



US 20050191195A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0191195 A1**

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(43) **Pub. Date:**

Sep. 1, 2005

(54) **DUAL RECIPROCATING BELLOWS PUMP WITH INTERLOCK SHAFT MEANS**

(52) **U.S. Cl.** 417/473; 417/472; 417/390

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(57) **ABSTRACT**

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It is sought to provide a dual reciprocating bellows pump having two, i.e., left and right, bellows interlocked by interlock shafts to each other, which is free of wear powder or wear dust generated by the frictional movement of the interlock shafts and bearings relative to one another from pump feed fluid in pumping chambers, permits ready use of synthetic resin as pump element material, is excellent in function and cost and readily permits size reduction design.

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Paired interlock shafts coupled to end members 6 of the pair of, i.e., left and right, bellows, are disposed in paired working air chambers 8, and are movably inserted in through bores provided in a pump head. Between each interlock shaft and each through elastic seal members are disposed, thus sealing the left and right working air chambers 8 from each other. No particular bearing is used for the interlock shafts. Lip seals are desirably used as the elastic seal members.

(21) **Appl. No.:** 11/043,134

(22) **Filed:** Jan. 27, 2005

(30) **Foreign Application Priority Data**

Jan. 27, 2004 (JP) 2004-18038

Publication Classification

(51) **Int. Cl.⁷** F04B 9/08; F04B 17/00

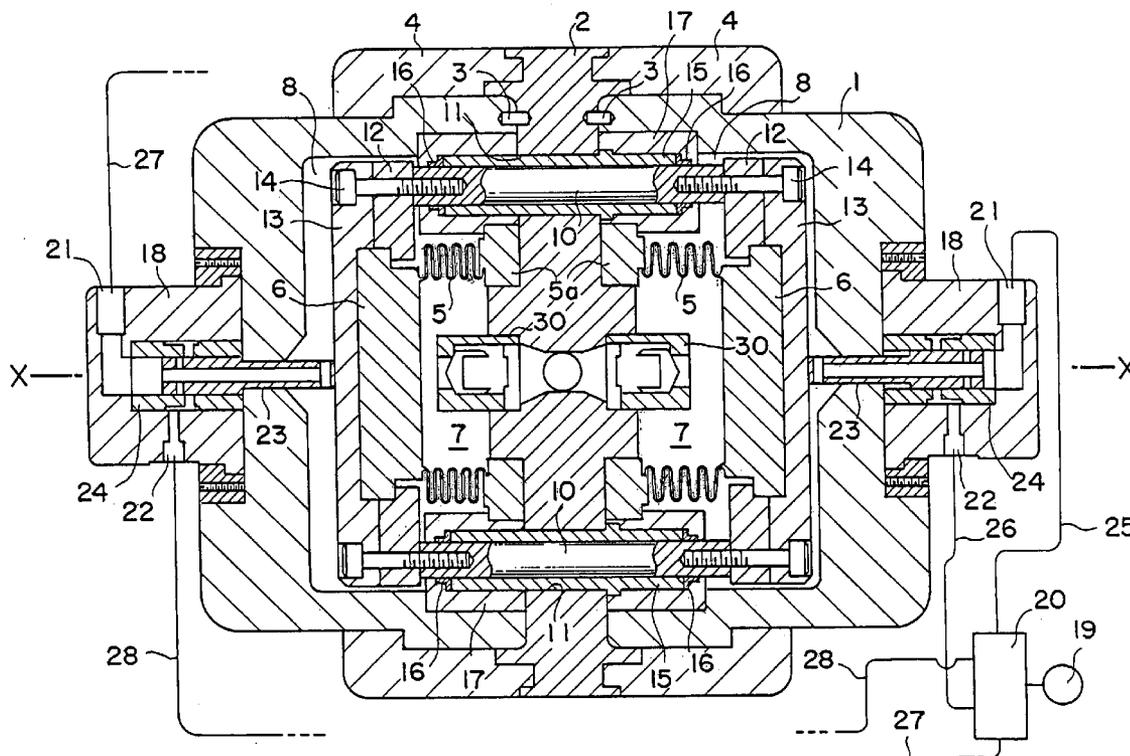


FIG. 2

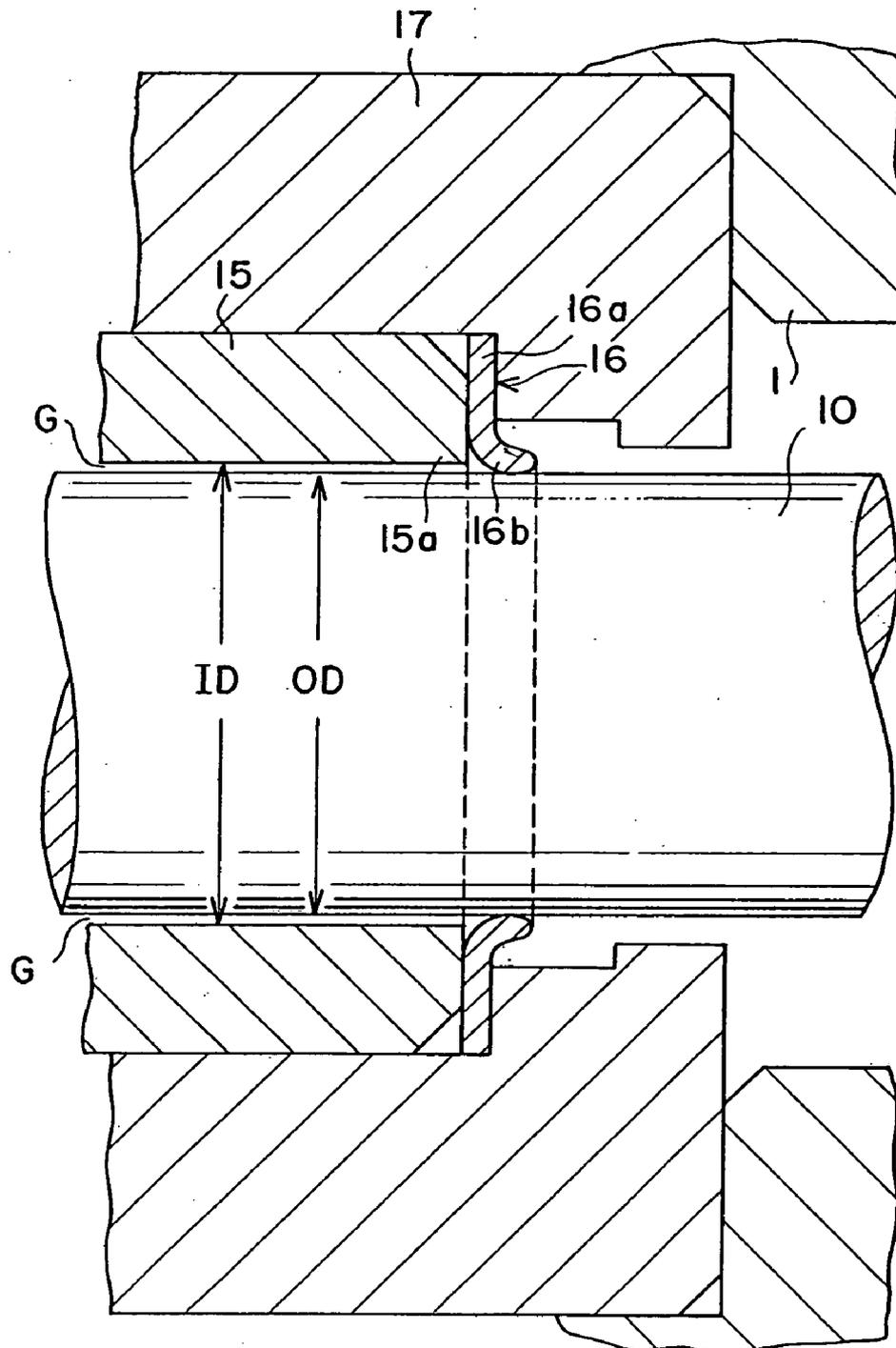


FIG. 2

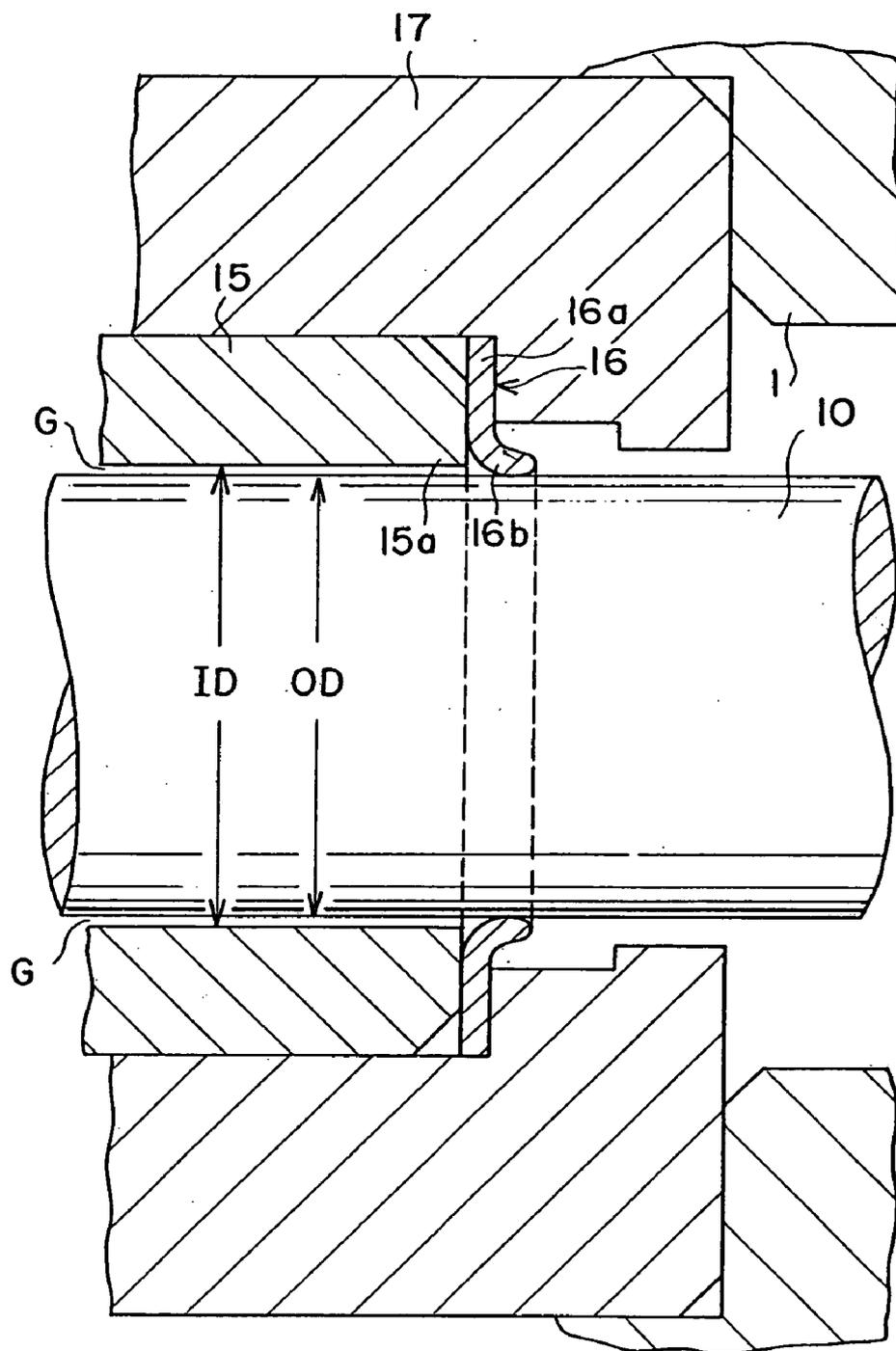


FIG. 3

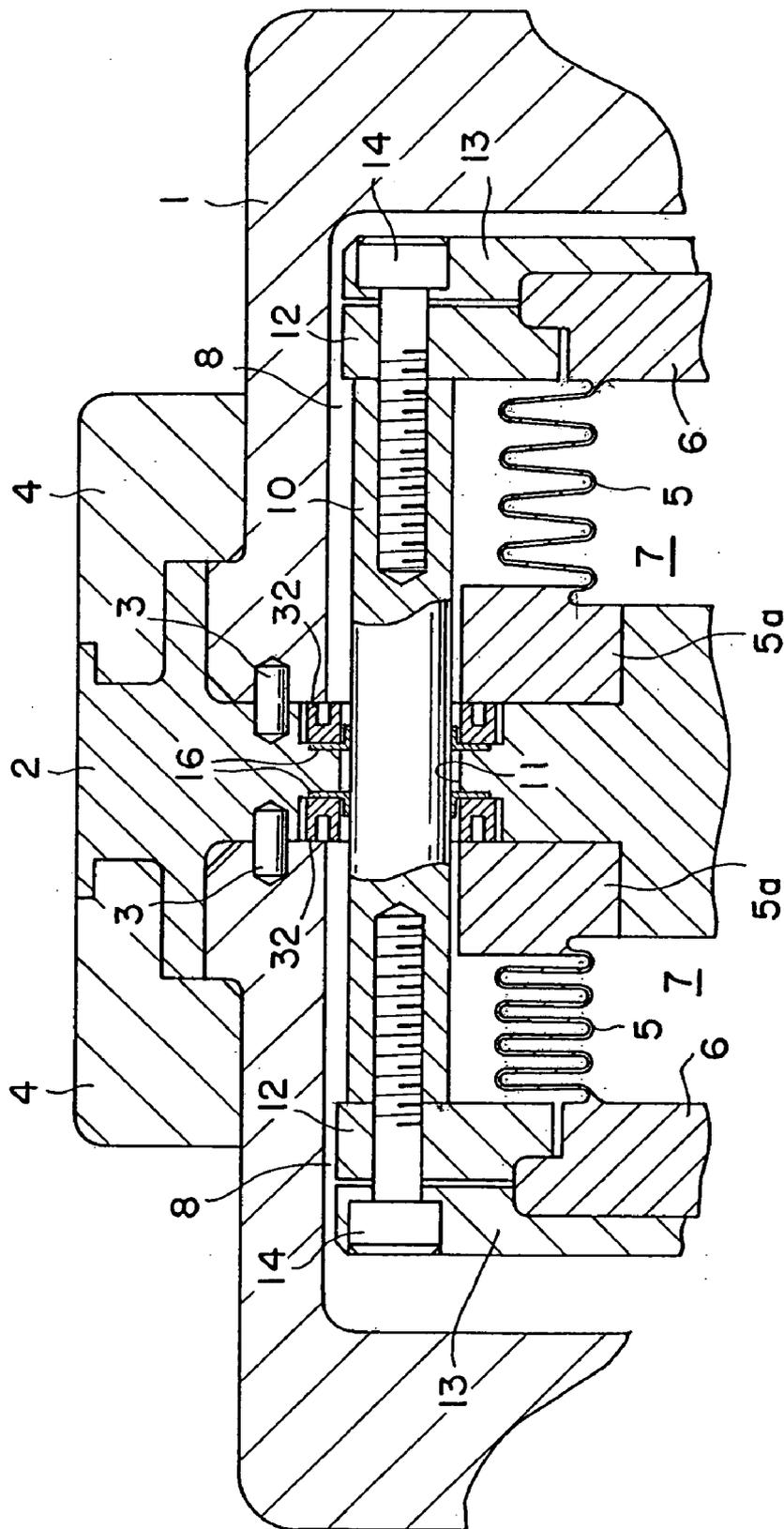


FIG. 4

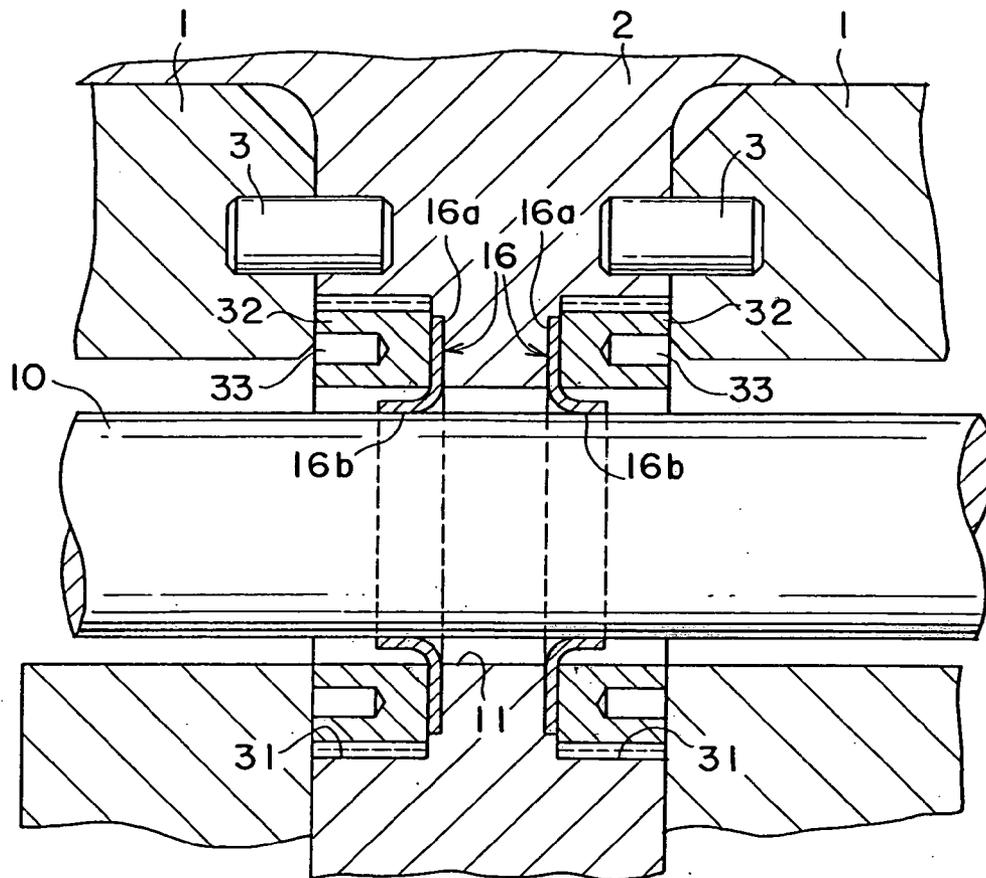
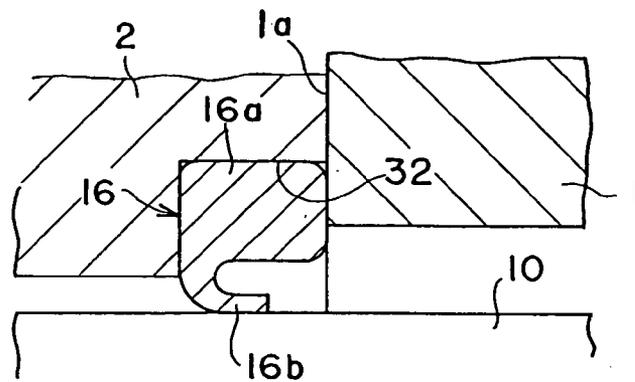


FIG. 5



DUAL RECIPROCATING BELLOWS PUMP WITH INTERLOCK SHAFT MEANS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to dual reciprocating bellows pumps with interlock shaft means, in which a pair of expansible and contractable cylindrical bellows, with a pump head interposed therebetween, are interlocked by paired