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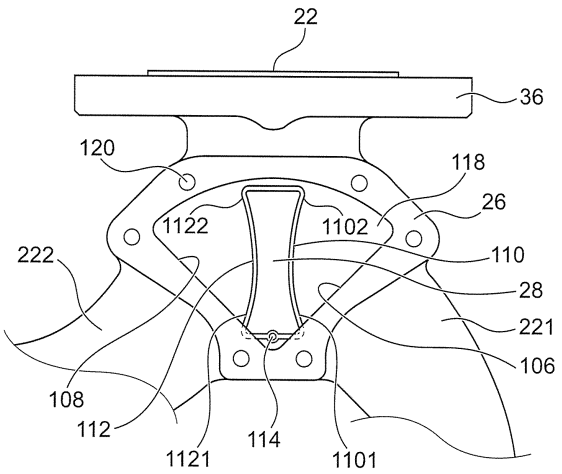
(54) **DISCHARGE MERGING PORTION, PUMP CASING, AND PUMP APPARATUS**

(57) There is provided a discharge merging portion for a plurality of passages to transfer the liquid, reduced in pressure loss as compared with an existing discharge merging portion. An on-off valve 28 includes a first surface 110 to close a first opening 106, and a second surface 112 to close a second opening 108. The first surface 110 and the second surface 112 are opposed to each other. Each of the first surface 110 and the second surface 112 includes an upstream end part 1101 positioned on an upstream side of the liquid which is transferable, a downstream end part 1102 positioned on a downstream side, and a center part 1103 positioned between the upstream end part 1101 and the downstream end part 1102. The first surface 110 is a curved surface curved toward the second surface 112. The center part 1103 of the first surface 110 is recessed toward the second surface 112 relative to the upstream end part 1101 and the downstream end part 1102 of the first surface 110, and a recessed amount is increased from the upstream end part 1101 and the downstream end part 1102 toward the center part 1103.

Fig. 6



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Description

[0001] The present invention relates to a discharge merging portion, a pump casing, and a pump apparatus.

[0002] A pump apparatus is conventionally used for various applications in various kinds of houses and in a site such as a factory. For example, an inline pump in which a pump section and a motor section are integrated, and a suction port and a discharge port of a pump are arranged on the same line is widely used because the inline pump is easily attachable in a middle of a pipe. In a case where the inline pump is installed in a construction facility, it is desirable to avoid stoppage of liquid supply when one inline pump has failed or one inline pump is subjected to periodic inspection.

[0003] To avoid stoppage of liquid supply, a case where two inline pumps are arranged in parallel such that one of the inline pumps backs up the other inline pump can be seen in markets of various countries. There is a product that is called a twin pump in which two inline pumps are arranged in parallel, one suction port and one discharge port are connected to the two inline pumps, and the two inline pumps share one suction port and one discharge port. Note that, in the following, in a case where the two inline pumps do not share one suction port and one discharge port, namely, in a case where each of the two inline pumps includes one suction port and one discharge port, each of the pumps is called a single pump.

[0004] In the case where the twin pump is installed, if trouble occurs on one of the pumps, or the like, parts other than a casing of the pump having the trouble are detached, and an upper part of the casing is covered with a blank flange. Examples of the parts other than the casing include an electric motor disposed on the upper part of the casing, a rotary shaft coupled to the electric motor, and an impeller fixed to the rotary shaft and housed in the casing. In the twin pump, operation can be continued by the other pump during a pump maintenance period or during a period when a spare part for the failed pump is prepared.

[0005] It is desirable to provide a pump requiring a small space and having a long lifetime. A pump manufacturer requires downsizing of devices to be incorporated in an own product in order to downsize the own product as much as possible. To meet the request, in a case of the twin pump, a length of a header pipe to branch a pipe into pipes for two single pumps or to merge pipes can be reduced as compared with a case where the two single pumps are arranged in parallel. Further, a valve such as a check valve for backflow prevention is shared by the two pumps configuring the twin pump, which makes it possible to achieve space saving. As a result, the twin pump manufacturer can meet space saving required by a customer. Further, alternately operating the two pumps configuring the twin pump makes it possible to simply double the pump lifetime.

[0006] A reference value is determined for performance difference between the two pumps configuring the twin pump. Further, positional relationship between the suction port and the discharge port, a distance between the suction port and the discharge port, and the like are preferably set to the same as those of the single pump in terms of installation and operation of the pump. Thus, PTL 1 discloses a technique in which a passage is appropriately designed to suppress performance difference between two pumps different in shapes. In PTL 1, rotary shafts of the two pumps are arranged such that the rotary shafts of the two pumps are symmetrical about a line connecting a center of a suction port and a center of a discharge port. Therefore, it is considered that efficiency of the pumps is sacrificed. Further, an on-off valve of a discharge merging portion substantially has a flat surface shape. Therefore, it is considered that the efficiency of the pumps is sacrificed. Also, in PTL 2, an on-off valve of a discharge merging portion substantially has a flat surface shape, and it is considered that efficiency of pumps is sacrificed.

PTL 1: European Patent Laid-Open No. 2161455
PTL 2: German Patent Laid-Open No. 3142638

[0007] An aspect of the present invention is made to solve such issues, and an object thereof is to provide a discharge merging portion for a plurality of passages to transfer a liquid, reduced in pressure loss as compared with an existing discharge merging portion.

[0008] To solve the above-described issues, according to a first aspect, a discharge merging portion used to transfer a liquid, includes: a first opening into which the liquid from a first discharge passage portion flows; a second opening into which the liquid from a second discharge passage portion flows; a discharge port from which the liquid flowing in from the first opening or the second opening flows out; and an on-off valve configured to close the first opening and the second opening, in which the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening, the first surface and the second surface are opposed to each other, each of the first surface and the second surface includes an upstream end part positioned on an upstream side of the liquid which is transferable, and a downstream end part positioned on a downstream side, at least one of the first surface and the second surface is a curved surface curved toward another surface that is the first surface or the second surface opposed to the one surface, and the curved surface is recessed toward the other surface relative to the upstream end part and the downstream end part of the one surface, and a recessed amount is increased toward an intermediate part of the one surface positioned between the upstream end part and the downstream end part of the one surface.

[0009] In the present aspect, at least one of the first surface and the second surface is a curved surface curved toward the other surface that is the first surface or the second surface opposed to the one surface. Therefore, a surface shape of the on-off valve (flap valve) is

approximate to a shape of the passage (i.e., curved surface shape). Since the first surface (or second surface) has an appropriate passage shape, head loss (pressure loss) is reduced. As a result, it is possible to provide the discharge merging portion for the plurality of passages to transfer the liquid, reduced in pressure loss as compared with an existing discharge merging portion. When the discharge merging portion according to the present aspect is applied to, for example, a twin pump, efficiency of the twin pump is improved by reduction of the pressure loss, as compared with an existing twin pump.

[0010] As compared with a case where the first surface (or second surface) has a flat surface shape as in the existing discharge merging portion, an area receiving the liquid such as water is increased in the present aspect. As a result, pressure for closing is increased as compared with the existing discharge merging portion, which makes it possible to surely close the passage.

[0011] According to a second aspect, in the discharge merging portion according to the first aspect, one of the first surface and the second surface is a flat surface.

[0012] According to a third aspect, a discharge merging portion used to transfer a liquid, includes: a first opening into which the liquid from a first discharge passage portion flows; a second opening into which the liquid from a second discharge passage portion flows; a discharge port from which the liquid flowing in from the first opening or the second opening flows out; an on-off valve configured to block inflow of the liquid from the first discharge passage portion and the second discharge passage portion; and a valve fixing portion including a third opening, a fourth opening, and a fifth opening that respectively face the first opening, the second opening, and the discharge port, and in which the on-off valve is disposed, in which the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening.

[0013] According to a fourth aspect, a discharge merging portion used to transfer a liquid, includes: a first opening into which the liquid from a first discharge passage portion flows; a second opening into which the liquid from a second discharge passage portion flows; a discharge port from which the liquid flowing in from the first opening or the second opening flows out; and an on-off valve configured to close the first opening and the second opening, in which the on-off valve includes a first closing portion including a first surface to close the first opening, and a second closing portion including a second surface to close the second opening, the first closing portion includes a third surface opposed to the first surface, the second closing portion includes a fourth surface opposed to the second surface, each of the third surface and the fourth surface includes an upstream end part positioned on an upstream side of the liquid which is transferable, and a downstream end part positioned on a downstream side, an interval between the third surface and the fourth surface is increased from the upstream end part toward the downstream end part, and a position of the second closing portion with respect to the first closing portion is fixed.

[0014] According to a fifth aspect, a discharge merging portion used to transfer a liquid, includes: a first opening into which the liquid from a first discharge passage portion flows; a second opening into which the liquid from a second discharge passage portion flows; a discharge port from which the liquid flowing in from the first opening or the second opening flows out; and an on-off valve configured to close the first opening and the second opening, in which the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening, the first surface and the second surface are opposed to each other, and a surface of the on-off valve does not allow the liquid to pass therethrough, and an inside of the on-off valve is porous.

[0015] According to a sixth aspect, a discharge merging portion used to transfer a liquid, includes: a first opening into which the liquid from a first discharge passage portion flows; a second opening into which the liquid from a second discharge passage portion flows; a discharge port from which the liquid flowing in from the first opening or the second opening flows out; and an on-off valve configured to close the first opening and the second opening, in which the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening, the first surface and the second surface are opposed to each other, the on-off valve is made of an elastic material, each of the first surface and the second surface includes an upstream end part positioned on an upstream side of the liquid which is transferable, a downstream end part positioned on a downstream side, and an intermediate part positioned between the upstream end part and the downstream end part, when receiving pressure from the liquid, the intermediate part of the first surface is recessed toward the second surface relative to the upstream end part and the downstream end part of the first surface, and when receiving pressure from the liquid, the intermediate part of the second surface is recessed toward the first surface relative to the upstream end part and the downstream end part of the second surface.

[0016] According to a seventh aspect, a discharge merging portion used to transfer a liquid, includes: a first opening into which the liquid from a first discharge passage portion flows; a second opening into which the liquid from a second discharge passage portion flows; a discharge port from which the liquid flowing in from the first opening or the second opening flows out; an on-off valve configured to block inflow of the liquid from the first discharge passage portion and the second discharge passage portion; and a valve fixing portion including a third opening, a fourth opening, and a fifth opening that respectively face the first opening, the second opening, and the discharge port, and in which the on-off valve is disposed, in which the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening, the on-off valve includes a first clos-

ing portion including the first surface, and a second closing portion including the second surface, the first closing portion includes a third surface opposed to the first surface, the second closing portion includes a fourth surface opposed to the second surface, each of the third surface and the fourth surface includes an upstream end part positioned on an upstream side of the liquid which is transferable, and a downstream end part positioned on a downstream side, an interval between the third surface and the fourth surface is increased from the upstream end part toward the downstream end part, a position of the second closing portion with respect to the first closing portion is fixed, each of the first surface and the second surface includes an upstream end part positioned on the upstream side, and a downstream end part positioned on the downstream side, at least one of the first surface and the second surface is a curved surface curved toward another surface that is the third surface or the fourth surface opposed to the one surface, the curved surface is recessed toward the other surface relative to the upstream end part and the downstream end part of the one surface, and a recessed amount is increased toward an intermediate part of the one surface positioned between the upstream end part and the downstream end part of the one surface, a surface of at least one of the first closing portion and the second closing portion does not allow the liquid to pass therethrough, and an inside of the closing portion is porous, and at least one of the first closing portion and the second closing portion is made of an elastic material.

[0017] According to an eighth aspect, a pump casing used for a pump apparatus to transfer a liquid, includes: a first pump casing; a first suction passage portion connected to the first pump casing; the first discharge passage portion connected to the first pump casing; a second pump casing; a second suction passage portion connected to the second pump casing; the second discharge passage portion connected to the second pump casing; a suction branching portion connected to the first suction passage portion and the second suction passage portion; and the discharge merging portion according to any one of the first to seventh aspects, connected to the first discharge passage portion and the second discharge passage portion.

[0018] According to a ninth aspect, a pump apparatus includes: a first electric motor; a first rotary shaft coupled to the first electric motor; a first impeller fixed to the first rotary shaft and housed in the first pump casing; a second electric motor; a second rotary shaft coupled to the second electric motor; a second impeller fixed to the second rotary shaft and housed in the second pump casing; and the pump casing according to the eighth aspect.

Fig. 1 is a schematic view illustrating an embodiment of a pump casing;
Fig. 2 is a schematic view illustrating an embodiment of a first pump apparatus;
Fig. 3 is a top view of the pump casing;
Fig. 4 is a perspective view of the pump casing;
Fig. 5 is a bottom view of the pump casing;
Fig. 6 is a detailed diagram of a discharge merging portion;
Fig. 7 is a detailed diagram of an on-off valve;
Fig. 8 is a detailed diagram of the discharge merging portion;
Fig. 9 is a detailed diagram of an on-off valve;
Fig. 10 is a detailed diagram of the discharge merging portion;
Fig. 11 is a detailed diagram of an on-off valve;
Fig. 12 is a detailed diagram of the discharge merging portion;
Fig. 13 is a detailed diagram of a valve fixing portion;
Fig. 14 is a detailed diagram of the discharge merging portion;
Fig. 15 is a detailed diagram of an on-off valve;
Fig. 16 is a detailed diagram of the discharge merging portion;
Fig. 17 is a detailed diagram of an on-off valve; and
Fig. 18 is a detailed diagram of the discharge merging portion.

[0019] Some embodiments of the present invention are described below with reference to drawings. Note that, in the following embodiments, the same or equivalent members are denoted by the same reference numerals, and repetitive descriptions are omitted in some cases. Further, characteristics described in each of the embodiments are applicable to another embodiment without conflicting with each other.

[0020] Fig. 1 illustrates a pump apparatus, in particular, a twin pump to which a discharge merging portion according to an embodiment is applied. Fig. 1 is a schematic view illustrating a pump casing 18 including the discharge merging portion according to the embodiment. The pump casing 18 is used for a pump apparatus 16 to transfer a liquid. One pump casing 18 includes a first pump casing 181, a first suction passage portion 201 connected to the first pump casing 181, and a first discharge passage portion 221 connected to the first pump casing 181. The pump casing 18 further includes a second pump casing 182, a second suction passage portion 202 connected to the second pump casing 182, and a second discharge passage portion 222 connected to the second pump casing 182.

