valve stem bearing cartridge and seal unit,
removing the contaminated lining of the valve,
installing a clean lining in the valve,
installing a clean valve stem bearing cartridge and seal,
installing a clean flapper disk.

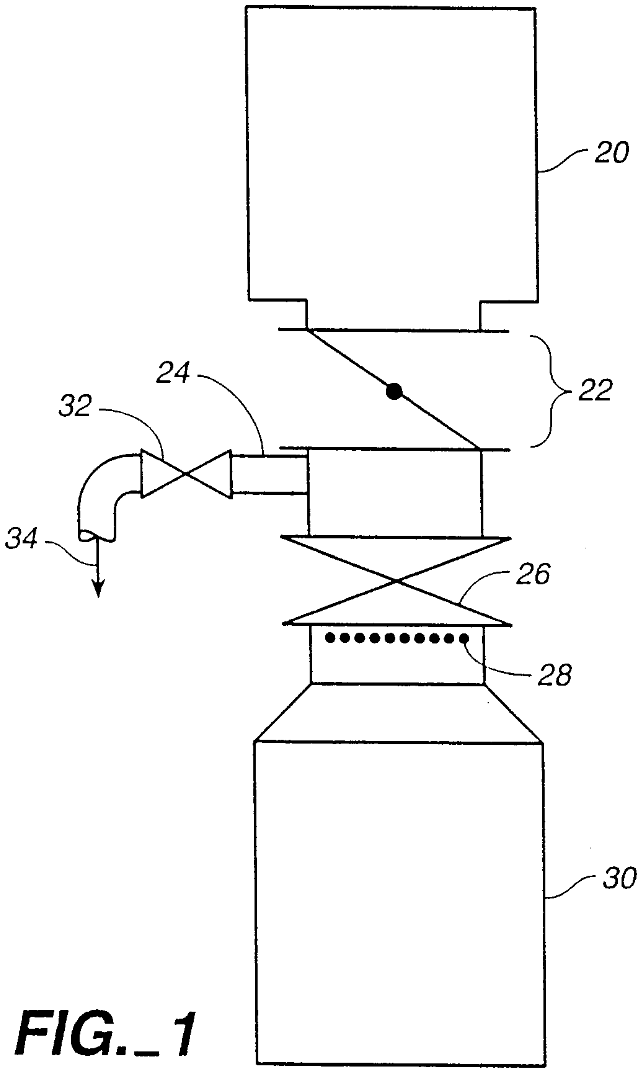
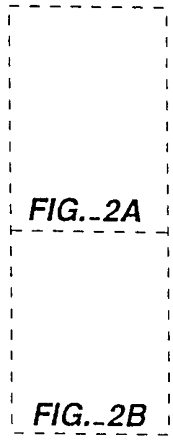