interlock shafts as the interlock shaft means to each other, with the inside of the cylindrical bellows made to be pumping chambers for pump fed fluid such as semiconductor processing liquid and with the outside of the cylindrical bellows provided with working air chambers defined by a pump housing.

[0003] 2. Description of the Prior Art

[0004] In this type of dual reciprocating bellows pump, interlock shaft means is provided to couple together a pair of, i.e., left and right, bellows, so as to interlock these bellows to each other. An arrangement of this type with the interlock shaft means disposed outside a pump housing and also another one with interlock shaft means disposed inside pumping chambers are well known in Japanese Patent disclosure No. 2003-314458. In the former arrangement, the interlock shaft means is coupled to the extended ends of a member, which is movable in unison with the bellows and is extended to the outside of the pump housing. In the latter arrangement, a pump head disposed at the center of a pump housing has through bores open in pumping chambers, and interlock shafts are inserted through the through bores to be in frictional contact with the bore inner periphery. The interlock shafts have their ends extending into the pumping chambers and operatively coupled to end members provided on the free ends of the bellows.

[0005] In the above prior art dual reciprocating bellows pump arrangement, in which the interlock shafts are disposed outside the pump housing, the coupling mechanism for transferring the bellows operation to the interlock shafts is complicated, and also the pump size and cost of manufacture are increased. In the case of the arrangement with the interlock shafts disposed inside the pumping chambers, the interlock shafts are in close frictional contact with the through bores of the pump head for isolating fluid in the pumping chambers. Therefore, wear powder or wear dust is generated in the frictional parts and introduced as undesired impurity in the pump feed fluid in the pumping chambers. Particularly, this poses very serious problems in the case, in which the pump feed liquid is semiconductor processing liquid with high purity required thereto.