[0021] The pump casing 18 further includes a suction branching portion 24 connected to the first suction passage portion 201 and the second suction passage portion 202, and a discharge merging portion 26 connected to the first discharge passage portion 221 and the second discharge passage portion 222. The first pump casing 181, the first suction passage portion 201, the first discharge passage portion 221, the second pump casing 182, the second suction passage portion 202, the second discharge passage portion 222, the suction branching portion 24, and the discharge merging portion 26 are integrally formed as a casting. Some of these portions, for

example, the first discharge passage portion 221, the second discharge passage portion 222, and the discharge merging portion 26 may be manufactured as castings other than the other portions. In other words, the first discharge passage portion 221 and the first pump casing 181 can be formed as an independent part, and/or the second discharge passage portion 222 and the second pump casing 182 can be formed as an independent part.

[0022] The first pump casing 181 and the second pump casing 182 substantially have the same shape in the present embodiment. The first discharge passage portion 221 and the second discharge passage portion 222 substantially have the same shape. The present invention is not limited to the case where the first pump casing 181 and the second pump casing 182 have the same shape. The present invention is not limited to the case where the second discharge passage portion 221 and the second discharge passage portion 222 have the same shape. The first pump casing 181 and the second pump casing 182 may have the same shape or different shapes. Likewise, the first discharge passage portion 221 and the second discharge passage portion 222 may have the same shape or different shapes.

[0023] In a case of the same shape, it is possible to easily settle performance difference of the two pumps within an ISO reference value, as compared with an existing technique. Various ISO reference values are present depending on a type of the pump and a grade of the pump. For example, a flow rate difference (m^3/minute) between the two pumps is within $\pm$9%, and a total pump head difference (m) is within $\pm$7%. Examples of an ISO standard include ISO 9906. Note that ISO 9906 is illustrative, and the present embodiment can adapt a similar standard other than ISO 9906.

[0024] The suction branching portion 24 corresponds to a section from a suction port 20 to a part branched to the first suction passage portion 201 and the second suction passage portion 202. More specifically, the suction branching portion 24 corresponds to a section from the suction port 20 to a start end part 58 of the first suction passage portion 201, and a section from the suction port 20 to a start end part 60 of the second suction passage portion 202. The discharge merging portion 26 corresponds to a section from a part where the first discharge passage portion 221 and the second discharge passage portion 222 merge with each other to a discharge port 22. More specifically, the discharge merging portion 26 corresponds to a section from a terminal end part 281 of the first discharge passage portion 221 to the discharge port 22, and a section from a terminal end part 282 of the second discharge passage portion 222 to the discharge port 22. The suction port 20 of the pump apparatus 16 is a connection portion between the pump apparatus 16 and a pipe (not illustrated) on a suction side of the pump apparatus 16. The discharge port 22 of the pump apparatus 16 is a connection portion between the pump apparatus 16 and a pipe (not illustrated) on a discharge side of the pump apparatus 16.

[0025] As described above, the first discharge passage portion 221 and the first pump casing 181 can be formed as an independent part, and/or the second discharge passage portion 222 and the second pump casing 182 can be formed as an independent part. In the case where the first discharge passage portion 221 and the first pump casing 181 are formed as an independent part, a boundary between the first discharge passage portion 221 and the first pump casing 181 is, for example, a connection portion 284 illustrated in Fig. 1. In the case where the second discharge passage portion 222 and the second pump casing 182 are formed as an independent part, a boundary between the second discharge passage portion 222 and the second pump casing 182 is, for example, a connection portion 285 illustrated in Fig. 1. Positions of the connection portion 284 and the connection portion 285 are illustrative. The boundaries may be provided at positions close to the discharge port 22 more than the positions of the connection portion 284 and the connection portion 285, or the boundaries may be provided at positions far from the discharge port 22 more than the positions of the connection portion 284 and the connection portion 285.

[0026] The pump apparatus 16 includes a first pump apparatus 161 and a second pump apparatus 162. The first pump apparatus 161 and the second pump apparatus 162 may have the same configuration or different configurations. In terms of compatibility, however, the first pump apparatus 161 and the second pump apparatus 162 preferably have the same configuration. In the present embodiment, the first pump apparatus 161 and the second pump apparatus 162 substantially have the same configuration. In other words, a first impeller 51, the first pump casing 181, and the first discharge passage portion 221 respectively have the same dimensional shapes as a second impeller 52, the second pump casing 182, and the second discharge passage portion 222. A rotation direction 54 of the first impeller 51 is the same as a rotation direction 56 of the second impeller 52. On the other hand, the dimensional shape of the first suction passage portion 201 and the dimensional shape of the second suction passage portion 202 are slightly different from each other.

[0027] In the present embodiment, the first pump apparatus 161 and the second pump apparatus 162 are centrifugal pumps; however, the first pump apparatus 161 and the second pump apparatus 162 are not limited to the centrifugal pumps as long as the first pump apparatus 161 and the second pump apparatus 162 are non-positive displacement pumps. In other words, the first pump apparatus 161 and the second pump apparatus 162 may be turbine pumps, axial-flow pumps, or mixed flow pumps.

[0028] Since the first pump apparatus 161 and the second pump apparatus 162 substantially have the same configuration, the configuration of the first pump apparatus 161 is described with reference to Fig. 2. Fig. 2 is a

schematic view illustrating an embodiment of the first pump apparatus 161. The first pump apparatus 161 includes a first electric motor 101, a first rotary shaft 121 coupled to the first electric motor 101, and the first impeller 51 that is fixed to the first rotary shaft 121 and is housed in the first pump casing 181.

[0029] Although not illustrated, the second pump apparatus 162 also have a second electric motor, a second rotary shaft coupled to the second electric motor, and the second impeller 52 that is fixed to the second rotary shaft and is housed in the second pump casing 182, as with the first pump apparatus 161.

[0030] In the first pump apparatus 161, the first impeller 51 is a centrifugal impeller. The rotary shaft 121 is rotatably supported by a bearing (not illustrated). The rotary shaft 121 and the first impeller 51 are integrally rotatable. The rotary shaft 121 and the first impeller 51 are rotated by the electric motor 101. A liner ring 102 is disposed around a fluid inlet 51a of the first impeller 51. The liner ring 102 is fixed to the first pump casing 181.

[0031] A casing cover 122 is disposed between the electric motor 101 and the first pump casing 181. An opening at an upper part of the first pump casing 181 is closed by the casing cover 122. The electric motor 101 is fixed to the casing cover 122. The first pump casing 181 and the casing cover 122 are formed as castings. A shaft sealing device 15 sealing a gap between the rotary shaft 121 and the casing cover 122 is disposed on a rear side of the first impeller 51. The shaft sealing device 15 is held by the casing cover 122. Examples of the shaft sealing device 15 include a mechanical seal. The above-described blank flange (not illustrated) is disposed at a position of the casing cover 122 at maintenance or the like. The blank flange is attached by using screw holes 62 (see Fig. 3) circumferentially arranged for attachment of the casing cover 122. The blank flange has a disk shape, and includes, on an outer edge of the blank flange, attachment holes circumferentially arranged at positions corresponding to the screw holes 62.

[0032] The pump casing 18 includes the suction branching portion 24 including the suction port 20, and the discharge merging portion 26 including the discharge port 22. The first impeller 51 is disposed inside the first pump casing 181. The suction port 20 and the discharge port 22 are arranged on one straight line. The pump apparatus 16 in which the suction port 20 and the discharge port 22 are arranged on one straight line is called an inline pump apparatus. In the present embodiment, two inline pumps are arranged in parallel, one suction port and one discharge port are connected to the two inline pumps, and the two inline pumps share one suction port and one discharge port. When the two inline pumps share one suction port and one discharge port, these pumps configure one twin pump as a whole.

[0033] A difference between one inline pump as a twin pump and two inline pumps (two single pumps) arranged in parallel is described. In the two single pumps arranged in parallel, discharge ports of the single pumps are connected to respective pipes on a discharge side, and the two pipes are then merged to form one pipe on a downstream side. Further, on a suction side, one pipe is branched into two pipes, and the two pipes are connected to suction ports of the respective single pumps. In contrast, in the twin pump, two discharge passage portions are merged at the discharge merging portion 26 on the discharge side, and the merged passage portion is connected to a pipe at the discharge port 22 of the twin pump. Further, on the suction side of the twin pump, a pipe is connected to the suction port 20 of the pump, and is then branched into two suction passage portions through the suction branching portion 24.

[0034] When the electric motor 101 rotates the first impeller 51, the liquid flows into the pump casing 18 from the suction port 20. More specifically, the liquid flows into the first suction passage portion 201 from the suction port 20, and then flows into the fluid inlet 51a of the first impeller 51 through the first suction passage portion 201. The rotating first impeller 51 applies velocity energy to the liquid, and the velocity energy of the liquid flowing through the first pump casing 181 is converted into pressure. The pressurized liquid is discharged from the pump casing 18 through the discharge port 22.

[0035] Various methods of operating the first pump apparatus 161 and the second pump apparatus 162 are usable. A method of operating only one of the first pump apparatus 161 and the second pump apparatus 162 and stopping the other pump apparatus, or a method of operating both of the first pump apparatus 161 and the second pump apparatus 162 at the same time is usable. As illustrated in Fig. 1, the discharge merging portion 26 includes an on-off valve 28. The on-off valve 28 closes the discharge passage portion connected to the stopped pump apparatus based on operation states of the first pump apparatus 161 and the second pump apparatus 162.

[0036] For example, when the first pump apparatus 161 operates and the second pump apparatus 162 stops, the on-off valve 28 is moved to a position 282 illustrated by a dotted line by hydraulic pressure from the first discharge passage portion 221, to close the second discharge passage portion 222. When the second pump apparatus 162 operates and the first pump apparatus 161 stops, the on-off valve 28 is moved to a position 281 illustrated by a dashed line by hydraulic pressure from the second discharge passage portion 222, to close the first discharge passage portion 221. When the first pump apparatus 161 and the second pump apparatus 162 both operate at the same time, the on-off valve 28 is moved to an intermediate position 283 illustrated by a solid line by hydraulic pressure from the first discharge passage portion 221 and hydraulic pressure from the second discharge passage portion 222.

[0037] Figs. 3 to 5 each illustrate a configuration of the single pump casing 18. Fig. 3 is a top view of the pump casing 18. Fig. 4 is a perspective view of the pump casing 18. Fig. 5 is a bottom view of the pump casing 18. Figs.

3 to 5 each illustrate the pump casing 18 in a state where the components other than the pump casing 18, namely, the first electric motor 101, the first rotary shaft 121, the first impeller 51, the second electric motor, the second rotary shaft, the second impeller 52, and the like are detached from the pump apparatus 16. The suction port 20 is provided in a suction flange 34. The suction flange 34 is to connect the pump casing 18 to a pipe. The discharge port 22 is provided in a discharge flange 36. The discharge flange 36 is to connect the pump casing 18 to a pipe.

[0038] The pump casing 18 can include leg portions 46 and 48 provided in the first pump casing 181 and the second pump casing 182. The reason why the leg portions 46 and 48 are provided at these positions is because a bottom part of the first pump casing 181 and a bottom part of the second pump casing 182 are located at the lowest positions in the pump apparatus 16 as illustrated in Fig. 2.

[0039] Fig. 6 illustrates an embodiment of the discharge merging portion 26. Fig. 6 is a detailed diagram of the discharge merging portion 26. As illustrated in the drawing, the discharge merging portion 26 used to transfer the liquid includes a first opening 106 into which the liquid from the first discharge passage portion 221 can flow, a second opening 108 into which the liquid from the second discharge passage portion 222 can flow, the discharge port 22 from which the liquid flowing in from the first opening 106 or the second opening 108 can flow out, and the on-off valve 28 that can close the first opening 106 and the second opening 108.

[0040] A detail of the on-off valve 28 is illustrated in Fig. 7. Fig. 7 is a detailed diagram of the on-off valve 28. Fig. 7(a) is a side view of the on-off valve 28, Fig. 7(b) is a front view of the on-off valve 28, Fig. 7(c) is a plan view of the on-off valve 28, and Fig. 7(d) is a perspective view of the on-off valve 28. The on-off valve 28 has a first surface 110 to close the first opening 106, and a second surface 112 to close the second opening 108. The first surface 110 and the second surface 112 are opposed to each other. The first surface 110 and the second surface 112 include upstream end parts 1101 and 1121 positioned on an upstream side of the liquid which is transferable, downstream end parts 1102 and 1122 positioned on a downstream side, and center parts 1103 and 1123 (intermediate parts) positioned between the upstream end parts 1101 and 1121 and the downstream end parts 1102 and 1122, respectively.

[0041] The first surface 110 is a curved surface curved toward the second surface 112 opposed to the first surface 110. The second surface 112 is a curved surface curved toward the first surface 110. The center part 1103 of the first surface 110 is recessed toward the second surface 112 relative to the upstream end part 1101 of the first surface 110. Further, the center part 1103 of the first surface 110 is recessed toward the second surface 112 relative to the downstream end part 1102 of the first surface 110. The center part 1123 of the second surface 112 is recessed toward the first surface 110 relative to the upstream end part 1121 of the second surface 112. Further, the center part 1123 of the second surface 112 is recessed toward the first surface 110 relative to the downstream end part 1122 of the second surface 112.

[0042] A recessed amount is increased from the upstream end part and the downstream end part toward the center part. The recessed amount of the second surface 112 is described as an example. The recessed amount at a point 168 on the second surface 112 is a length of a line 170 that perpendicularly extends from the point 168 on the second surface 112 to a plane 160 connecting an upstream end 156 and a downstream end 158 of the second surface 112. The recessed amount of the first surface 110 is similarly defined.

[0043] The recessed amounts of the first surface 110 and the second surface 112 are preferably determined such that a surface shape of the on-off valve 28 (flap valve) minimizes pressure loss. The surface shape is preferably a shape approximate to a shape (curved surface shape) of a passage formed by the flowing liquid so as not to inhibit the flow of the liquid as much as possible. The on-off valve 28 has a suitable passage shape as illustrated in the drawing. Therefore, pressure loss (head loss) is reduced. As a result, efficiency of the pump apparatus is improved. As compared with an existing case where the first surface 110 and the second surface 112 are flat surfaces, an area receiving the liquid such as water is increased. As a result, in the present embodiment, force to close the passage is enhanced, and the passage can be surely closed as compared with the existing case.