FIG._1

FIG._2



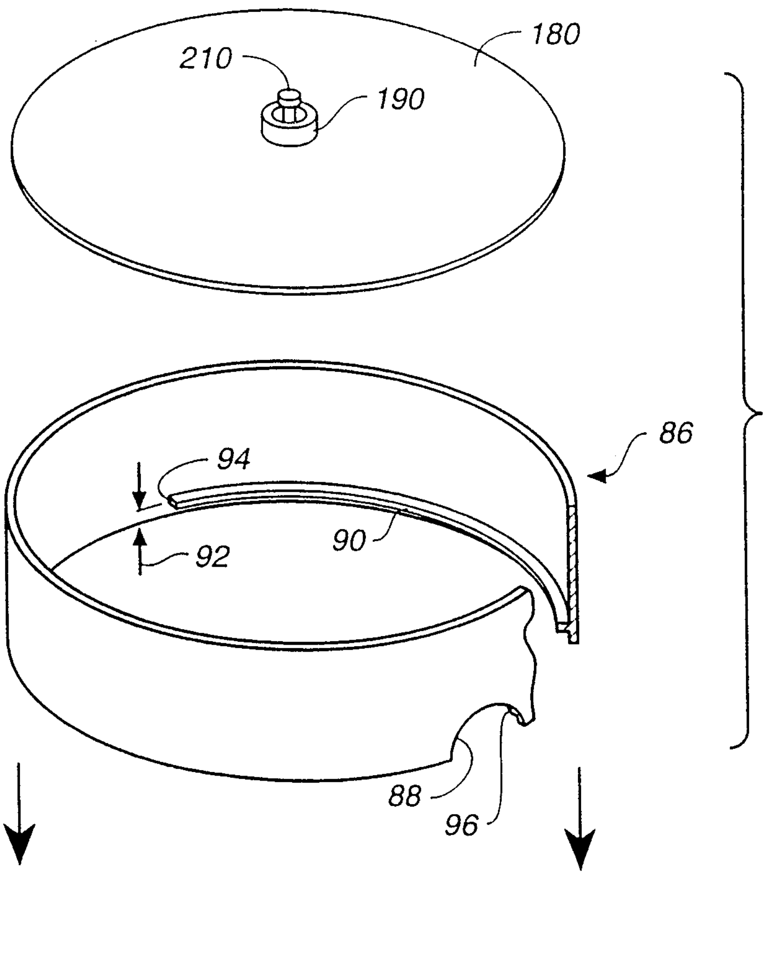


FIG._2A

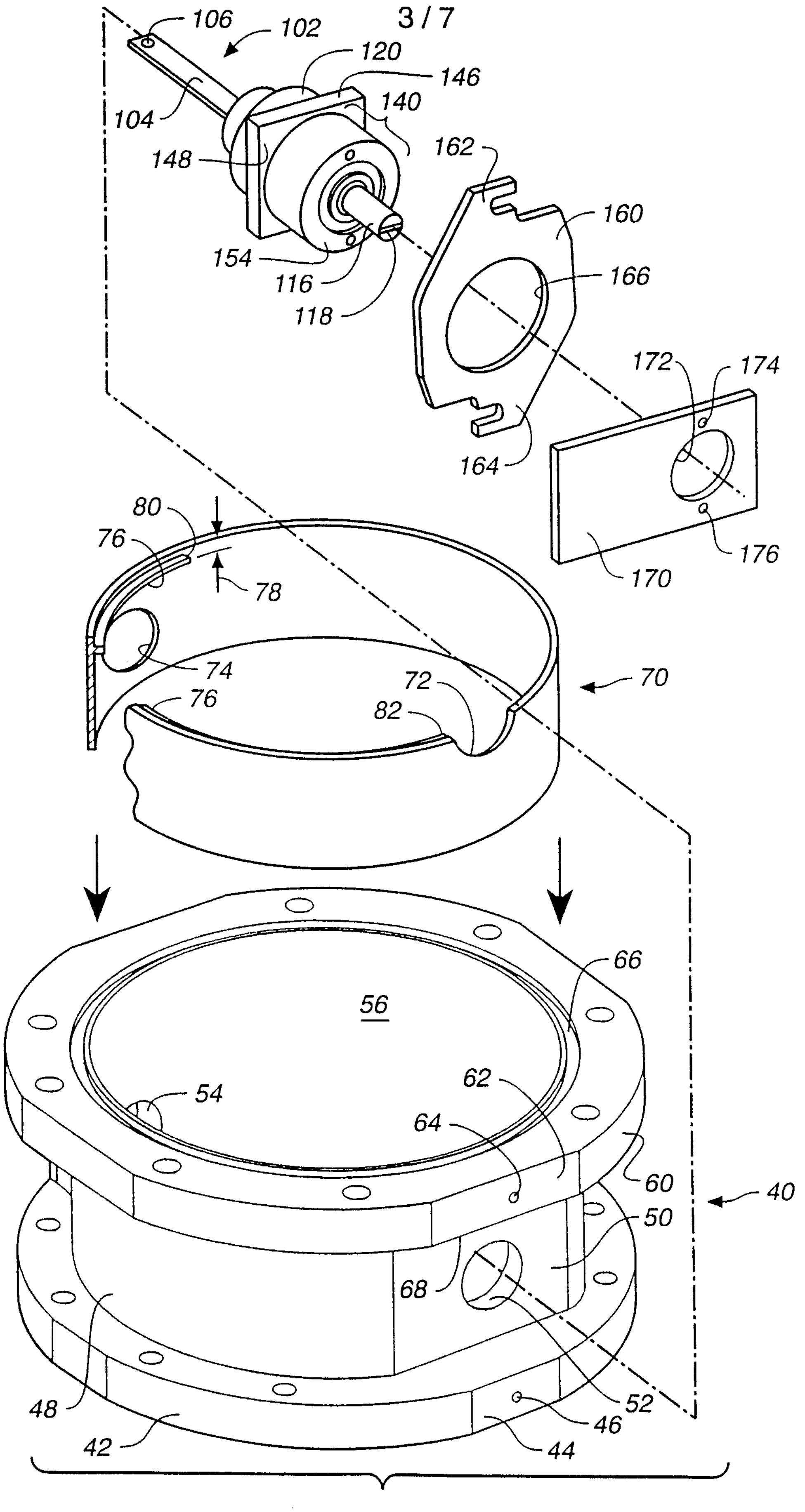