[0006] In the pump, in which semiconductor processing liquids or chemicals are dealt with as shown in the above, richly corrosion-resistant synthetic resin is used in lieu of metal as the material the contact-with-liquid materials in the pumping chambers, and up to date pumps, in which all the pump constituents are all made of synthetic resin, are spread because they are desired in view of function and cost. As shown, even in the case of adopting a pump arrangement using synthetic resin for the contact-with-liquid parts, so long as the interlock shafts are disposed in the pump chambers, no grease or like lubricant can be used for the frictional parts between the pump head and the through

bores. Also, the carbon-containing resin excellent in the frictional property can not be used due to the occurrence of corrosion resistance and wear particles. Accordingly, it is inevitable to adopt an arrangement, in which synthetic resin interlock shafts are in close frictional contact with through bores of a synthetic resin pump head via synthetic resin bearings. Thus, even slight distortion at the time of assembling applies great load on the frictional parts to give rise to a "scratch" phenomenon and disturb smooth movement of the interlock shafts and, in an extreme case, results in the stop of the pumping operation.

[0007] This invention is made in view of the above various problems, and its object is to provide a dual reciprocating bellows pump with interlock shaft means, which can prevent intrusion of undesired impurities in the pump feed liquid, is excellent in function and cost and permits ready size reduction design.

SUMMARY OF THE INVENTION

[0008] To attain the above object of the invention, according to the invention it is sought to provide a dual reciprocating bellows pump with interlock shaft means comprising a pump housing, a pump head assembled in the pump housing at the center along the longitudinal axis thereof and capable of withdrawing and discharging pump feed liquid, a pair of, i.e., left and right, bellows having respective end parts sealedly mounted on the pump head and capable of expansively and contractably, reciprocating with a predetermined stroke in the pump housing in longitudinal directions thereof, paired end members each sealedly coupled to the free end of each bellows and capable of cooperating with the pump head defining pumping chambers inside the bellows and also defining working air chambers between the bellows and the housing, paired interlock shafts each having the two ends coupled to the pair of end members such as to cause reciprocation of each bellows in an interlocked relation to the reciprocation of the other bellows, inserted through through bores formed in the pump head and capable of being displaced in the longitudinal directions of the pump housing, working air feed means for selectively feeding working air to the part of, i.e., left and right, working air chamber, and paired valve means mounted on the pump head in correspondence to the pumping chambers, respectively, in the pair of, i.e., left and right, bellows reciprocated in response to pressure changes of working air fed by the working air feed means, for controlling the flow of the pump feed fluid into and out of the pumping chamber, wherein : said through bores formed in the pump head are open in the pair of, i.e., left and right, working air chambers; said interlock shafts extend through said through bores into the pair of, i.e., left and right, working air chambers; and seal means is provided between said interlock shaft and the corresponding through bore of the pump head so as to isolate said pair of, i.e., left and right, working air chambers.

[0009] In the above arrangement according to the invention, the interlock shafts extend, in their state open to the left and right working air chambers, through through bores provided in the pump head into the working air chambers, and are not disposed in the pumping chambers. Seal means are provided between each through bores and each working air chamber, whereby the left and right working air chambers are isolated. Here, no bearing means for supporting any interlock shaft is needed.

[0010] According to the invention, it is also sought to provide a dual reciprocating bellows pump with interlock shaft means, wherein the seal means each include a cylindrical guide member open at the two ends, inserted and secured in each through bore of the pump head extending into the left and right working air chambers, and paired elastic seal members each mounted in each open end of the guide member, the interlock shafts are each movably inserted in each cylindrical guide member, the inner diameter of the cylindrical guide members being greater than the outer diameter of the interlock shafts, and the elastic seal members effect isolation of the left and right working air chambers in sealed contact with the interlock shafts.

[0011] In the above specific arrangement of said seal means according to the invention, said cylindrical guide members are inserted through and secured in the through bores, and said elastic seal members are mounted on the two open ends of the guide members to be in sealed contact with the interlock shaft movable in said guide members. In the contact parts, a seal action of isolating the left and right working air chambers is executed. The inner diameter of the cylindrical guide members is set to be greater than the outer diameter of the interlock shafts, and thus there is no possibility that the movement of the interlock shafts is interfered in contact with the cylindrical guide members.

[0012] According to the invention it is further sought to provide a dual reciprocating bellows pump with interlock shaft means, wherein the inner diameter of the through bores of the pump head is greater than the outer diameter of the interlock shafts, and paired elastic seal members are disposed in the through bores such as to be able to be in sealed contact with the interlock shafts, thereby effecting the isolation of the left and right working air chambers.

[0013] In the above specific arrangement according to the invention, the interlock shafts are directly inserted through the through bores of the pump head, and a pair of elastic seal members are disposed in each through bore between the interlock shaft and the through bore. Again in this case, no bearing for supporting any interlock shaft is provided.

[0014] According to the invention, it is further sought to provide a dual reciprocating bellows pump with interlock shaft means, wherein said elastic seal members are constituted by lip seals.