[0044] The on-off valve 28 can be fabricated by press molding or resin molding. The on-off valve 28 is configured by a thin plate member made of a metal or a resin. The passage in the discharge direction is formed by the on-off valve 28 having the curved surface shape. Therefore, head loss is reduced, and pump efficiency is improved. The passage surfaces, namely, the first surface 110 and the second surface 112 each have the curved surface shape or a curved line shape. Therefore, the area receiving the water is increased as compared with a flat surface, and the passage is easily closed. A procedure of assembling the on-off valve 28 to the discharge merging portion 26 is as follows. After the on-off valve 28 is manufactured as a part, the on-off valve 28 is attached to the discharge merging portion 26 by inserting a rotary shaft 114 of the discharge merging portion 26 into a hole 1141 (see Fig. 7(b)) of the on-off valve 28. Next, a cover is placed on the on-off valve 28, and the cover is fixed to the on-off valve 28 by attaching screws to six screw holes 120 (see Fig. 6) provided in the on-off valve 28. The cover includes, at a position corresponding to the rotary shaft 114, a recess or a hole that can receive the rotary shaft 114. As a result, the on-off valve 28 is rotatably disposed inside the discharge merging portion 26. The cover also functions as a lid of the discharge merging portion 26.

[0045] As described above, the on-off valve 28 is ro-

tatable around the rotary shaft 114 provided in the discharge merging portion 26. To do so, the on-off valve 28 includes the hole 1141 into which the rotary shaft 114 is insertable. A height 116 (see Fig. 7(a)) of the on-off valve 28 is substantially equal to a distance between a bottom part 118 (see Fig. 6) of the discharge merging portion 26 and a lower surface of the cover (not illustrated) of the discharge merging portion 26. The reason why the height 116 and the distance are made equal to each other is to reduce, when the first surface 110 or the second surface 112 closes the first opening 106 or the second opening 108, liquid leakage caused by a gap between the cover and the first opening 106 or the second opening 108.

[0046] Note that the phrase "being recessed toward the second surface relative to the upstream end part and the downstream end part of the first surface" can be paraphrased as "protruding toward the second surface" or "having a convex shape". Further, the recessed shape of the first surface 110 and the recessed shape of the second surface 112 illustrated in Fig. 7 are each approximate to a side surface shape of a column or an elliptic column. As the recessed shape of the first surface 110 or the second surface 112, a spherical surface or a part of a surface of an ellipsoid may be adopted. These recessed shapes are curved surface shapes curved along the passage of the liquid flowing from the second opening 108 of the discharge merging portion 26 to the discharge port 22. Since the recessed shapes are the curved surface shapes curved along the passage of the liquid, the recessed shapes can reduce the head loss. The recessed shape of the first surface 110 can be similarly configured. Further, in the present embodiment, the center part 1103 is adopted as the most recessed part; however, the most recessed part is not limited to the center part 1103. As the most recessed part, a part close to the upstream end part 1101 more than the center part 1103 may be adopted, or a part close to the downstream end part 1102 more than the center part 1103 may be adopted.

[0047] An on-off valve 2801 having a configuration similar to the configuration illustrated in Figs. 6 and 7 is described with reference to Figs. 8 and 9. Fig. 8 is a detailed diagram of the discharge merging portion 26. Fig. 9 is a detailed diagram of the on-off valve 2801. Fig. 9(a) is a side view of the on-off valve 2801, Fig. 9(b) is a front view of the on-off valve 2801, Fig. 9(c) is a plan view of the on-off valve 2801, and Fig. 9(d) is a perspective view of the on-off valve 2801. In the on-off valve 2801 illustrated in Fig. 8, a length 126 (see Fig. 9(c)) in a width direction is less than a length 1261 (see Fig. 7(c)) of the on-off valve 28 in a width direction. Further, the on-off valve 2801 is solid. In contrast, the on-off valve 28 is hollow as illustrated in Fig. 7(b). The on-off valve 2801 is solid but the width thereof is narrow. Therefore, weight difference between the on-off valve 2801 and the on-off valve 28 is small.

[0048] Each of the first surface 110 and the second surface 112 includes two surfaces 128 and 130 that are curved surfaces. The center part 1103 of the first surface 110 is recessed toward the second surface 112 relative to the upstream end part 1101 of the first surface 110. Further, the center part 1103 of the first surface 110 is recessed toward the second surface 112 relative to the downstream end part 1102 of the first surface 110.

[0049] Next, Fig. 10 illustrates another embodiment of the discharge merging portion 26. Fig. 10 is a detailed diagram of the discharge merging portion 26. In the present embodiment, one of the first surface 110 and the second surface 112 is a flat surface. In the drawing, the first surface 110 is a flat surface. A detail of an on-off valve 2802 is illustrated in Fig. 11. Fig. 11 is a detailed diagram of the on-off valve 2802. Fig. 11(a) is a bottom view of the on-off valve 2802, Fig. 11(b) is a side view of the on-off valve 2802, Fig. 11(c) is a front view of the on-off valve 2802, Fig. 11(d) is a plan view of the on-off valve 2802, and Fig. 11(e) is a perspective view of the on-off valve 2802.

[0050] The second surface 112 is a curved surface curved toward the first surface 110 opposed to the second surface 112. The center part 1123 of the second surface 112 is recessed toward the first surface 110 relative to the upstream end part 1121 and the downstream end part 1122 of the second surface 112. The recessed amount is increased from the upstream end part 1121 and the downstream end part 1122 of the second surface 112 toward the center part 1123 of the second surface 112.

[0051] The surface shape of the second surface 112 is a passage shape (curved surface shape) as in the embodiment illustrated in Fig. 7. Therefore, as compared with an existing on-off valve having a flat surface shape, the head loss is reduced. As a result, efficiency of the pump apparatus is improved as compared with the existing pump apparatus. As compared with the existing on-off valve having a flat surface shape, an area of the second surface 112 receiving water is increased. As a result, the first opening 106 can be surely closed as compared with the existing on-off valve.

[0052] In the present embodiment, one side is recessed, namely, has a curved surface shape, and the other side is a flat plate. As a result, in a case where pump performance is different between the first pump casing 181 and the second pump casing 182, the on-off valve 2802 can absorb the performance difference to reduce the performance difference between the two pumps, namely, right and left pumps of the twin pump. For example, it is assumed that the pump performance by the first pump casing 181 is superior to the pump performance by the second pump casing 182. In this case, when the on-off valve 2802 according to the present embodiment is used, the pump performance by the first pump casing 181 is not changed as compared with the case of using the existing on-off valve. However, the pump performance by the second pump casing 182 is improved. Therefore, it is possible to reduce the performance difference between the two pumps as compared

with the case of using the existing on-off valve.

[0053] Next, Fig. 12 illustrates still another embodiment of the discharge merging portion 26. Fig. 12 is a detailed diagram of the discharge merging portion 26. In the present embodiment, the discharge merging portion 26 includes an on-off valve 2803 and a valve fixing portion 134. The valve fixing portion 134 includes a third opening 1061, a fourth opening 1081, and a fifth opening 2201 that respectively face the first opening 106, the second opening 108, and the discharge port 22, and in which the on-off valve 2803 is disposed. The on-off valve 2803 includes the first surface 110 to directly or indirectly close the first opening 106, and the second surface 112 to directly or indirectly close the second opening. A detail of the valve fixing portion 134 is illustrated in Fig. 13. Fig. 13 is a detailed diagram of the valve fixing portion 134. Fig. 13(a) is a plan view of the valve fixing portion 134, Fig. 13(b) is a side view of the valve fixing portion 134, Fig. 13(c) is a front view of the valve fixing portion 134, and Fig. 13(d) is a perspective view of the valve fixing portion 134.

[0054] To reduce the pressure loss, an internal space of the valve fixing portion 134 is preferably wide as much as possible. To do so, an outer shape and an outer dimension of the valve fixing portion 134 are matched to an internal shape and an internal dimension of the discharge merging portion 26. Further, an internal shape and an internal dimension of the valve fixing portion 134 are configured such that the internal space of the valve fixing portion 134 is wide as much as possible. In the present embodiment, the discharge merging portion 26 has a fan shape. Therefore, the valve fixing portion 134 also has a fan shape. Further, a member of the valve fixing portion 134 is preferably thin or small. The valve fixing portion 134 is fixed to an inside of the discharge merging portion 26 by interference fit, welding, or the like.

[0055] The third opening 1061, the fourth opening 1081, and the fifth opening 2201 are preferably openings as large as possible in order to reduce the pressure loss. The third opening 1061, the fourth opening 1081, and the fifth opening 2201 are at least greater than the first opening 106, the second opening 108, and the discharge port 22, respectively. In the valve fixing portion 134 illustrated in Fig. 13, a framework thereof is configured by a thin frame 136, and parts other than the frame 136 serve as the openings.

[0056] The on-off valve 2803 is preferably the on-off valve according to any of the embodiments of the present invention. However, the on-off valve 2803 is not limited thereto, and the on-off valve 2803 may be an existing on-off valve. The on-off valve 2803 is rotatably attached to a shaft portion 138 of the valve fixing portion 134. After the on-off valve 2803 is attached to the shaft portion 138, the valve fixing portion 134 is fixed to the rotary shaft 114 of the discharge merging portion 26 by using the hole 1141 of the valve fixing portion 134.

[0057] In a case where the first surface 110 and the second surface 112 of the on-off valve 2803 respectively close the third opening 1061 and the fourth opening 1081, to indirectly close the first opening 106 and the second opening 108, a sliding portion and a movable portion caused by direct contact are not present between the discharge merging portion 26 and the on-off valve 2803. A seal portion and/or a sliding portion/movable portion can be provided between the valve fixing portion 134 and the on-off valve 2803. As a result, i) it is possible to separately and independently fabricate the shaft portion 138 for rotation of the on-off valve 2803, from fabrication of a main body of the discharge merging portion 26. Further, ii) it is possible to separately and independently fabricate a seal configuration of a movable portion and a fixing portion between the valve fixing portion 134 and the on-off valve 2803, from fabrication of the main body of the discharge merging portion 26.

[0058] From the facts i) and ii), the valve fixing portion 134 that is manufactured by, for example, pressing and includes the hole 1141 is disposed inside the discharge merging portion 26. This improves fixing stability of the on-off valve 2803. In a case where a seal surface is provided between the valve fixing portion 134 and the on-off valve 2803, the seal surface of the valve fixing portion 134 is a metal surface. The first opening 106 and the second opening 108 are castings, and the metal surface is smoother than a surface of the casting. This improves sealing property. Further, since the valve fixing portion 134 includes the shaft portion 138 to fix the on-off valve 2803, there are advantages as follows. Since the valve fixing portion 134 can be attached to the discharge merging portion 26 by welding or the like, hole processing of the discharge merging portion 26 is reduced. For example, a hole or a recess for attachment of the on-off valve 2803 may not be provided in the cover.

[0059] Next, Fig. 14 illustrates still another embodiment of the discharge merging portion 26. Fig. 14 is a detailed diagram of the discharge merging portion 26. In the present embodiment, an on-off valve 2804 that can close the first opening 106 and the second opening 108 includes a first closing portion 146 having the first surface 110 to close the first opening 106, and a second closing portion 148 including the second surface 112 to close the second opening 108. A detail of the on-off valve 2804 is illustrated in Fig. 15. Fig. 15 is a detailed diagram of the on-off valve 2804.

[0060] The first closing portion 146 includes a third surface 150 opposed to the first surface 110, and the second closing portion 148 incudes a fourth surface 152 opposed to the second surface 112. The third surface 150 and the fourth surface 152 include upstream end parts 1501 and 1521 positioned on the upstream side of the liquid which is transferable, and downstream end parts 1502 and 1522 positioned on the downstream side, respectively. An interval 154 between the third surface 150 and the fourth surface 152 is increased from the upstream end parts 1501 and 1521 toward the downstream end parts 1502 and 1522.

[0061] An angle 172 (see Fig. 14) between the first

surface 110 and the second surface 112 is preferably less than or equal to an angle 176 between a center line 174 of the discharge merging portion 26 and the first opening 106. The position of the second closing portion 148 with respect to the first closing portion 146 is fixed. The first surface 110 and the second surface 112 are each preferably recessed as illustrated in Fig. 6; however, the first surface 110 and the second surface 112 each may be a flat surface without a recess.

[0062] In the present embodiment, since the on-off valve 2804 includes the first closing portion 146 and the second closing portion 148, the on-off valve 2804 includes two flaps. When one of the first closing portion 146 and the second closing portion 148 is in a pressure receiving state to receive pressure from the liquid, the other closing portion is in a closing state to close the first opening 106 or the second opening 108. The first closing portion 146 and the second closing portion 148 share a pressure receiving function and a closing function. As a result, it is possible to surely achieve closing. An existing on-off valve includes one flap. Therefore, when one of surfaces of the flap is in the pressure receiving state to receive pressure from the liquid, the opposite surface of the flap is in the closing state to close the first opening 106 or the second opening 108. One flap performs both of the pressure receiving function and the closing function. Therefore, when the received pressure is varied and the position of the flap is changed, the closing function is directly influenced and is varied. In the embodiment illustrated in Fig. 14, even when the received pressure is varied and the position of one of the flaps is changed, influence on the other flap is relaxed, and influence on the closing function is accordingly reduced.

[0063] Next, Fig. 16 illustrates still another embodiment of the discharge merging portion 26. Fig. 16 is a detailed diagram of the discharge merging portion 26. In the present embodiment, the first surface 110 and the second surface 112 are opposed to each other and are flat surfaces. A surface of an on-off valve 2805 does not allow the liquid to pass therethrough, and an inside of the on-off valve 2805 is porous. A detail of the on-off valve 2805 is illustrated in Fig. 17. Fig. 17 is a detailed diagram of the on-off valve 2805. Fig. 17(a) is a plan view of the on-off valve 2805, Fig. 17(b) is a front view of the on-off valve 2805, Fig. 17(c) is a side view of the on-off valve 2805, and Fig. 17(d) is a perspective view of the on-off valve 2805.