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FIG._2B

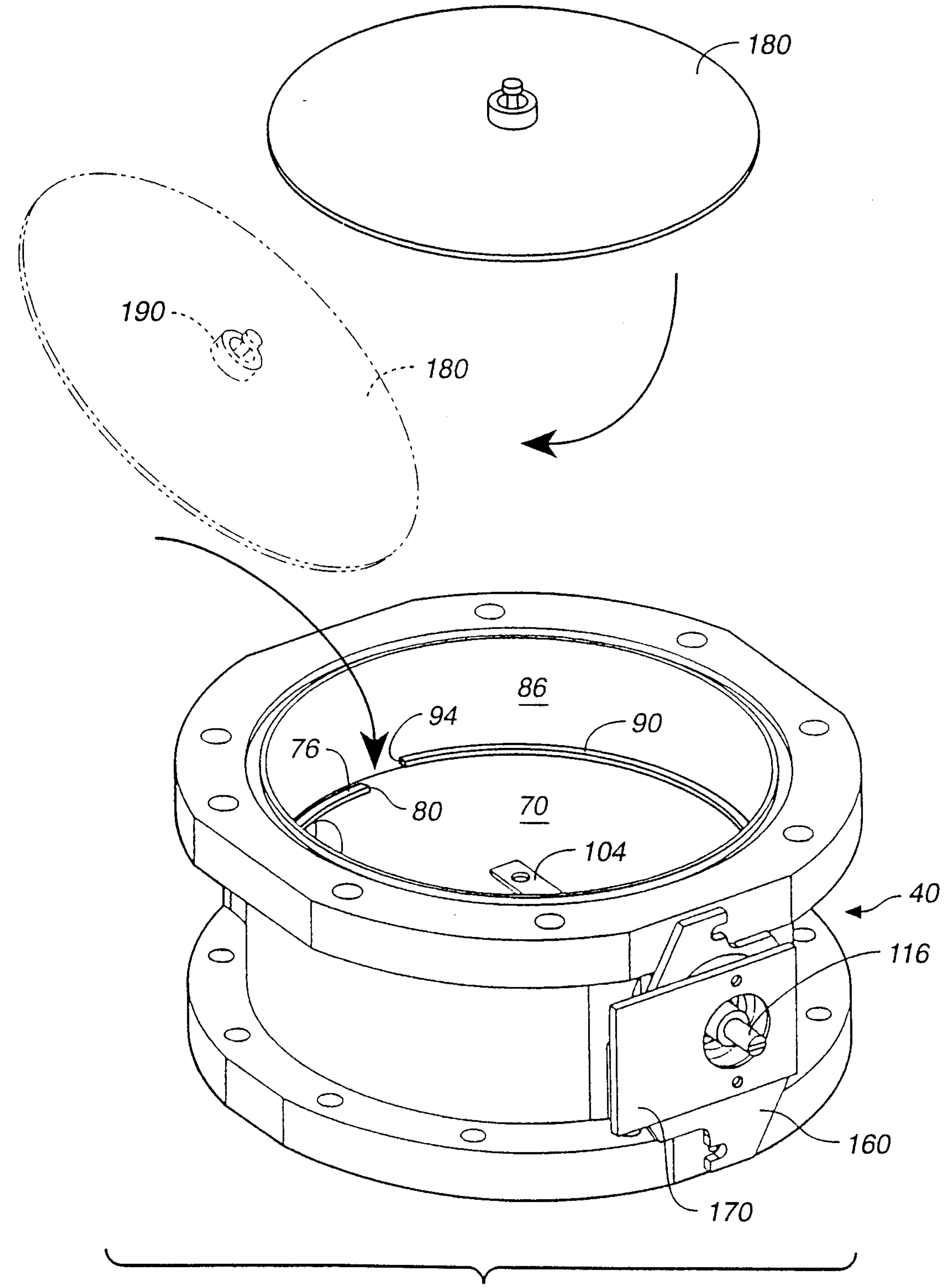

FIG._3

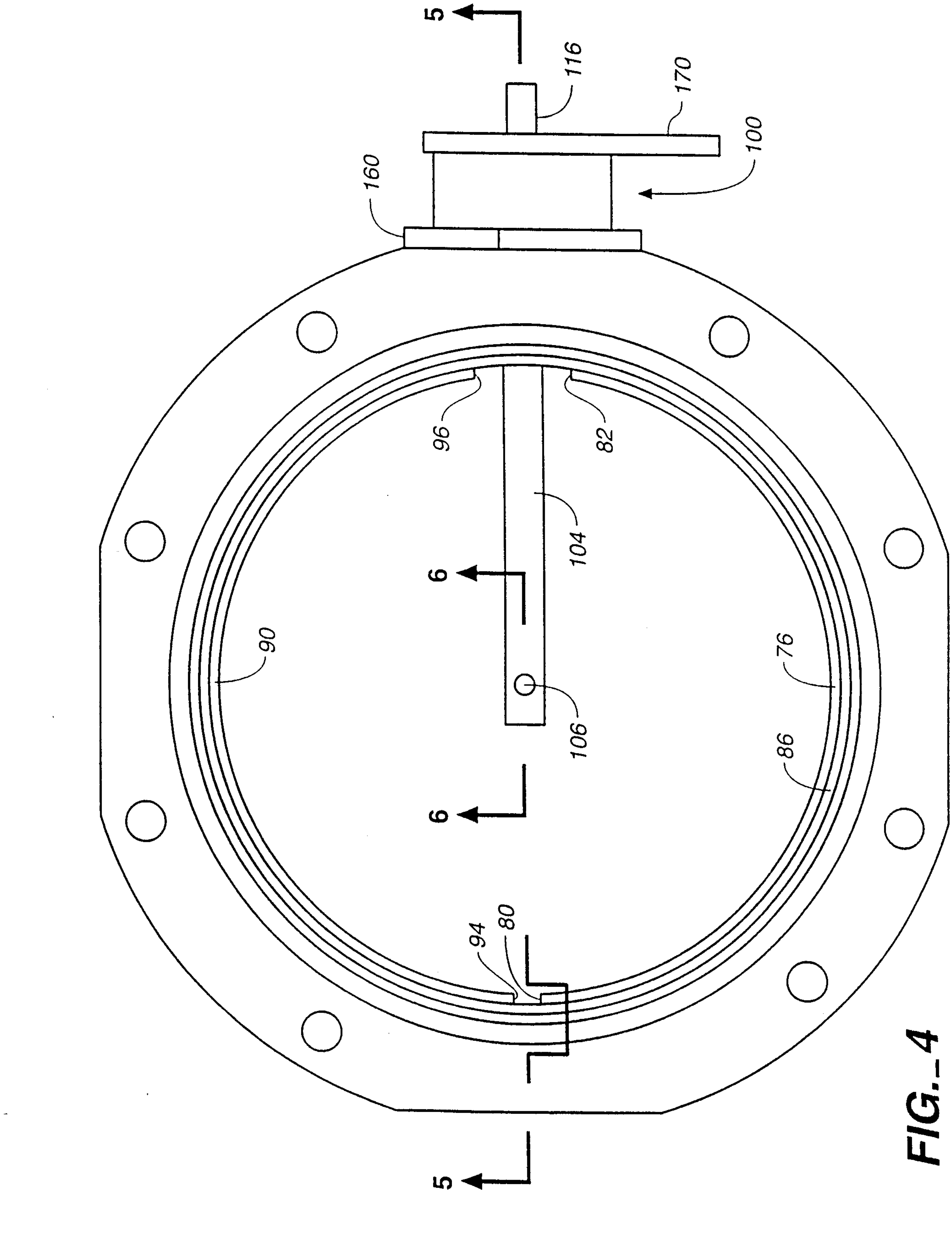

FIG._4