[0015] In the above specific arrangement according to the invention, the elastic seal members are each constituted by a so-called lip seal having a thin tongue-like seal contact part. The lip seals are richly flexible, and can thus absorb even a slight distortion at the time of the pump assembling. During the pump operation, the left and right bellows are held in a pressurized state by working air. With this pressure balance, the bellows are thought to be horizontally reciprocating without great distortion. Thus, no greater load than on the interlock shaft in sealed contact with the lip seals is applied to the lip seals.

[0016] According to the invention, it is further sought to provide a dual reciprocating bellows pump with interlock shaft means, wherein the pump constituent elements are all made of synthetic resin.

[0017] In the above specific arrangement according to the invention, synthetic resin is used as the material of the pump constituent members inclusive of contact-with-liquid mem-

bers of the pumping chambers accommodating pump feed fluid, that is, all resin pump design is made.

[0018] According to the invention, since the interlock shafts are disposed in the working air chambers outside the bellows, there is no possibility that wear powder and wear dust are introduced into fluid in the pumping chambers defined in the bellows. Also, since the interlock shafts are disposed inside the pump housing, the coupling structure with respect to the bellows is simple, and size reduction design of the entire pump can be readily made.

[0019] Furthermore, the left and right bellows are held in a state pressurized by working air with the pumping operation. With this pressure balance, seal means for isolating the working air chambers between interlock shafts and through bores of the pump head penetrated by the interlock shafts, undergo reciprocation substantially horizontally without generation of great distortion, and thus it may be of a relatively simple arrangement. Besides, since no particular bearing is necessary between each interlock shaft and each through bore, the load on the interlock shafts is reduced, and it is possible to obtain smooth pumping operation.

[0020] Thus, in the case of adopting the arrangement that cylindrical guide members for guiding the interlock shafts in the movement therefore inserted through and secured to the through bores, the interlock shafts will not be in direct frictional contact with the guide members in their movement by setting the inner diameter of the guide members to be greater than the outer diameter of the interlock shafts. As the seal, the elastic seal members mounted on the open ends of the guide members can sufficiently effect isolation of the working air chambers.

[0021] In the case of the arrangement without provision of any cylindrical guide member, by setting the inner diameter of the through bores to be greater than the outer diameter of the interlock shafts, a pair of elastic seal members is disposed between each through bore and each interlock shaft. Thus, it is not only possible to avoid the frictional contact of the interlock shafts with the corresponding through bores during movement, but also effect sufficient isolation of the working air chambers with the pair of elastic seal members.

[0022] Moreover, by using lip seals as the elastic seal members, it is possible to obtain soft contact with the interlock shafts and absorb even slight distortion at the time of the pump assembling in the contact parts. The load on the interlock shafts thus can be further reduced.

[0023] With the arrangement as shown above, according to the invention, by using synthetic resin as the material of various pump constituent members such as contact-with-liquid parts of the pumping chambers accommodating pump feed fluid, all resin pump design can be readily made, and it is possible to provide a pump, which is suited for dealing with semiconductor processing liquids or chemicals as the pump feed fluid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The invention will become more apparent upon a reading of the following detailed specification with reference to the accompanying drawings, in which:

[0025] FIG. 1 is a schematic sectional view showing a first embodiment of the dual reciprocating bellows pump with interlock shaft means according to the invention;

[0026] FIG. 2 is a fragmentary enlarged-scale view showing the pump shown in FIG. 1;

[0027] FIG. 3 is a fragmentary sectional schematic view showing a second embodiment of the dual reciprocating bellows pump with interlock shaft means according to the invention;

[0028] FIG. 4 is a fragmentary enlarged-scale view showing the pump shown in FIG. 3; and

[0029] FIG. 5 is a fragmentary view showing a modification of the lip seal shown in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Embodiments of the present invention will now be described with reference to the drawings. FIGS. 1 and 2 show the first embodiment of the dual reciprocating bellows pump with interlock shafts as interlock shaft means. Reference numeral 1 designates a pump housing. Reference numeral 2 designates a pump head disposed in the pump housing 1 at the center thereof in the longitudinal axis X-X. The pump housing 1 comprises a pair of, i.e., left and right, parts with the pump head 2 as a border. These parts are assembled to be integral with the pump head 2 by a pair of assembling frames in a stage positioned by pins 3.

[0031] Reference numeral 5 designates a pair of, i.e., left and right, cylindrical bellows, which have their stem parts 5a mounted in a sealed stage on the central pump head 2 and expansively and contractably reciprocal with a predetermined stroke along the longitudinal axis X-X of the pump housing 1. Reference numeral 6 designates end members, which are each coupled in a sealed state to the free end of each bellows 5, each define a pumping chamber 7 in each bellows 5 in cooperation with the pump head 2 and define a working air chamber 8 between each bellows 5 and the pump housing 1. In this embodiment, the end members 6 are formed to be integral with the bellows 5, respectively.

[0032] Reference numeral 10 designates interlock shafts constituted as the interlock shaft means, which are inserted through bores 11 open to a pair of, i.e., working air chambers 8, and extend into the working air chambers 8, respectively. Each free bellows end part is coupled by bolts 14 to each end member 6 via two coupling members 12 and 13. The two coupling members 12 and 13 are mounted by the bolts 14 to the corresponding end member 6 such as to sandwich the end member 6. The pair interlock shafts 10 are provided face to face in the working air chambers 8 in concentric positions in radial direction centered on the longitudinal axis X-X. These interlock shafts 10 are movable along and parallel with the axis X-X such that one of the bellows 5 is interlocked with good balance to the reciprocation of the other bellows 5 along the axis X-X.