[0064] The first surface 110 and the second surface 112 of the on-off valve 2805 may not be flat surfaces. The first surface 110 and the second surface 112 are each preferably a curved surface recessed as illustrated in Fig. 6; however, the first surface 110 and the second surface 112 may be flat surfaces without a recess. The surfaces of the on-off valve 2805 are smooth, and a penetrating portion such as a hole connecting any of the surfaces and the inside of the on-off valve 2805 is not provided on all of the surfaces. The on-off valve 2805 includes one flap in which the inside of the on-off valve 2805 is porous. Such a structure can be fabricated by using, for example, a 3(d) printer. The on-off valve 2805 is made of a metal, a resin, or the like. The on-off valve 2805 is preferably made of a lightweight material. Since the on-off valve 2805 is porous and is made of a lightweight material, the on-off valve 2805 smoothly moves. As a result, the pressure variation when the two right and left pumps operate at the same time can be suppressed as compared with pressure variation when an existing heavy on-off valve is used.

[0065] Next, Fig. 18 illustrate still another embodiment of the discharge merging portion 26. Fig. 18 is a detailed diagram of the discharge merging portion 26. Fig. 18(a) is a diagram illustrating a position of an on-off valve 2806 when the pump does not operate, or when hydraulic pressure to the on-off valve 2806 by a water flow from the first discharge passage portion 221 and hydraulic pressure to the on-off valve 2806 by a water flow from the second discharge passage portion 222 are equivalent to each other. Fig. 18(b) is a diagram illustrating the position of the on-off valve 2806 when the first pump operates and the on-off valve 2806 closes the second opening 108 by a water flow 171 from the first discharge passage portion 221. Fig. 18(c) is a diagram illustrating the position of the on-off valve 2806 when the second pump operates and the on-off valve 2806 closes the first opening 106 by a water flow 173 from the second discharge passage portion 222.

[0066] In the present embodiment, the on-off valve 2806 is made of an elastic material, for example, a rubber. Each of the first surface 110 and the second surface 112 includes the upstream end part 1101 positioned on the upstream side of the liquid which is transferable, the downstream end part 1102 positioned on the downstream side, and the center part 1103 positioned between the upstream end part 1101 and the downstream end part 1102. When receiving pressure from the liquid, the center part 1103 of the first surface 110 is recessed toward the second surface 112 relative to the upstream end part 1101 and the downstream end part 1102 of the first surface, which forms the first surface 110 into a curved surface. When receiving pressure from the liquid, the center part 1103 of the second surface 112 is recessed toward the first surface 110 relative to the upstream end part 1101 and the downstream end part 1102 of the second surface 112, which forms the second surface 112 into a curved surface.

[0067] The surface shape of the on-off valve 2806 becomes a shape curved along the passage. As a result, the pressure loss is reduced, and the efficiency of the pump apparatus is improved. The pressure loss is reduced as compared with an existing on-off valve by making the on-off valve 2806 deformable by pressure of the water flow.

[0068] The first to sixth aspects are described as the embodiments according to the present invention. The first to sixth aspects can be optionally combined. The above-described seventh aspect as an example of the

optional combination includes all of the first to sixth aspects.

[0069] Although the exemplary embodiments of the present invention are described above, the above-described embodiments of the present invention are to facilitate understanding of the present invention, and do not limit the present invention. Needless to say, the present invention can be modified and improved without departing from the spirit of the present invention, and includes equivalents thereof. Further, the components described in the claims and the specification can be optionally combined or omitted within a range where at least a part of the above-described issues is solved or within a range where at least a part of the effects is achieved.

16	Pump apparatus
18	Pump casing
20	Suction port
22	Discharge port
24	Suction branching portion
26	Discharge merging portion
28	On-off valve
51	First impeller
52	Second impeller
106	First opening
108	Second opening
110	First surface
112	Second surface
134	Valve fixing portion
161	First pump apparatus
162	Second pump apparatus
201	First suction passage portion
202	Second suction passage portion
221	First discharge passage portion
222	Second discharge passage portion
1061	Third opening
1081	Fourth opening
1101	Upstream end part
1102	Downstream end part
1103	Center part

Claims

1. A discharge merging portion used to transfer a liquid, the discharge merging portion comprising:

a first opening into which the liquid from a first discharge passage portion flows;
a second opening into which the liquid from a second discharge passage portion flows;
a discharge port from which the liquid flowing in from the first opening or the second opening flows out; and
an on-off valve configured to close the first opening and the second opening, wherein
the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening,
the first surface and the second surface are opposed to each other,
each of the first surface and the second surface includes an upstream end part positioned on an upstream side of the liquid which is transferable, and a downstream end part positioned on a downstream side,
at least one of the first surface and the second surface is a curved surface curved toward another surface that is the first surface or the second surface opposed to the one surface, and
the curved surface is recessed toward the other surface relative to the upstream end part and the downstream end part of the one surface, and
a recessed amount is increased toward an intermediate part of the one surface positioned between the upstream end part and the downstream end part of the one surface.

2. The discharge merging portion according to claim 1, wherein one of the first surface and the second surface is a flat surface.

3. A discharge merging portion used to transfer a liquid, the discharge merging portion comprising:

a first opening into which the liquid from a first discharge passage portion flows;
a second opening into which the liquid from a second discharge passage portion flows;
a discharge port from which the liquid flowing in from the first opening or the second opening flows out;
an on-off valve configured to block inflow of the liquid from the first discharge passage portion and the second discharge passage portion; and
a valve fixing portion including a third opening, a fourth opening, and a fifth opening that respectively face the first opening, the second opening, and the discharge port, and in which the on-off valve is disposed, wherein
the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening.

4. A discharge merging portion used to transfer a liquid, the discharge merging portion comprising:

a first opening into which the liquid from a first discharge passage portion flows;
a second opening into which the liquid from a second discharge passage portion flows;
a discharge port from which the liquid flowing in from the first opening or the second opening flows out; and
an on-off valve configured to close the first opening and the second opening, wherein

the on-off valve includes a first closing portion including a first surface to close the first opening, and a second closing portion including a second surface to close the second opening,
the first closing portion includes a third surface opposed to the first surface,
the second closing portion includes a fourth surface opposed to the second surface,
each of the third surface and the fourth surface includes an upstream end part positioned on an upstream side of the liquid which is transferable, and a downstream end part positioned on a downstream side,
an interval between the third surface and the fourth surface is increased from the upstream end part toward the downstream end part, and
a position of the second closing portion with respect to the first closing portion is fixed.

5. A discharge merging portion used to transfer a liquid, the discharge merging portion comprising:

a first opening into which the liquid from a first discharge passage portion flows;
a second opening into which the liquid from a second discharge passage portion flows;
a discharge port from which the liquid flowing in from the first opening or the second opening flows out; and
an on-off valve configured to close the first opening and the second opening, wherein
the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening,
the first surface and the second surface are opposed to each other, and
a surface of the on-off valve does not allow the liquid to pass therethrough, and an inside of the on-off valve is porous.

6. A discharge merging portion used to transfer a liquid, the discharge merging portion comprising:

a first opening into which the liquid from a first discharge passage portion flows;
a second opening into which the liquid from a second discharge passage portion flows;
a discharge port from which the liquid flowing in from the first opening or the second opening flows out; and
an on-off valve configured to close the first opening and the second opening, wherein
the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening,
the first surface and the second surface are opposed to each other,
the on-off valve is made of an elastic material,
each of the first surface and the second surface includes an upstream end part positioned on an upstream side of the liquid which is transferable, a downstream end part positioned on a downstream side, and an intermediate part positioned between the upstream end part and the downstream end part,
when receiving pressure from the liquid, the intermediate part of the first surface is recessed toward the second surface relative to the upstream end part and the downstream end part of the first surface, and
when receiving pressure from the liquid, the intermediate part of the second surface is recessed toward the first surface relative to the upstream end part and the downstream end part of the second surface.

7. A discharge merging portion used to transfer a liquid, the discharge merging portion comprising:

a first opening into which the liquid from a first discharge passage portion flows;
a second opening into which the liquid from a second discharge passage portion flows;
a discharge port from which the liquid flowing in from the first opening or the second opening flows out;
an on-off valve configured to block inflow of the liquid from the first discharge passage portion and the second discharge passage portion; and
a valve fixing portion including a third opening, a fourth opening, and a fifth opening that respectively face the first opening, the second opening, and the discharge port, and in which the on-off valve is disposed, wherein
the on-off valve includes a first surface to close the first opening, and a second surface to close the second opening,
the on-off valve includes a first closing portion including the first surface, and a second closing portion including the second surface,
the first closing portion includes a third surface opposed to the first surface,
the second closing portion includes a fourth surface opposed to the second surface,
each of the third surface and the fourth surface includes an upstream end part positioned on an upstream side of the liquid which is transferable, and a downstream end part positioned on a downstream side,
an interval between the third surface and the fourth surface is increased from the upstream end part toward the downstream end part,
a position of the second closing portion with respect to the first closing portion is fixed,
each of the first surface and the second surface includes an upstream end part positioned on the

upstream side, and a downstream end part positioned on the downstream side,
at least one of the first surface and the second surface is a curved surface curved toward another surface that is the third surface or the fourth surface opposed to the one surface,
the curved surface is recessed toward the other surface relative to the upstream end part and the downstream end part of the one surface, and
a recessed amount is increased toward an intermediate part of the one surface positioned between the upstream end part and the downstream end part of the one surface,
a surface of at least one of the first closing portion and the second closing portion does not allow the liquid to pass therethrough, and an inside of the closing portion is porous, and
at least one of the first closing portion and the second closing portion is made of an elastic material.

8. A pump casing used for a pump apparatus to transfer a liquid, the pump casing comprising:

a first pump casing;
a first suction passage portion connected to the first pump casing;
the first discharge passage portion connected to the first pump casing;
a second pump casing;
a second suction passage portion connected to the second pump casing;
the second discharge passage portion connected to the second pump casing;
a suction branching portion connected to the first suction passage portion and the second suction passage portion; and
the discharge merging portion according to any one of claims 1 to 7, connected to the first discharge passage portion and the second discharge passage portion.

9. A pump apparatus, comprising:

a first electric motor;
a first rotary shaft coupled to the first electric motor;
a first impeller fixed to the first rotary shaft and housed in the first pump casing;
a second electric motor;
a second rotary shaft coupled to the second electric motor;
a second impeller fixed to the second rotary shaft and housed in the second pump casing; and
the pump casing according to claim 8.

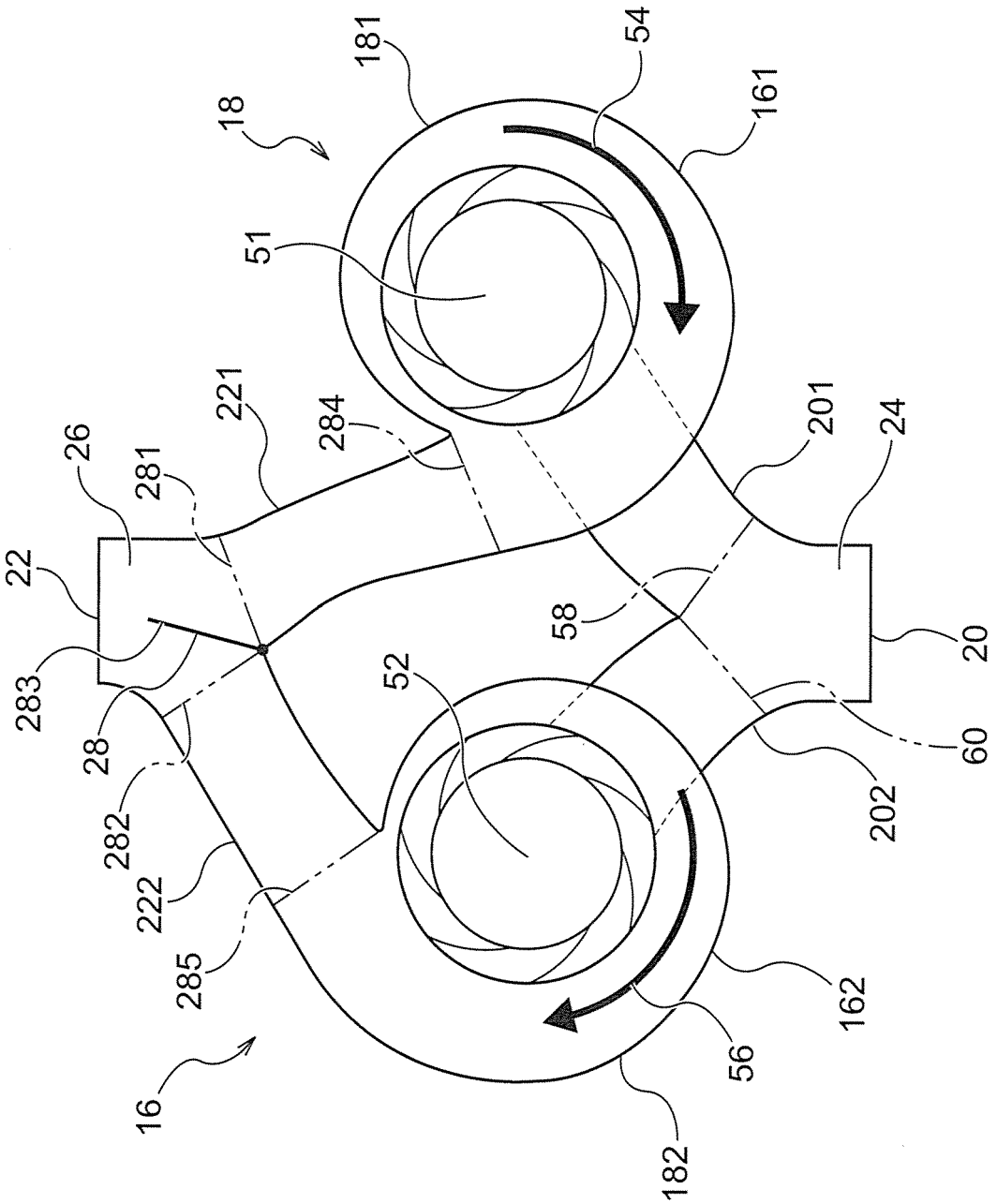
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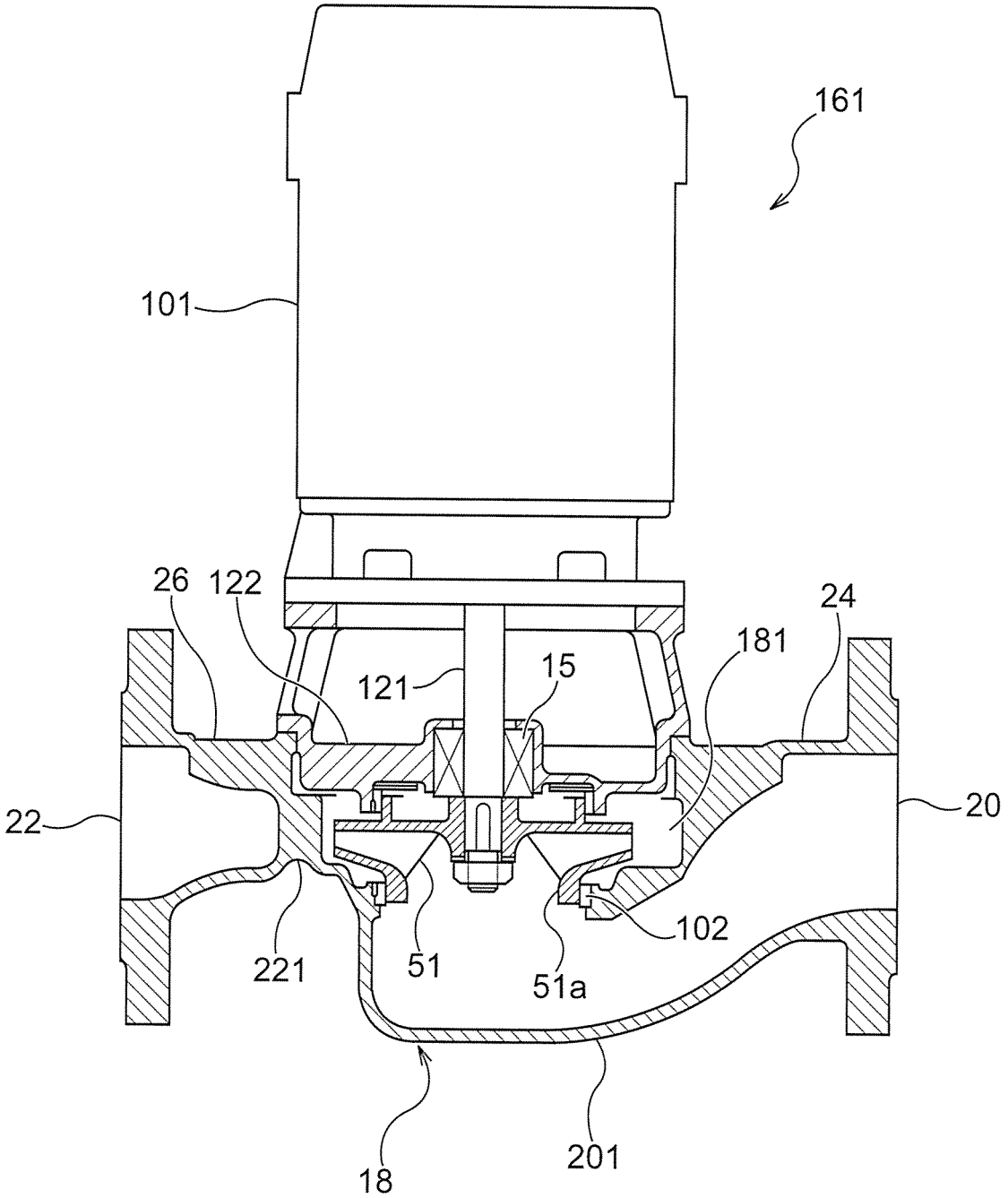
Fig. 1