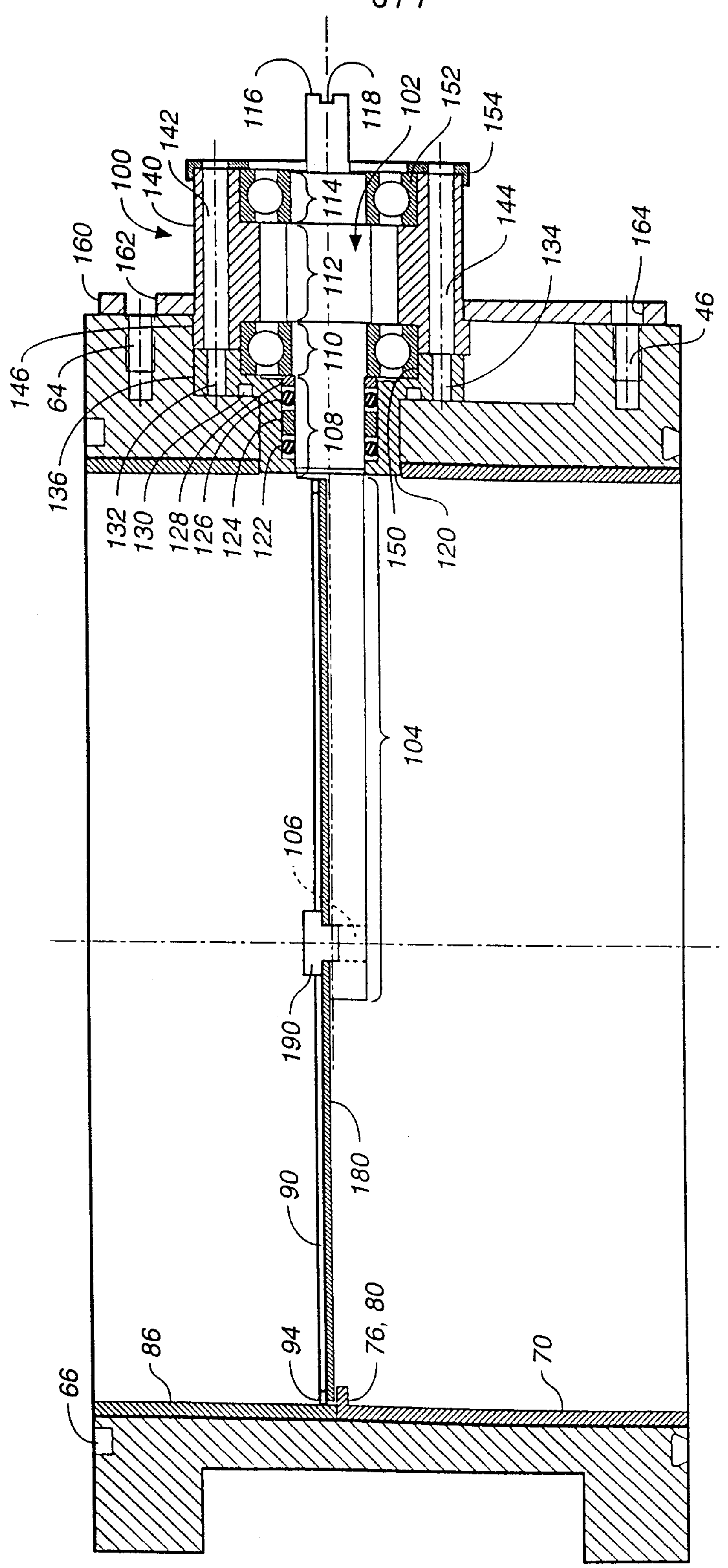
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FIG._5