[0033] Reference numeral 15 designates paired cylindrical guide members, which are each inserted in and secured to each through bore 11. Each interlock shaft 10 is movably inserted in each guide member 15. As shown in FIG. 2, the inner diameter ID of the guide members 15 is set to be greater than the outer diameter OD of the interlock shafts 10. When each interlock shaft 10 is moved in the longitudinal direction, it is not in frictional contact with the inner periphery of the guide member 15 owing to a gap G held between it and an elastic seal member 16 to be described later.

[0034] The elastic seal members 16 have a ring-like shape, and are mounted on the open end parts 15a of each cylindrical guide member 15 to be in elastic contact with the outer periphery of the interlock shaft 10, thus effecting the sealed contact. As the elastic seal members 16, it is particularly desired to use thin tong-like lip seals as in this embodiment.

[0035] Each elastic seal member 16 constituted by a lip seal is secured in its state that it is pushed against the open end part 15a of the associated cylindrical guide member 15 and with its stem part 16a clamped from the back side by a back-up member 17, and its tong part 16b extending radially inwardly is elastically held in sealed contact with the entire outer periphery of the associated interlock shaft 10. Thus, the pair of, i.e., left and right, elastic seal members 16 isolate the flow of working air in the left and right working air chambers 8.

[0036] Working air feed switching mechanisms 18 mounted on the opposite end parts of the pump housing 1 selectively feed working air from an air source 19 via a control valve 20 to the part of, i.e., working air chambers 8. When working air is thus fed to one of the working air chambers 8, the associated bellows 5 undergoes contracting movement, which is transmitted via the interlock shafts 10 to the other bellows 5, while causing release of the working air from the other bellows 5 to cause expansion movement thereof. This operation is repeated.

[0037] The working air feed switching mechanisms 18 each include an air inlet port 21, an air discharge port 22, a piston 23 and a cylinder 24, and they constitute an operating air feed means together with the control valve 20 and the air source 19 connected via ducts 25 to 28 to them. This means may be the same as what is disclosed in Japanese Patent Disclosure No. 2003-314458, and its detailed arrangement is not described.

[0038] The left and right bellows 5 repeatedly undergo expansion and contracting movement in response to the working air feed switching operation to cause pumping operation of withdrawing and discharging pump feed fluid such as semiconductor processing liquid or a chemical liquid accommodated in the pumping chambers 7 in the bellows 5. The in-flow and out-flow of the pump feed liquid to and from the pumping chambers 7 are effected via valves 30 provided on the pump head 2. Each pumping chamber 7 has a withdrawal guide and a discharge guide valve 30 provided as a pair. In FIG. 1, these paired valves 30 are shown side by side in the direction of the paper surface, and only one set of the paired valves 30 is seen. These valves are communicated with withdrawal and discharge ports (not shown) provided on the pump head 2. The arrangement in this part is the same as what is disclosed in the above Japanese Patent Disclosure No. 2003-314458, and its detailed description is not given.

[0039] In the dual reciprocating bellows pump having the above arrangement, as described above the pumping operation is executed in such a manner that the pair of, i.e., left and right, bellows 5 undergoes reciprocation along the longitudinal axis X-X in a state that they are interlocked to each other by the interlock shafts 10 in response to the selective feed of working air. In this operation, the left and right working air chambers 8 are always in a state pressurized by working air and held balanced. The bellows 5 thus are not excessively deviated from the direction of the axis

X-X and distorted or do not bring about vibrations. Thus, the interlock shafts **10** are likewise moved substantially along the direction of the axis X-X, and they do not come to be in excessive contact with the cylindrical guide members **10** and can be moved smoothly. With this arrangement, the interlock shafts **10** do not require any special bearing, but require only the elastic seal members **16**, which isolate the left and right working air chambers **8** and are solely in contact at the time of the usual movement. The load on the interlock shafts **10** is thus extremely reduced, and the generation of wear powder, wear particles and wear dust from the contact parts are suppressed as much as possible.

[0040] The pump constituents may all be readily manufactured from synthetic resin. Particularly, it is desirable to use richly corrosion-resistant synthetic resin for the contact-with-liquid parts of the pumping members **7** accommodating the pump feed liquid, such as the bellows **5**, the pump head **2** and the valve **30**. The interlock shafts **10** and cylindrical guide members **15** are desirably made of such synthetic resin as PEEK (polyetheretherketone) resin. The lip seals constituting the elastic seal members **16** are desirably filler-containing PTFE (polytetrafluoroethylene) resin.

[0041] When the lip seals made of the filler-containing PTFE resin is in contact with the interlock shafts **10** made of PEEK, PTFE is transferred as initial wear to the frictional surfaces of the shaft **10**. As a result, the lip seals of the filler-containing PTFE come to be in frictional contact with the filler-containing PTFE having been transferred to the surfaces of the PEEK resin. Thus, the wear does not proceed greatly. It is thus an advantage that the sole lip seals permit sufficient seal, so that no particular bearing is necessary.

[0042] FIGS. 3 and 4 show a second embodiment of the dual reciprocating bellows pump according to the invention. In the figures, elements like those in the preceding first embodiment are designated by like reference numerals, and their description is not given in detail. In this embodiment, the inner diameter of the through bores **11** formed on the central pump head **2** is set to be greater than the outer diameter of the interlock shafts **10**. In each through bore **11**, a pair of, i.e., left and right, ring-like elastic seal members **16** are disposed in a spaced-apart relation to each other and held in contact with the interlock shaft **10** inserted through the through bore **11**, thus blocking the flow of working air in the left and right operating air chambers **8** to effect isolation of the two chambers **8**.