Fig. 2



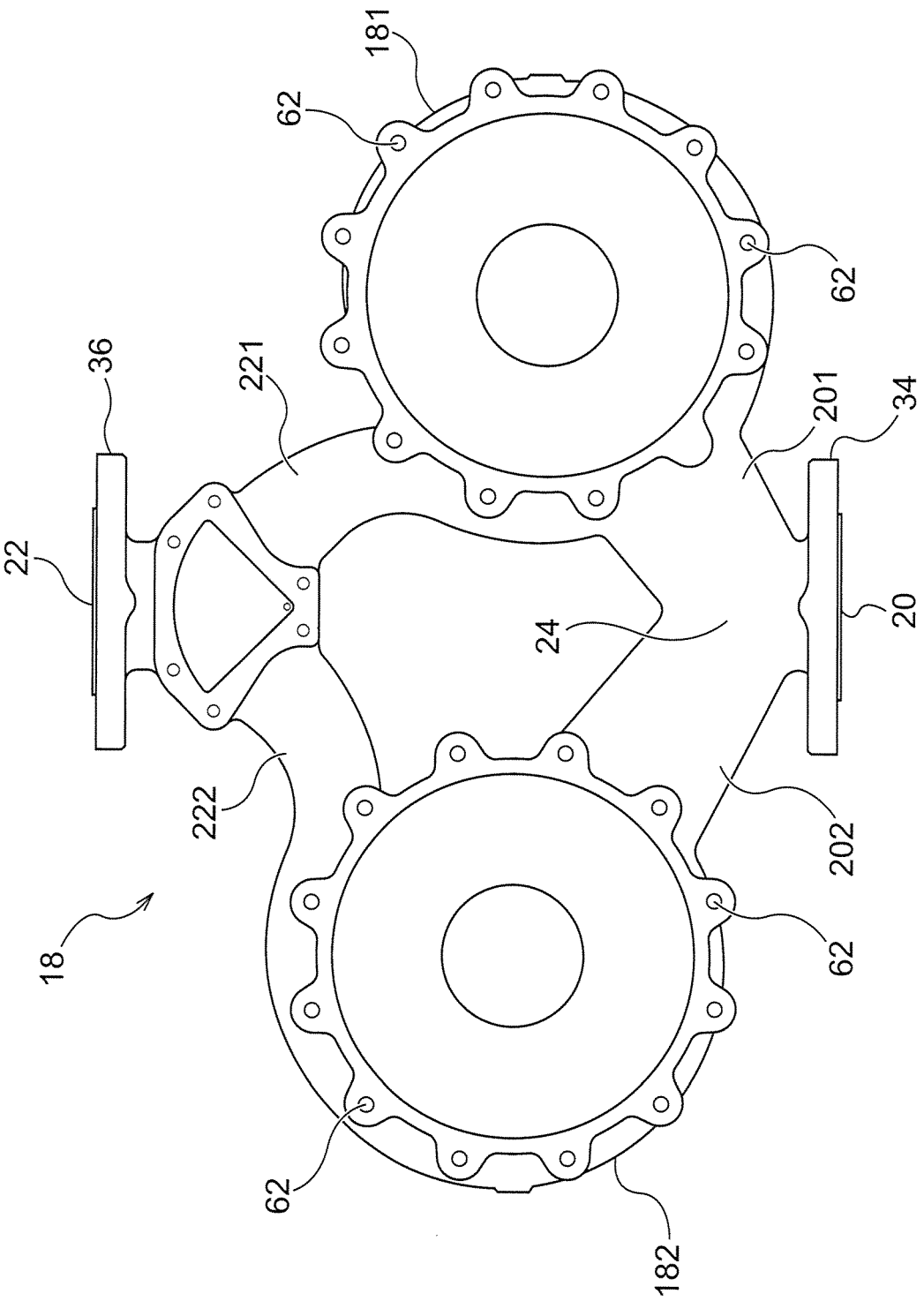


Fig. 3

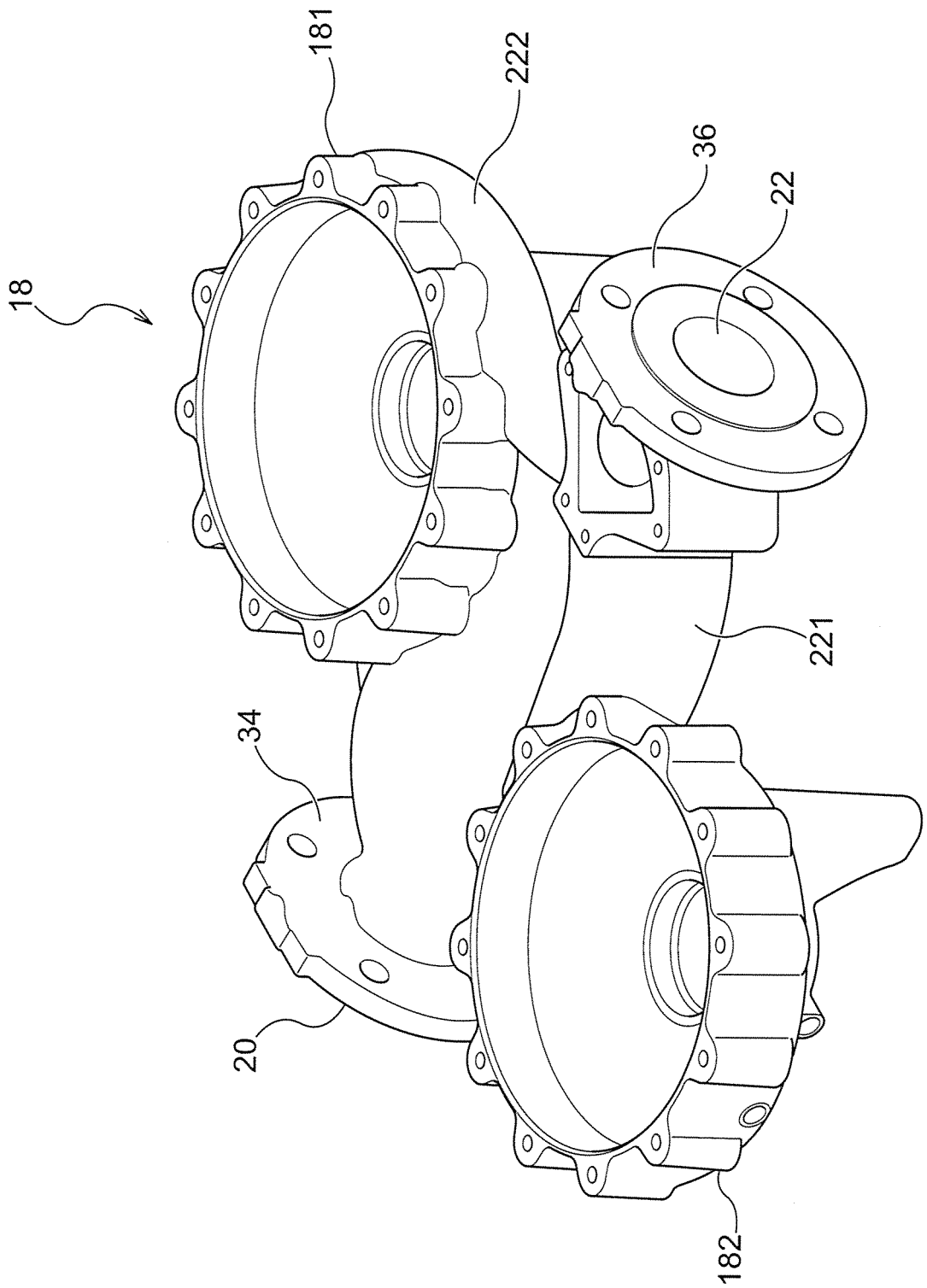


Fig. 4

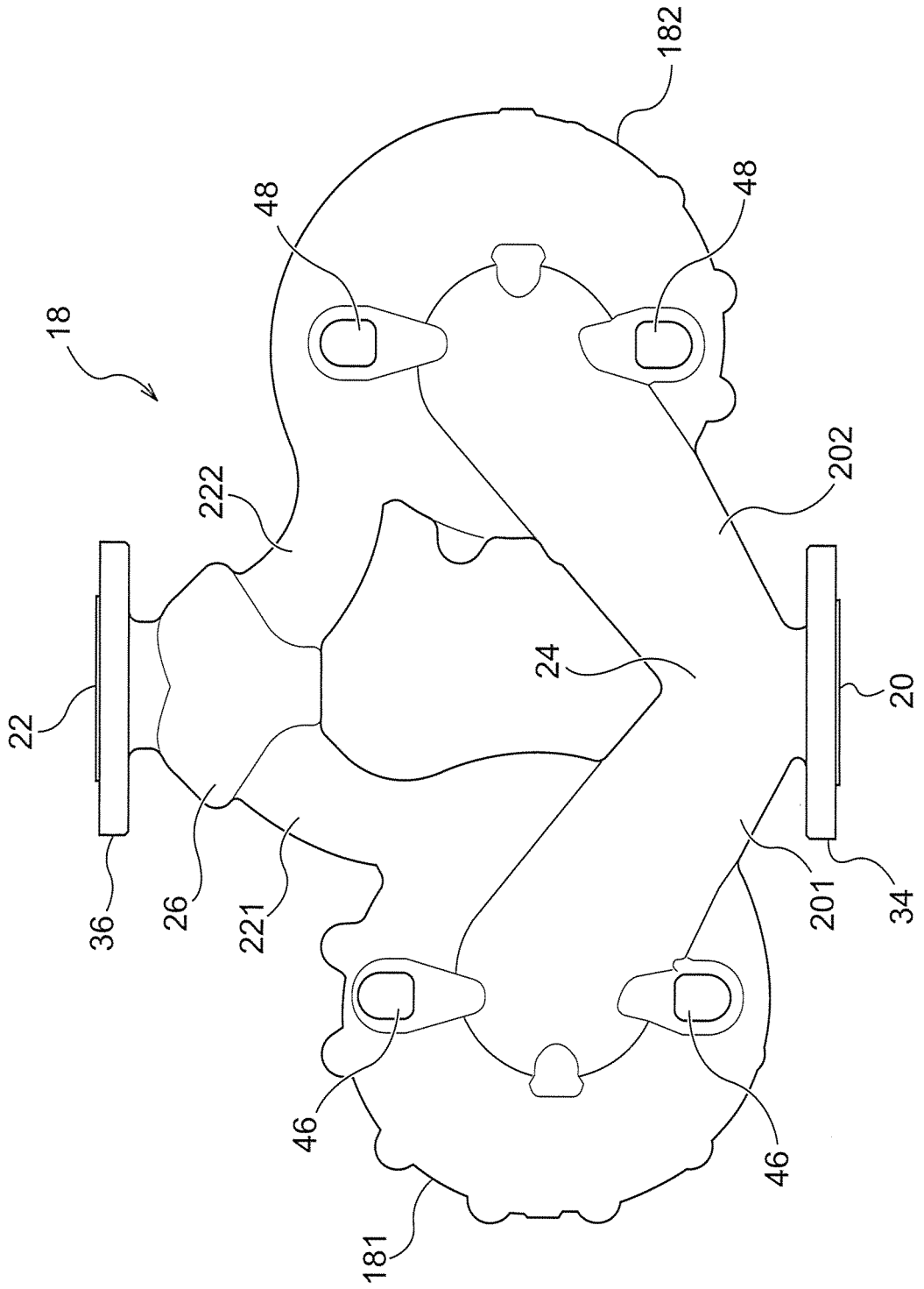


Fig. 5

Fig. 6

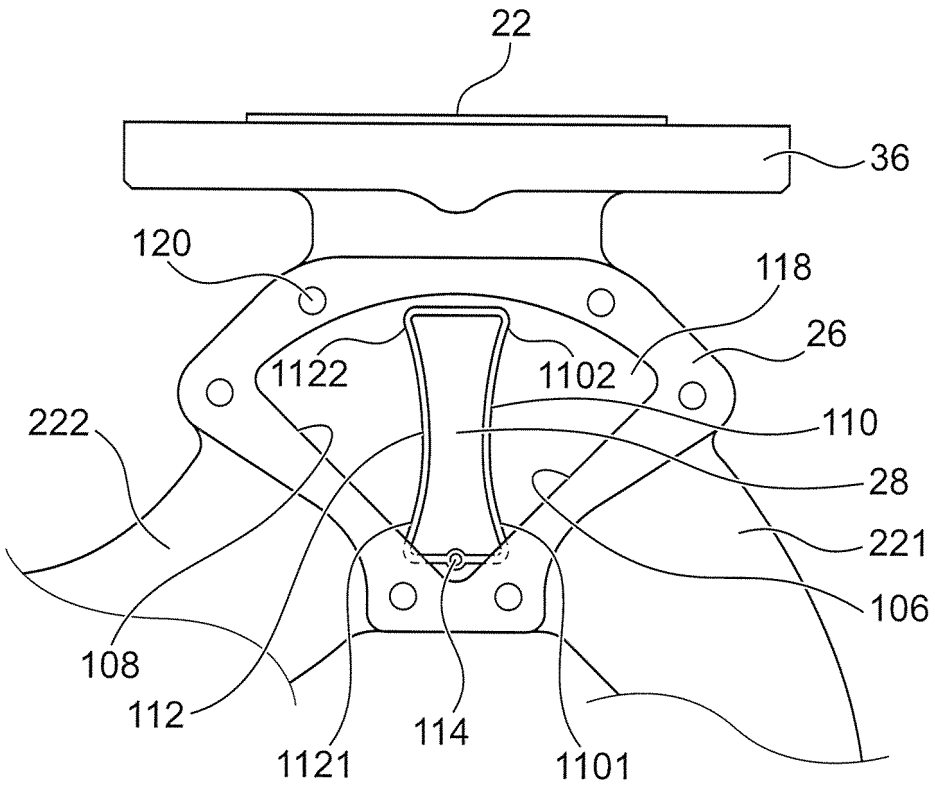

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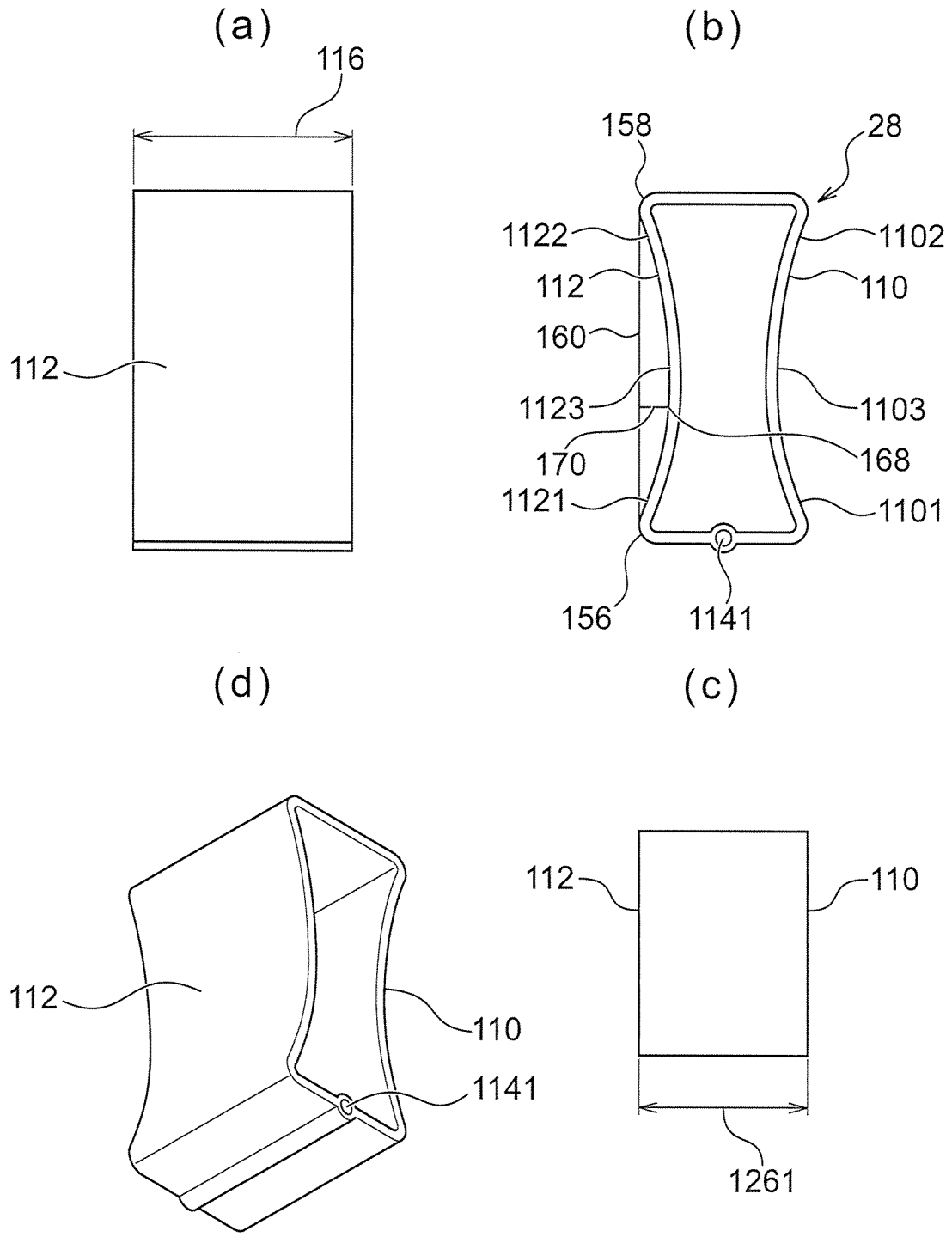