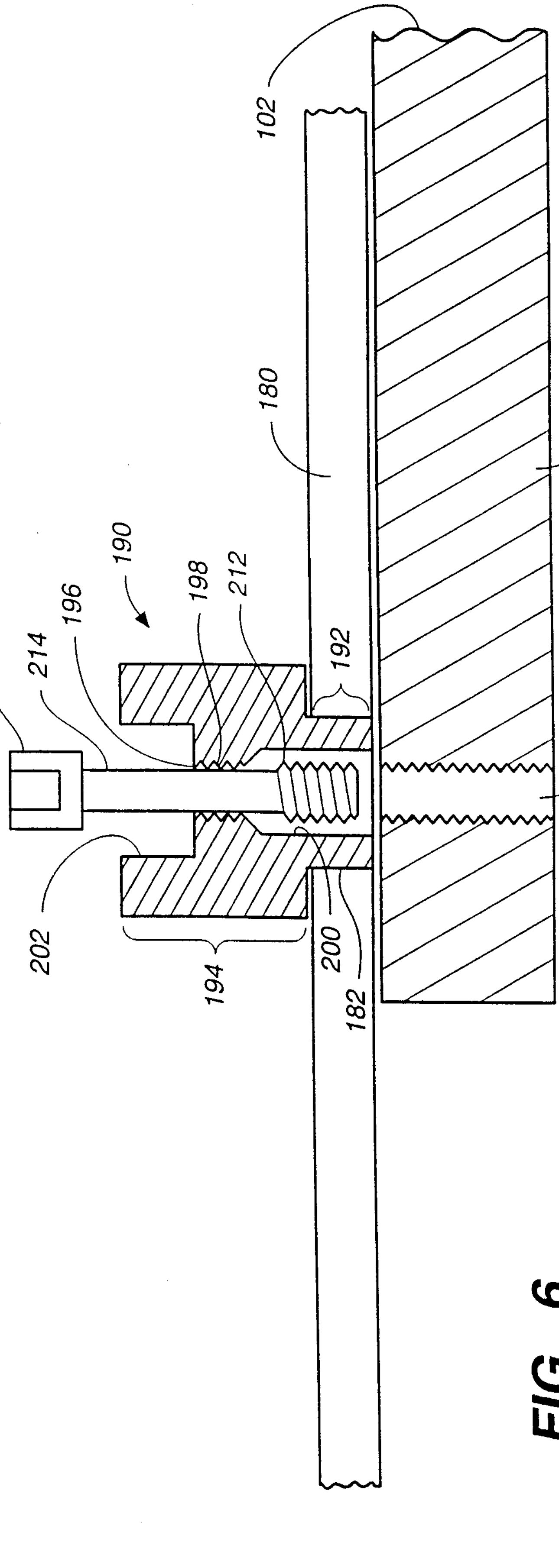

FIG._6

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/US 98/17023

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16K51/02 F16K1/22 F16K27/02

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)
IPC 6 F16K

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 practical, 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.
A	WO 91 11647 A (POWERS KELLY B) 8 August 1991 see abstract; figures 2,22 ---	1,22,27
A	GB 1 087 463 A (A.E.H. ELMER) 18 October 1967 see figures 1,2 ---	1,22,27
A	US 3 306 316 A (C.K. STILLWAGON) 28 February 1967 see figures 1-7 see column 8, line 74 - column 9, line 7 ---	1,22,27
A	PATENT ABSTRACTS OF JAPAN vol. 096, no. 010, 31 October 1996 & JP 08 145196 A (KUBOTA CORP), 4 June 1996 see abstract ---	1,22,27
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 November 1998	25/11/1998

Name and mailing address of the ISA	Authorized officer
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Internal Application No
PCT/US 98/17023

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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...ormation on patent family members

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