[0043] The second embodiment of the pump is simpler in arrangement than the first embodiment with omission of the cylindrical guide members **15**. Here, the elastic seal members **16**, like the first embodiment, are constituted by thin tong-like lip seals. As shown in an enlarged scale in FIG. 4, each elastic seal member **16** constituted by a lip seal has an L-shaped sectional profile, and its stem part **16a** is secured in a threaded annular recess **31** formed on each side of the pump head **2** by screwing a threaded ring-like seal retainer **32** in the recess **31**. Reference numeral **33** designates a tool insertion bore formed in the seal retainer **32**. The seal retainer **32** is fitted in the annular recess **31** by inserting a suitable tool. A tong part **16b** of the lip seal **16**, extending from the stem part **16a** and bent radially inwardly, is in elastic frictional contact in a ring-like form on the entire outer periphery of the interlock shaft **10**, thus effecting a seal contact therein. Thus, during their moving operation the

interlock shafts **10** are in contact only with these elastic seal members **16** and not in direct contact with the inner surfaces of the through bores **11** of the pump head **2**. Thus, again in this embodiment no particular bearing for the interlock shafts **10** is necessary.

[0044] FIGS. 3 and 4 are provided for describing one interlock shaft **10** and relative arrangement thereto. However, like the first embodiment a pair of interlock shafts **10** are disposed in the working air chambers **8**. Also, as the material of these constituent members, like the first embodiment all the elements can be readily made from appropriate resin.

[0045] FIG. 5 shows a modification of the lip seal constituting the elastic seal member in corresponding to the part shown in FIG. 4. As in the seal retainer **32** in the second embodiment, the stem part **16a** is formed to have an enlarged shape so that it also serves as the seal retainer **16** shown in the second embodiment. Here, the stem part **16a** of the lip seal **16** is held in an annular recess **31** without thread such that it is pushed from the outside by the end face **1a** of the housing **1**, and the thin tong part **16b** extends such that it is bent radially inwardly to be in sealed contact with the outer periphery of the interlock shaft **10**.

[0046] As shown, the elastic seal member **16** may be of various shapes, but its part in contact with the interlock shaft **10** is desirably of a thin tong-like shape.

[0047] While preferred embodiments and modifications of the arrangement according to the invention have even described with reference to the drawings, the interlock shafts **10** are shown to be of rod-like shape. However, it is possible to use any other shape such as angular shapes as well, and the illustrated arrangement is by no means limitative.

What is claimed is:

1. A dual reciprocating bellows pump with interlock shaft means comprising;
 - a pump housing;
 - a pump head assembled in the pump housing at the center along a longitudinal axis thereof and capable of withdrawing and discharging pump feed liquid;
 - a pair of left and right cylindrical bellows having respective end parts sealedly mounted on the pump head and capable of expansively and contractably reciprocating with a predetermined stroke in the pump housing in longitudinal directions thereof;
 - paired end members each sealedly coupled to the free end of each bellows and capable of cooperating with the pump head defining pumping chambers inside the bellows and also defining working air chambers between the bellows and the housing;
 - paired interlock shafts as said interlock shaft means, each having the two ends coupled to the pair of end members such as to cause reciprocation of each bellows in an interlocked relation to the reciprocation of the other bellows, inserted through through bores formed in the pump head and capable of being displaced in the longitudinal directions of the pump housing;
 - working air feed means for selectively feeding working air to the pair of left and right working air chambers, and

paired valve means mounted on the pump head in correspondence to the pumping chambers, respectively, in the pair of left and right bellows reciprocated in response to pressure changes of working air fed by the working air feed means, for controlling the flow of the pump feed fluid into and out of the pumping chambers;

wherein:

said through bores formed in the pump head are open in the pair of left and right working air chambers;

said interlock shafts extend through said through bores into the pair of left and right working air chambers; and

seal means is provided between said interlock shaft and the corresponding through bore so as to isolate said left and right working air chambers.

2. The dual reciprocating bellows pump with interlock shaft means according to claim 1, wherein:

said seal means includes a cylindrical guide member open at the two ends, inserted and secured in said through bore of the pump head and extending into the left and right working air chamber, and an elastic seal member mounted in said open ends of the guide member;

said interlock shaft is movably inserted in said corresponding cylindrical guide member, the inner diameter

of the cylindrical guide member being greater than the outer diameter of said interlock shaft; and

said elastic seal member effects isolation of the left and right working air chambers in sealed contact with said corresponding interlock shaft.

3. The dual reciprocating bellows pump with interlock shaft means according to claim 1, wherein:

said inner diameter of said through bore of the pump head is greater than the outer diameter of said interlock shaft; and

an elastic seal member is disposed in said corresponding through bores such as to be able to be in sealed contact with said interlock shaft, thereby effecting the isolation of the left and right working air chambers.

4. The two-ganged interlock bellows pump with interlock shaft means according to claim 3, wherein:

said elastic seal member is constituted by a lip seal.

5. The dual reciprocating bellows pump with interlock shaft means according to claim 4, wherein:

said pump constituent elements are all made of synthetic resin.

* * * * *