Fig. 7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1122
1102
112
110
160
1123
1103
170
168
1121
1101
156
1141
(d)
112
110
1141
(c)
112
110
1261

Fig. 8

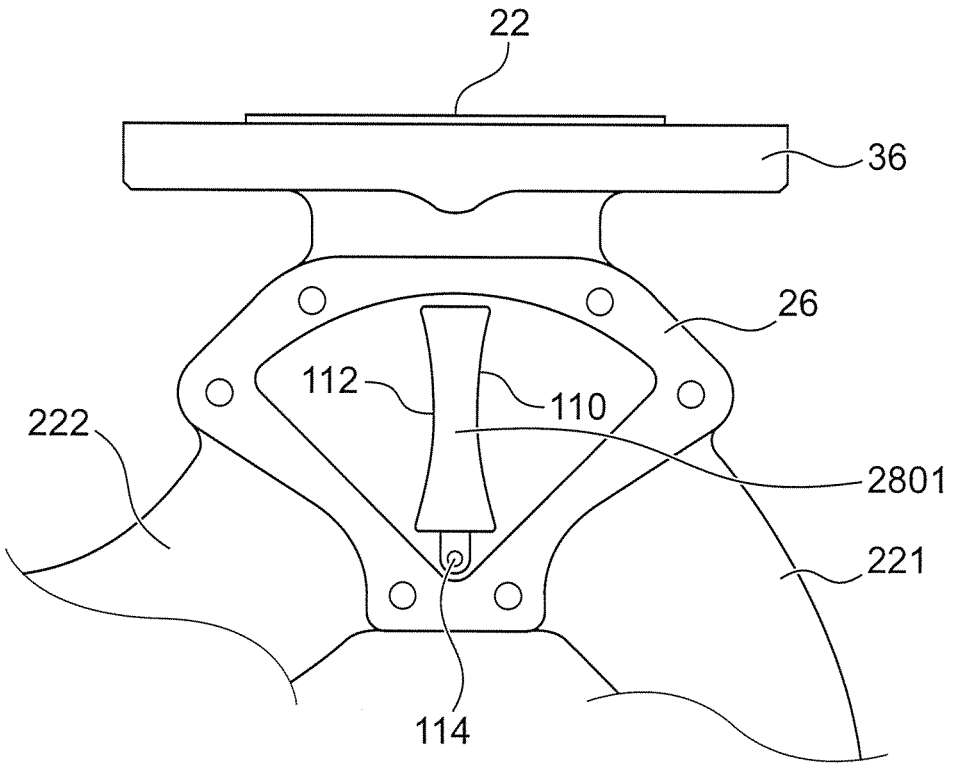


Fig. 9

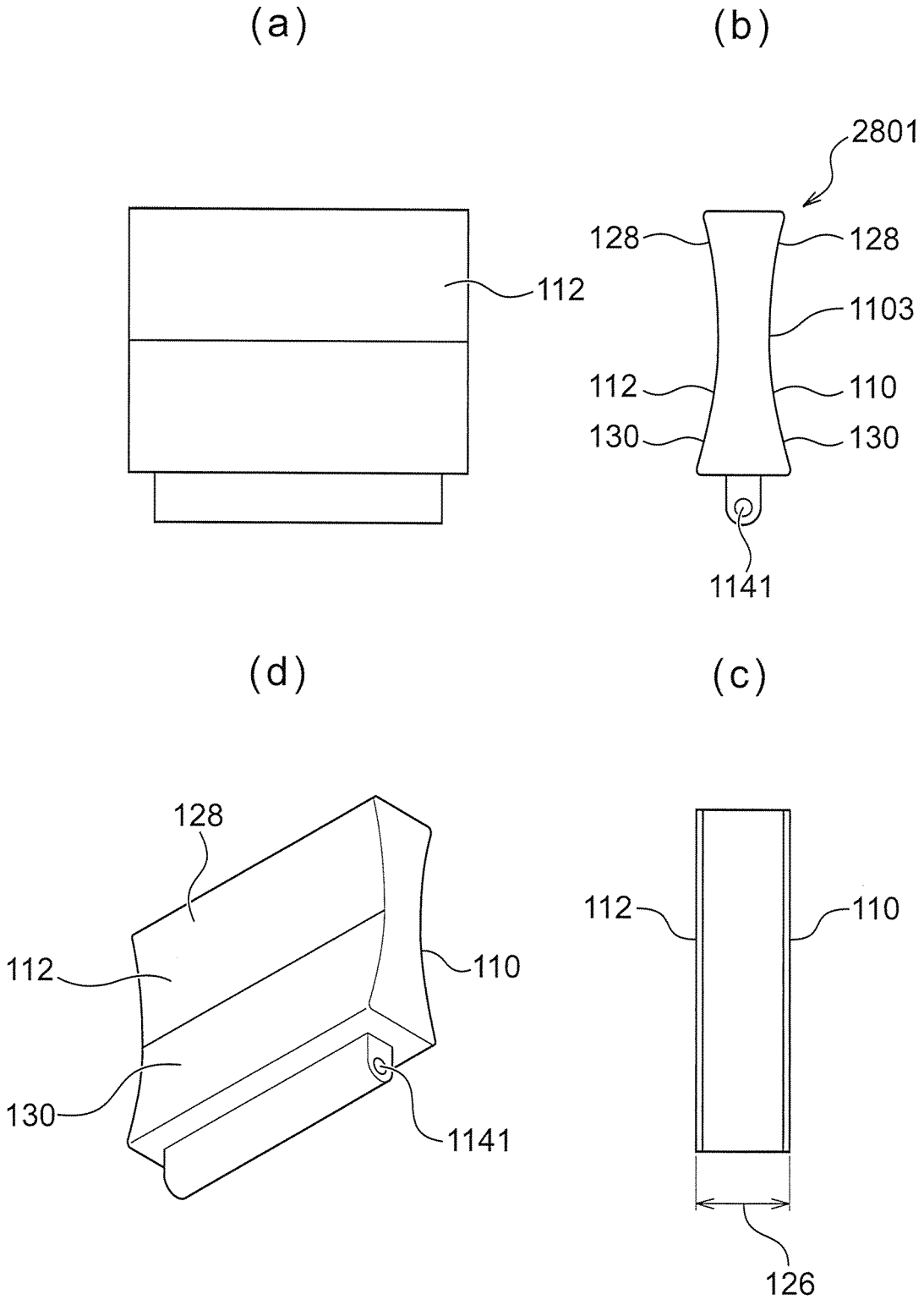

(a)
(b)
2801
128
128
112
1103
112
110
130
130
1141
(d)
(c)
128
112
110
130
1141
112
110
126

Fig. 10

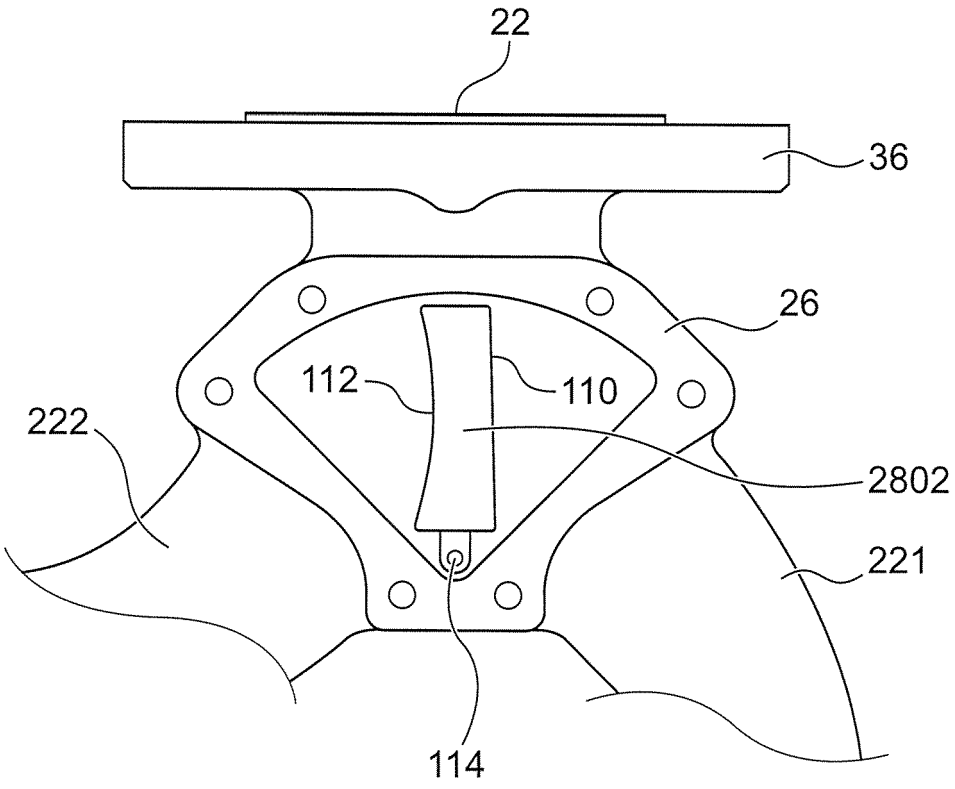


Fig. 11

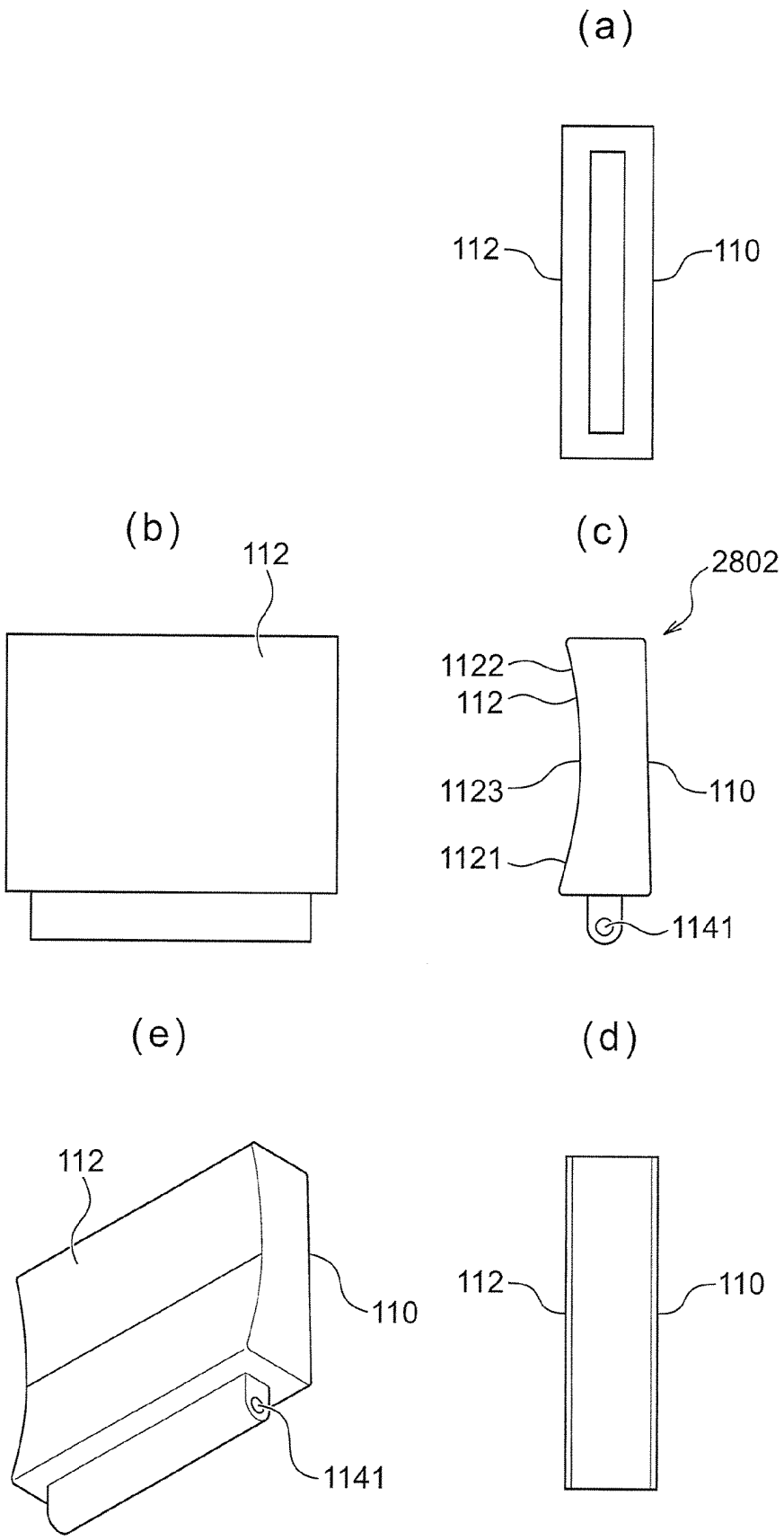

(a)
112
110
(b)
112
(c)
2802
1122
112
1123
110
1121
1141
(e)
112
110
1141
(d)
112
110

Fig. 12

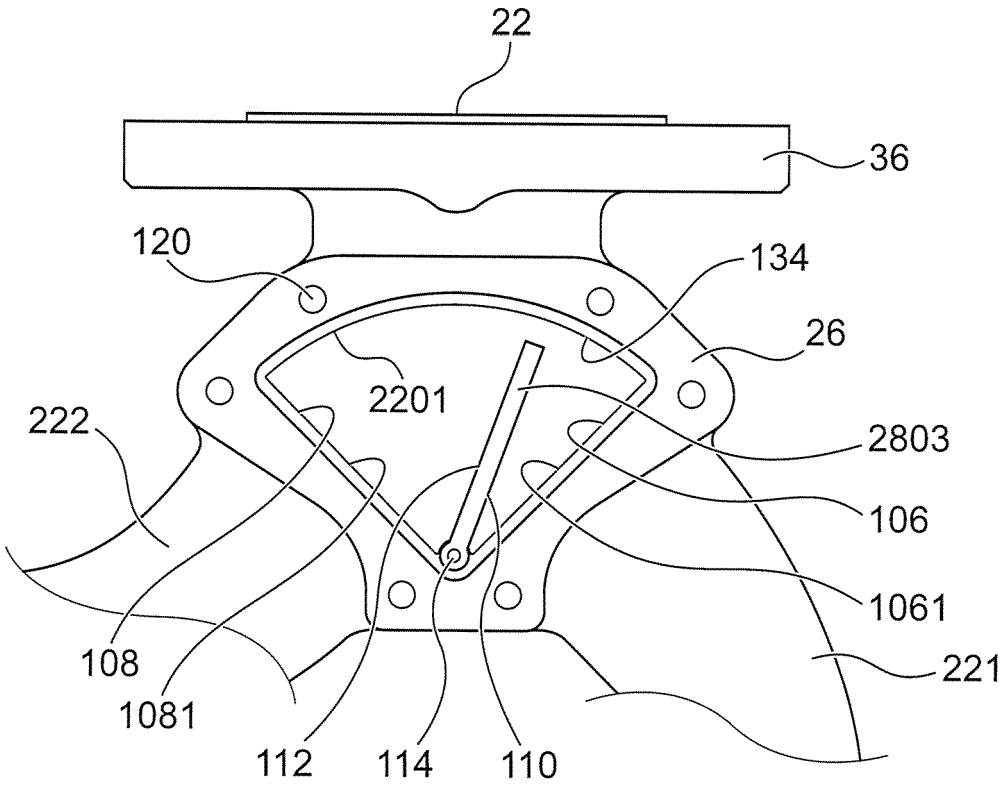


Fig. 13

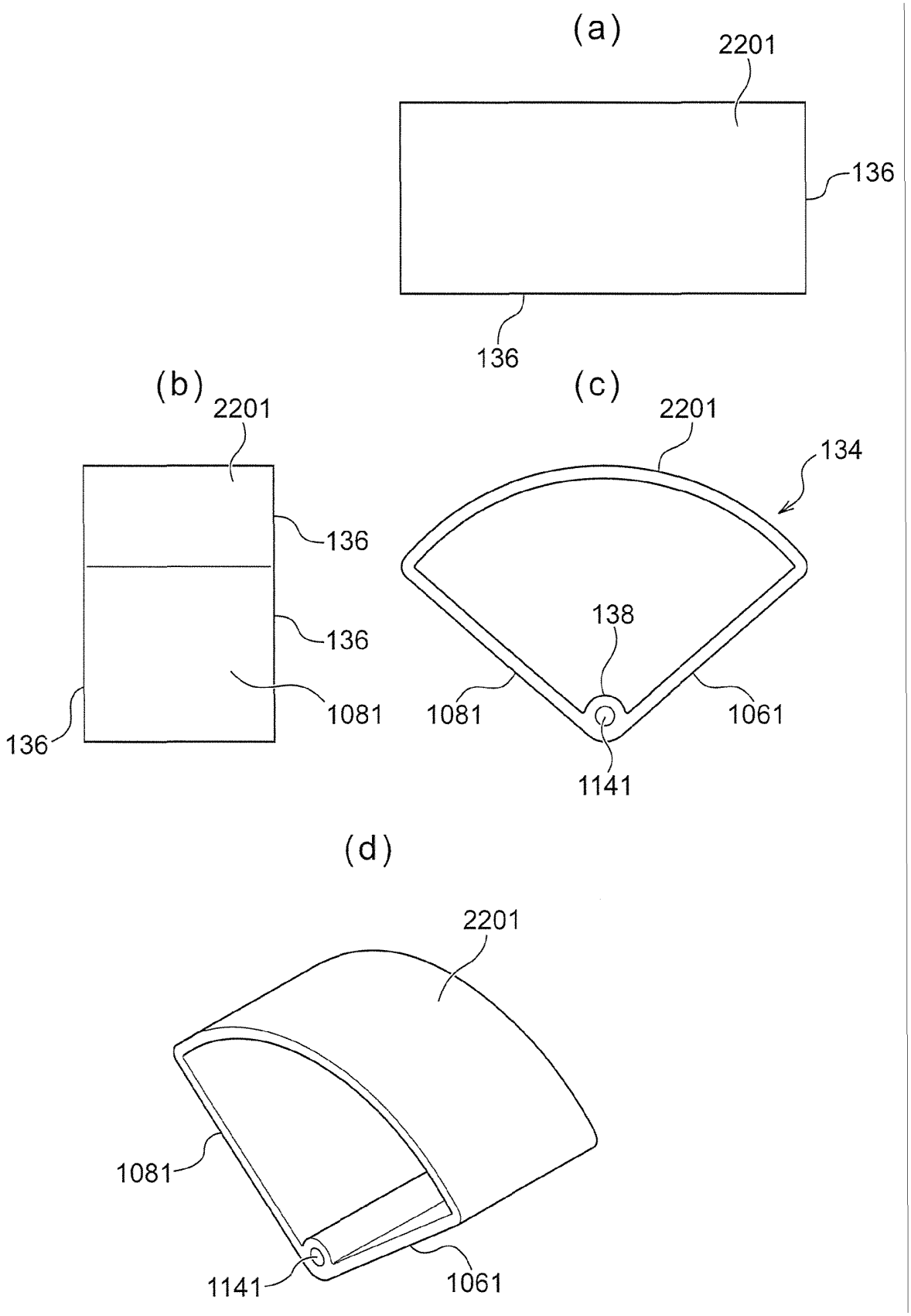

(a)
2201
136
136
(b)
2201
136
136
1081
136
(c)
2201
134
138
1081
1061
1141
(d)
2201
1081
1141
1061

Fig. 14

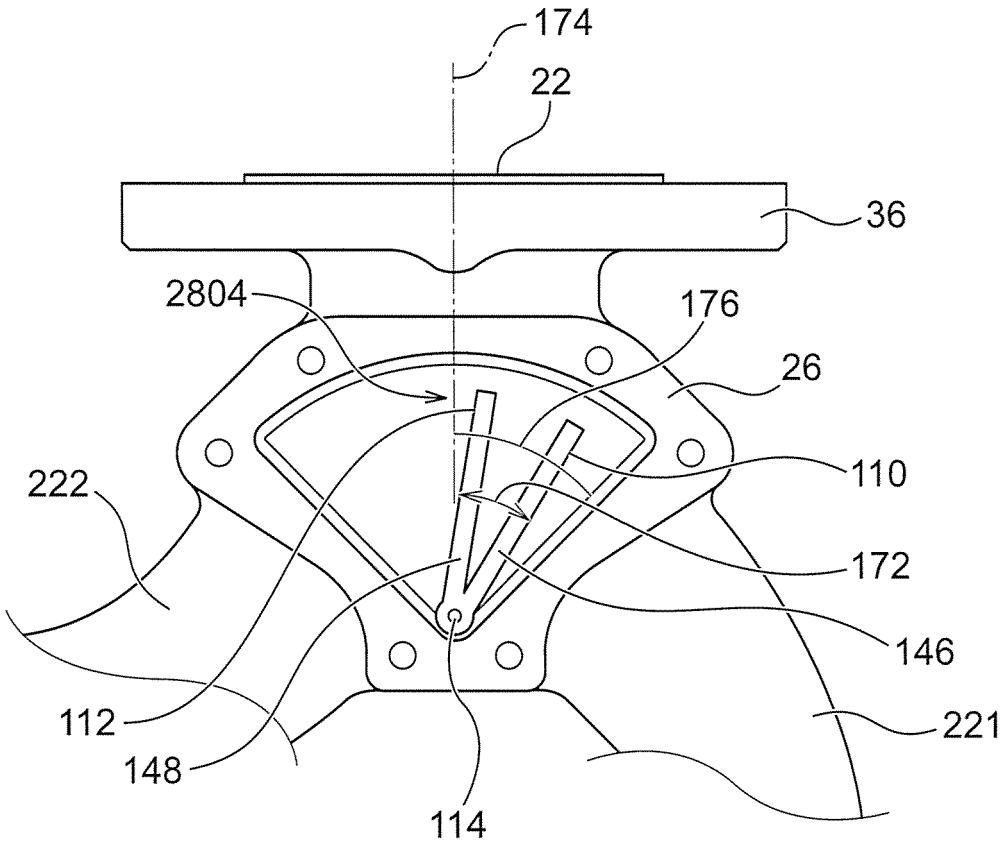


Fig. 15

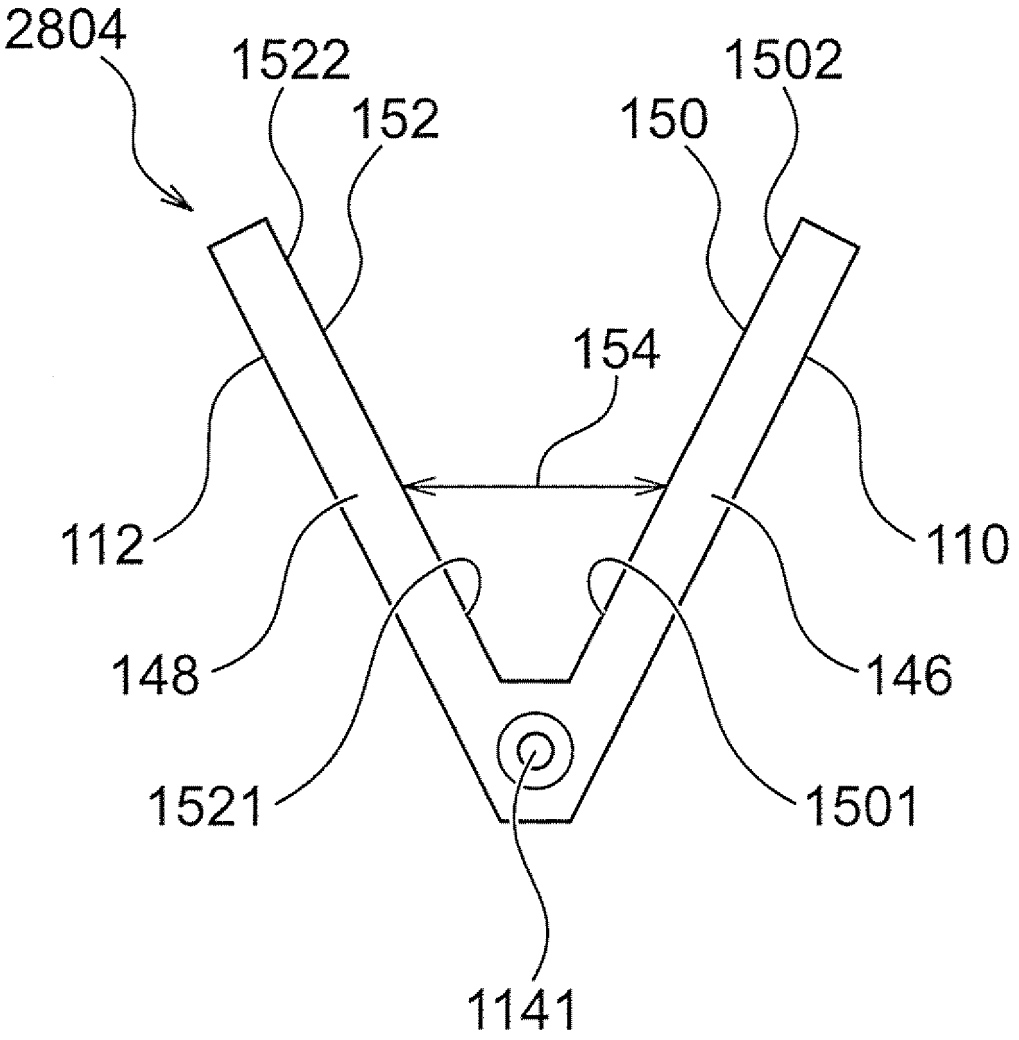


Fig. 16

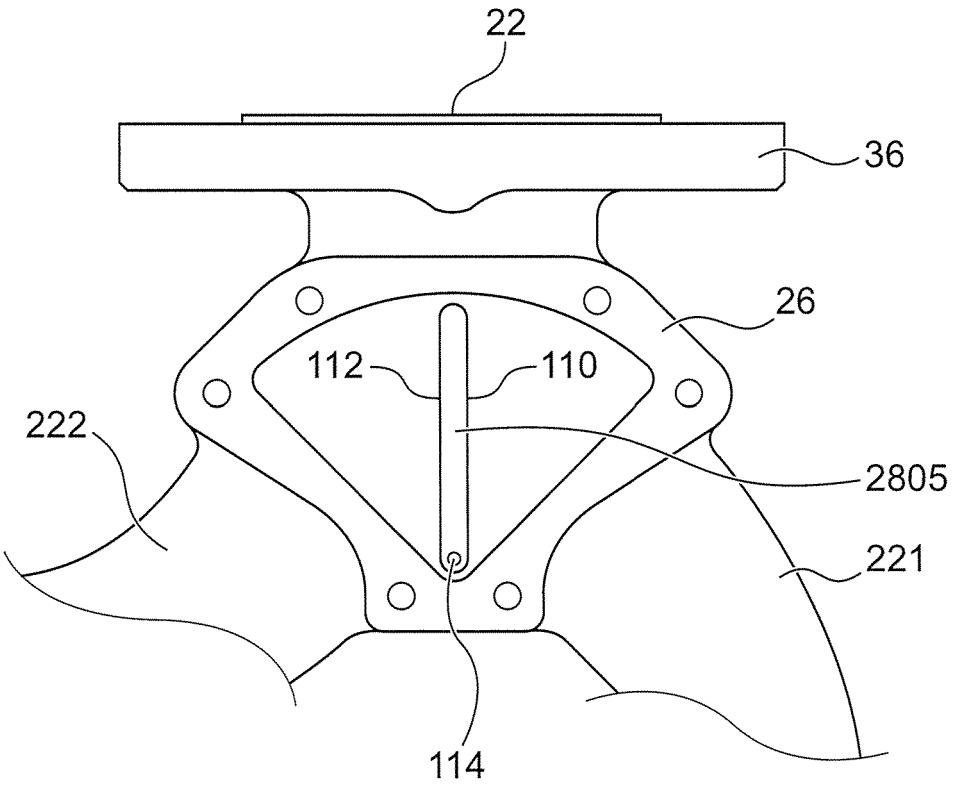


Fig. 17

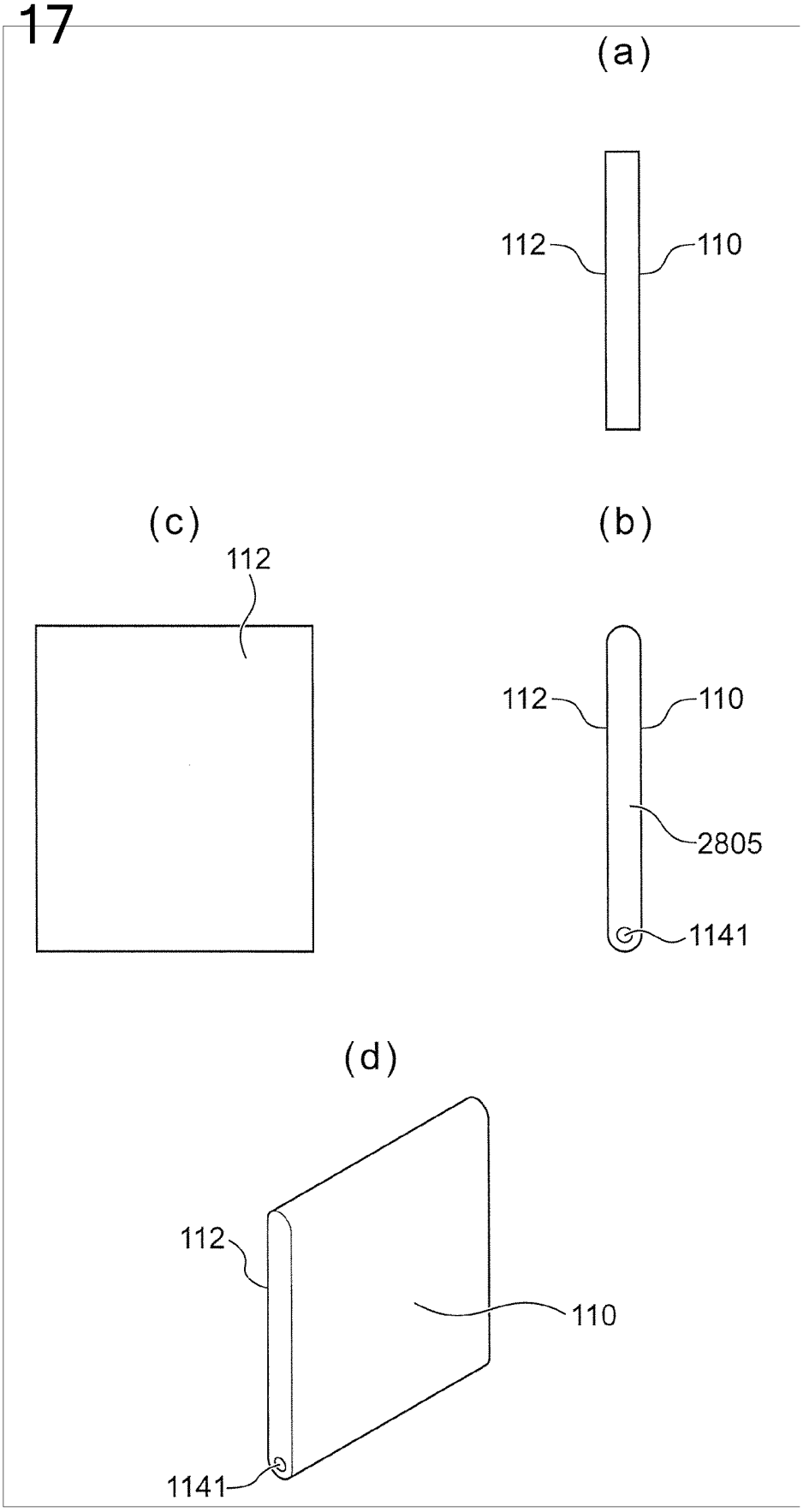
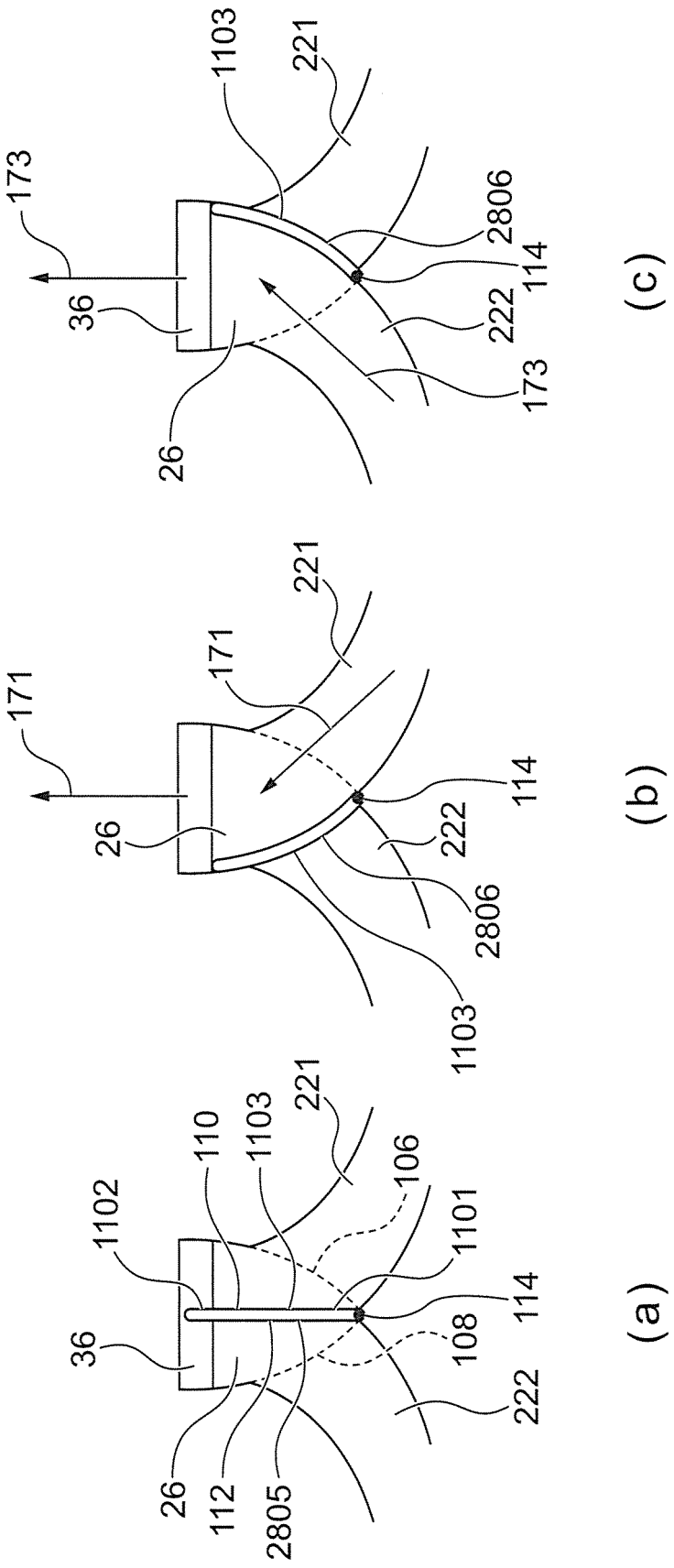


Fig. 18


(a)
(b)
(c)
36
26
112
2805
1102
110
1103
221
106
1101
114
108
222
171
173
2806
1103

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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